    

Regenerative Agriculture for New England:

SUSTAINING FARMLAND PRODUCTIVITY IN A CHANGING CLIMATE

AMERICAN FARMLAND TRUST | CONSERVATION LAW FOUNDATION

APRIL 2022

American Farmland Trust
SAVING THE LAND THAT SUSTAINS US

ABOUT AMERICAN FARMLAND TRUST

American Farmland Trust (AFT) is the largest national organization dedicated to protecting farmland, promoting sound farming practices, and keeping farmers on the land. AFT unites farmers and environmentalists in developing practical solutions that protect farmland and the environment. We work from "kitchen tables to Congress," tailoring solutions that are effective for farmers and communities and can be magnified to have greater impact. Since our founding, AFT has helped to protect more than six and a half million acres of farmland and led the way for the adoption of conservation practices on millions more. AFT has a national office in Washington, D.C., and a network of offices across America where farmland is under threat.

For more information, visit us at www.farmland.org

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ABOUT CONSERVATION LAW FOUNDATION

Conservation Law Foundation (CLF) is a non-profit organization committed to building a regional food system that supports access to fresh healthy food, creates jobs, cuts greenhouse gas emissions, protects farmland, and grows our local economy. CLF supports policies and programs that help farmers invest in regenerative farming practices that build soil health, protect water quality, and reduce harmful emissions. CLF provides critical legal support to small farmers in New England through the Legal Food Hub, a pro bono legal services clearinghouse. New England farmers are our partners in building healthy soils to combat climate change and support a healthy ecosystem, and building an equitable, vibrant local food system.

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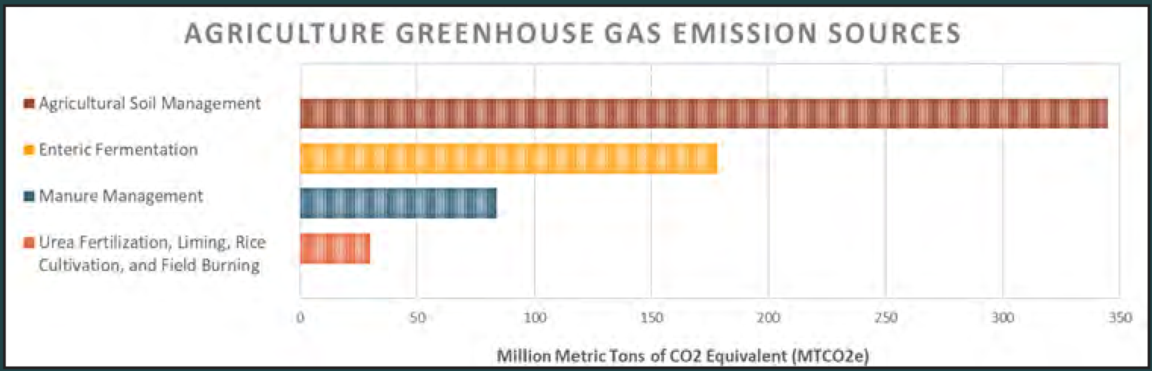
INTRODUCTION

New England states have passed ambitious climate goals that include greenhouse gas (GHG) emission reductions targets[1]. Agriculture contributes approximately 9.3% of US GHG emissions, so we must reduce the impact of our agricultural sector while continuing to provide healthy, local food for our communities. Agricultural lands have a critical role to play in meeting these climate goals through reducing GHG emissions and increasing carbon sequestration on natural and working lands. Today, soils store more than double the carbon dioxide (CO_2) that is stored in all vegetation and the atmosphere combined (IPCC, 2019). However, two centuries of changes in land-use and increased intensive soil management practices, such as plowing, have depleted our nation's soils of approximately half of the organic carbon originally stored within them, causing soil degradation, poor soil health, and increased GHG emissions (Bruner et al., 2020; Sanderman et al., 2017).

Agriculture's GHG emissions are mostly comprised of nitrous oxide (N_2O) and methane (CH_4). However, for ease of comparison to other GHG sources, the relative warming impact of gases are presented as "CO_2 equivalents." Figure 1 (below) presents the largest sources of GHG emissions in millions of metric tons of carbon dioxide equivalents (MMT CO_2 eq or millions $MTCO_2e$). Agriculture GHG emissions total approximately 618.5 million $MTCO_2e$ annually. Agricultural soil management is by far the largest contributor at 345 million $MTCO_2e$, nearly double the emissions released by enteric fermentation from livestock (note: on-farm fuel and energy use is not included in the agricultural inventory, but in the energy inventory) (USEPA, 2021).

FIGURE 1: MAJOR SOURCES OF AGRICULTURE GREENHOUSE GAS EMISSIONS



Adapted from 2019 Agriculture Greenhouse Gas Emission Sources, from the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019.

Transitioning to regenerative agricultural practices can reduce emissions from all the above sources within agriculture. Regenerative agricultural practices can also increase carbon sequestration, improve soil health, increase crop yields, and protect water quality. In addition, these practices can also increase resilience to the impacts of climate change that our farmers face every year, including more frequent droughts, floods, and fires, altered growing seasons, and increased pests and disease. Farmers are at the frontline of climate change, yet they can also have a major role in combatting it

1. Five New England states have passed landmark climate change legislation: Global Warming Solutions, Connecticut (2008) Global Warming Solutions Act, Massachusetts (2008) updated by An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy (2021) An Act to Promote Clean Energy Jobs and to Establish the Maine Climate Council, Maine (2019) Global Warming Solutions Act, Vermont (2020), and Act on Climate, Rhode Island (2021).

through the adoption of climate-smart regenerative agriculture. However, if New England's farmers are to adopt regenerative agriculture on a meaningful scale, they must be provided sufficient technical and financial support to facilitate the transition.

FARMING IN NEW ENGLAND

New England's agricultural history is long and complex, beginning with the Indigenous communities that first inhabited the forested region after the last glacier receded, and changing significantly with the arrival of European settlers. Throughout the 18th century, Indigenous peoples were forced off their lands, which were subsequently cleared for European-style agricultural uses, peaking in the early 19th century with as much as 60-80% of New England cleared of native forests. More than a century later, most of that abandoned farmland has returned to woodlands through ecological succession, with the result that more than 70% of New England is forested once again (Hall et al., 2002).

What farmland remains is dominated by young soils, which are generally acidic, nutrient-poor, and often have very low organic matter content - making sustaining long-term productive agriculture more challenging than other regions of the U.S. New England does have some very productive soils where glacial lakes were once located, including the fertile floodplains in the Connecticut River Valley. Due in part to such high fertility, these soils have been farmed continuously for more than two centuries so they too could benefit from regenerative agricultural practices.

New England's agricultural history, forested landscape, limited soil fertility, and high population have all shaped our regional agriculture, where small farms are the rule, not the exception. According to 50by60 - A New England Food Vision (FSNE, n.d.), New England only supplies 10% of its food, mainly dairy products and vegetables. To meet the New England Food Vision goal of locally producing 50% of the food consumed in the region by 2060, New England agriculture will require an additional 4 million acres of farmland. Yet, urban development and sprawl converted or threatened more than 105,000 acres between 2001 and 2016, and there is increased vulnerability to development as farmland changes hands over the next decade, farmers retire, and high land values create significant barriers for new and beginning farmers to purchase land.

Research has shown that the adoption of regenerative agricultural practices can have a quantifiable impact on carbon sequestration and the reduction of greenhouse gas emissions (Paustian et al., 2020), and that the benefits go beyond crop yield and soil health ("co-benefits") of regenerative agriculture are good for farmers, farmland, and the surrounding environment (Moriasi et al., 2020). One of the core tenets of regenerative agriculture is rebuilding soil health, which is crucial to sustaining agriculture, enhancing the profitability of farmers and ranchers, and combatting climate change. Farmers and ranchers are one of our nation's greatest allies in fighting climate change. To do this, however, policymakers must invest in our farmers and their farmland so they can reduce emissions and adapt to climate change through the adoption of regenerative agriculture.

Regenerative agriculture is key to improving the resiliency of New England's farmland, protecting our environment, feeding our region, and combatting climate change, but transforming the agricultural system requires a holistic approach that balances the protection of our agroecosystem with the financial realities of modern farming. While the adoption of regenerative practices has been challenging, both technically and financially for farmers across the United States, regenerative agriculture has gained momentum among farmers as a means of producing food with lower environmental and social impacts (Rhodes, 2017; Newton et al., 2020). And in recent years, the principles and practices of regenerative agriculture have seen renewed interest from policymakers and farmers for their added environmental and social benefits. Documented evidence of these benefits is increasingly used to direct research, policy, and technology in support of shifting agricultural practices (Paustian et al., 2020).

New England's land pressures and economic challenges only underscore the urgency of shifting to regenerative agriculture systems now. Our regional demographics of smaller and family farms make profitability a continuous struggle. Regionally, increased adoption of regenerative practices such as no-till, reduced tillage, and cover cropping have been supported by large initiatives coming from state agencies of agriculture, the Natural Resources Conservation Service (NRCS) (USDA NRCS, n.d.), and other non-governmental organizations (AFT, 2021). Prioritizing funding for current programs that assist farmers in their transition to regenerative agriculture, using both public and private funding, can provide the support necessary for farmers to move past the barriers to adoption.

FARMING IN A CHANGING CLIMATE

Agricultural production both contributes to climate change and is vulnerable to the impacts of climate change. Agricultural activities are responsible for 10-12% of global anthropogenic greenhouse gas emissions, and in the U.S., accounting for 9.3% of the total GHG emissions in 2018 (618.5 million MTCO2e). Most of these agricultural emissions are from practices that increase soil nitrogen levels, such as fertilization, manuring, and growing legumes (55%, mainly as N_2O) or from the digestive process of ruminant livestock and manure management (42%, mainly as CH_4) (USEPA, 2021).

Agricultural lands are also affected by a changing climate, with up to 70% of recent productivity losses driven by climate factors, including extreme weather events and shifts in temperature (Liang et al., 2017). New England is predicted to experience more extreme changes in climate than other regions of the U.S. (Dupigny-Giroux, 2018). Most concerningly, our region is already experiencing changes in precipitation, with less frequent but more intense rainfall, concentrated in the winter and spring months. Winter temperatures are increasing, leading to more freeze-thaw periods resulting in less time soils are frozen overall. Heavier winter and spring rains combined with earlier soil thaw leaves New England crop lands more vulnerable to early-season erosion.

The challenges posed by extreme weather are compounded by the economic realities for New England dairy farmers, for whom maximizing on-farm feed production is often the singular focus in determining management practices. Recent extreme weather events in New England underscore these challenges for New England's farmers. A 2016 drought reduced New Hampshire's hay crop by 75%, and wells in Connecticut, Massachusetts, New Hampshire, and Vermont ran dry (Bidgood, 2016). Just two years later, farmers were once again impacted by drought conditions which increased purchased- feed costs significantly. Because maximizing yield is often the singular focus for determining crop variety and management practices, many farmers are choosing varieties of silage corn that require extremely long growing seasons (100+ days to maturity) and in New England's somewhat abbreviated summers, the harvest of silage corn often occurs too late to plant winter cover crops. This leaves fields exposed to harsh precipitation, topsoil erosion, and nutrient loss, and threatens local water quality, amplifying the vulnerability of New England's farmland to its increasingly unpredictable precipitation and temperature swings.

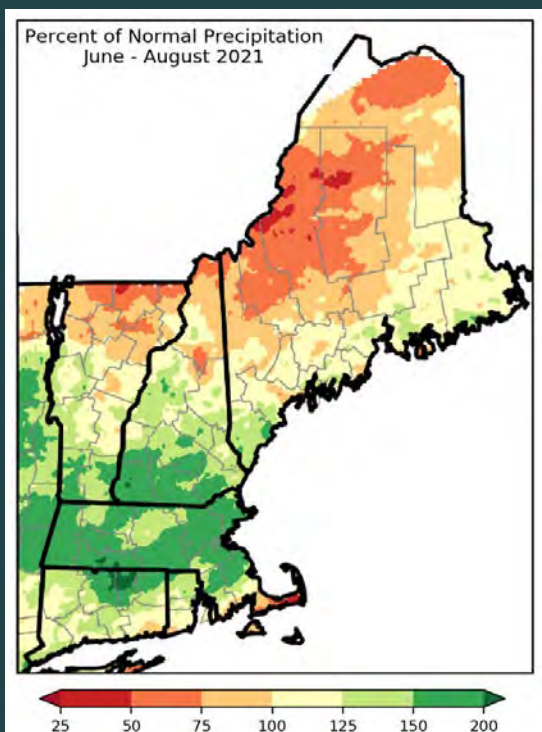


FIGURE 2: Percent change in normal precipitation across New England

From June-August 2021, regions across New England experienced opposite precipitation extremes. Inland Maine received less than 75% of the normal precipitation, while Massachusetts and bordering counties received anywhere from 125% to more than 175% of the average precipitation for those three summer months.

This followed a significant drought across the region that began in September 2020. These events led to agricultural disasters being declared due to the damage or complete failure of crops in all six New England states during the 2021 calendar year.

OVERVIEW OF REGENERATIVE AGRICULTURE

Regenerative agriculture supports thriving humans, farms, and ecosystems, in contrast to practices that emphasize extraction and production. The principles of regenerative agriculture are built from the traditional knowledge and practice of generations of Indigenous people and other land caretakers (Heim, 2020).

In the Northeastern United States, the Indigenous method of planting corn, beans, and squash, or the "Three Sisters" emerged from a creation myth of the Haudenosaunee (also known as the Iroquois). This creation myth described how those three plants provided food and sustenance to ensure the survival of their people. Corn would be planted in the center of a small hill, with beans following a few weeks later around the corn, and then lastly squash planted between the hills of corn and beans. The corn grows tall and provides support for the vining beans, which fix nitrogen in the soil, while the squash lies close to the ground, shading weeds with its large leaves. These sisters do not grow at the expense of each other but mature together and benefit from companion planting. The Three Sisters companion planting method is situated within a complex and sophisticated set of agricultural practices used by the Indigenous people of the Americas. Increasing biodiversity in agriculture, as companion planting like the Three Sisters does, is a core principle of regenerative agriculture.

Drawing on these practices, modern-day regenerative agriculture includes a suite of practices that actively restore the natural resources of the land, as well as versions of practices we now call agroforestry, forest gardening, silvopasture, crop rotation, reduced tillage, controlled burning, succession permaculture, and cover cropping. The aim of modern day regenerative agriculture is to regenerate “the health, vitality, and evolutionary capability of whole living systems” (Soloviev & Landua, 2016). The founding principles initially articulated by Maria and Bob Rodale (Rodale, n.d.), can be summarized as:

These principles of regenerative agriculture are backed by scientific research that demonstrates that such practices can build soil health, improve the resilience of farmland, reduce chemical inputs, prevent degradation of soil, and improve water quality.

For the purposes of this paper, regenerative agricultural practices are grouped into broad categories to help differentiate where and how they may be integrated into a production system. These broad categories are:

FIGURE 3: PRINCIPLES OF REGENERATIVE AGRICULTURE

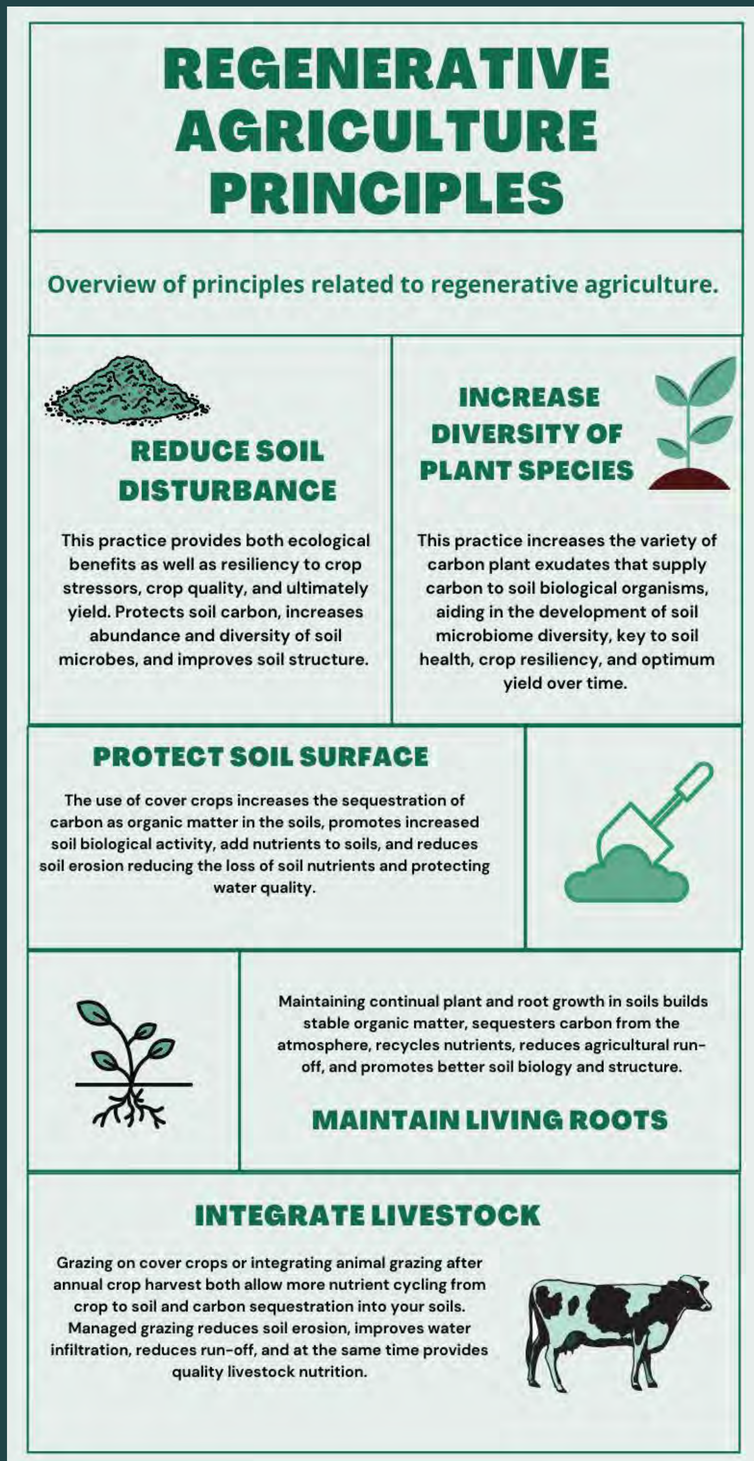


FIGURE 4: REGENERATIVE AGRICULTURE PRACTICE DEFINITIONS AND CO-BENEFITS

Category	Practice	Definition	IMPROVE SOIL COMPACTION	PROTECT WATER QUALITY	REDUCE ON-FARM FUEL CONSUMPTION	REDUCE ON-FARM FUEL CONSUMPTION	BENEFIT WILDLIFE INCLUDING INVERTEBRATES	REDUCE WEED AND PLANT PEST PRESSURES
SOIL MANAGEMENT	Post-harvest plant material incorporation	Leaving plant material in the field after harvest and then incorporating plant material (e.g. corn stalks) into the soil before the next planting, instead of removing the material from the soil.	✓	✓	✓	✓		
SOIL MANAGEMENT	Alternation of soil amendments	Altering soil amendments from inorganic inputs to organic inputs (e.g. switching from fertilizer to comport or manure, adding biochar amendments).	✓	✓	✓			
SOIL MANAGEMENT	No-till and reduced tillage	No-till is a technique that leaves the soil intact when planting rather than disturbing the soil through plowing and reduced tillage are practices that disturb the soil minimally.	✓	✓	✓	✓	✓	
SOIL MANAGEMENT	Nutrient management	Following the Four “Rs”: right rate, right source, right placement, and right timing for fertilizing crops to maximize efficiency and minimize application.	✓	✓	✓	✓		
CROP MANAGEMENT	Cover crops	Plants grown between or after regular crop for adding of organic matter to soil, protection against erosion, improve heat and drought resilience, and increase soil carbon.	✓	✓	✓		✓	✓
CROP MANAGEMENT	Crop rotation and/or diversitication	Increasing crop diversity by planting more and different types of crops (particularly if focus is on increasing perennial plants).	✓	✓			✓	✓
CROP MANAGEMENT	Planting of conservation buffers	Vegetation planted around cropping systems to act as habitat for beneficial insects and other organisms, reduce soil erosion, increase carbon sequestration, and protect water quality when planted near streams or wetlands.	✓	✓	✓			
CROP MANAGEMENT	Crop or production alterations	Changing varieties of crops that are grown, crop rotations, and/or the timing or mode of seeding crops all to better align or adapt to ecological conditions, including moving to perennial crops or converting croplands to pasture for grazing.	✓	✓	✓	✓	✓	✓
INTEGRATING TREES AND LIVESTOCK	Agroforestry in crop systems	Intentionally integrating of woody perennials (trees, shrubs, etc.) within other crop production systems.	✓	✓	✓	✓	✓	✓
INTEGRATING TREES AND LIVESTOCK	Silvopasture in livestock systems	Intentionally integrating tree planting (agroforestry) within livestock systems and/or integrating livestock into tree/orchard systems, managed for both forest products and forage.	✓	✓	✓	✓	✓	✓
INTEGRATING TREES AND LIVESTOCK	Holistically managed grazing	Carefully controlling livestock density, timing, and intensity of grazing within a rotational grazing system, often utilizing high densities for short intervals.	✓	✓	✓		✓	✓

There are many practices that fit within the definition of regenerative agriculture. Figure 4 (above) highlights those practices best suited for New England's agricultural landscape of diverse farm enterprises, smaller farm size, large dairy industry, and forested land cover. Figure 4 provides practice definitions and presents the potential co-benefits for each highlighted practice.

Policymakers are also exploring regenerative agriculture practices as an additional tool to mitigate climate change by reducing greenhouse gas emissions associated with farming, and to help adapt to a changing climate by making farmland more resilient to extreme weather events. Recent research and policy has been directed towards assessing practices that can help support both objectives simultaneously (Barbieri, 2021). For example, planting riparian buffers and pasture on marginal land helps sequester soil carbon, preserves water quality, and protects soil. Manure management via appropriate manure application helps mitigate climate change by reducing the amount of GHG emissions and/or sequester increasing carbon in biomass and soil (Duncan, 2008). Regenerative agricultural practices also have the potential to significantly buffer the negative impacts of New England's changing climate. Conservation tillage, pasture restoration, and crop rotation improve the resilience of our farmland under the increasing damage of heavy precipitation events and longer and more severe periods of drought.

Photo by Caro Roszell

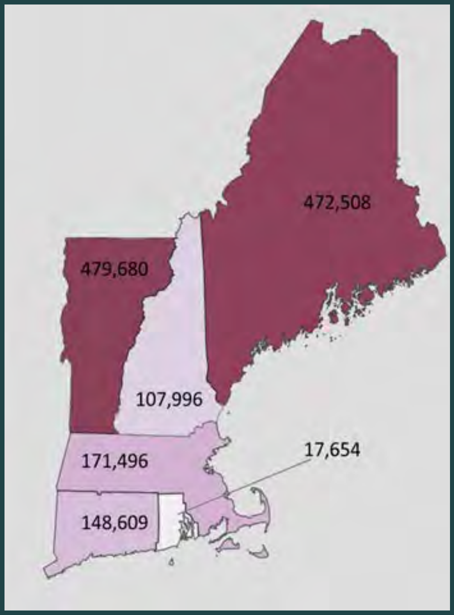
REGENERATIVE AGRICULTURE PRACTICES IN NEW ENGLAND

SNAPSHOT OF NEW ENGLAND AGRICULTURE

To assess the potential impact of regenerative farming systems in New England, we need to understand our region's unique agricultural landscape. Although less than 5% of the land is still producing food, agriculture remains an important aspect of New England's regional identity, history, and landscape, and it is fundamental for local food production needs[2]. While many unique and high-value crops (e.g., sweet corn, apples, berries) support New England's agriculture economy, dairy and the supporting feedstock crops anchor the region.

Approximately half of all New England cropland is used to produce hay or haylage. This is important to note for several reasons. Firstly, hay is a valuable feed crop for many types of livestock, making it valuable for animal agriculture across the region. Secondly, many hay and forage plant species are perennial, producing for multiple years before rotating to a different crop. Therefore, hay production limits soil disturbance, leaves living roots in place, and protects the soil surface, as compared to annual crops that usually require soil disturbance before annual planting. Separating hayland out of the larger cropland category provides a more nuanced account of the remaining cropland that could benefit from the increased adoption of regenerative agriculture practices.

FIGURE 5: NEW ENGLAND TOTAL CROPLAND BY STATE



Dairy farming has been a part of New England's agricultural history since the settling of Plymouth Colony. Today milk is the top animal product across the six-state region, producing more than half of the milk and milk products consumed in the region (USDA NASS 2020). In 2019, dairy farms represented 5% of total farm operations in New England. Yet, as Table 1 (below) indicates, those dairy farms are on average far larger than other enterprises. This illustrates a landscape with a relatively small number of dairy farms that utilize nearly ¼ of all New England cropland, much of which is dedicated to feed crops like corn. Financial and technical support for advancing regenerative agriculture practices within the dairy industry could provide an opportunity for climate mitigation as well as improved resilience for a struggling dairy economy.

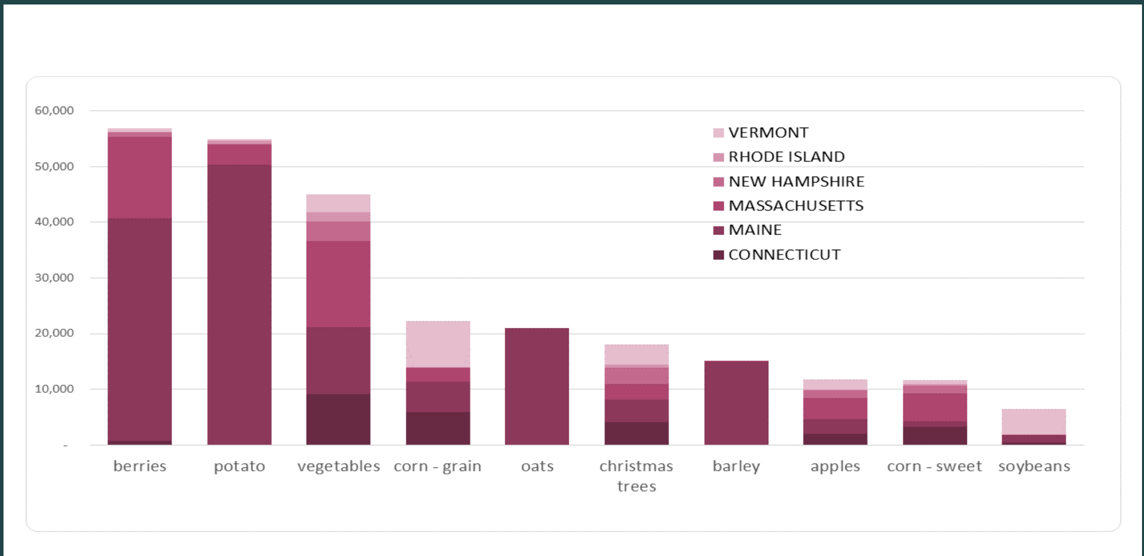
2. Agricultural lands in New England are under continued threat of being converted to more intensively developed lands. Simply being under agricultural production may also provide more carbon sequestration and ecosystem benefits than would otherwise happen if farmland was not conserved (e.g., New York calculates 66x more GHG release when farmland is developed) (Arjomand & Haight, 2017).

Table 1: Average On-Farm Cropland Reported by Enterprise				
State	**Vegetable Operations**	**Fruit Operations**	**Dairy Operations**	**Beef Cattle Operations**
Connecticut	18	18	371	31
Maine	158	62	320	53
Massachusetts	28	30	244	28
New Hampshire	18	19	244	45
Rhode Island	20	15	--	50
Vermont	18	15	414	67
New England Average	**61**	**35**	**357**	**48**

Source USDA NASS, 2017

Figure 6 (below) shows the wide array of crops grown on New England cropland (excluding hay and corn silage feed crop acres). In addition to dairies, a significant portion of New England agriculture is devoted to apple orchards, blueberry, and cranberry production, as well as potatoes and diverse vegetable production. Fruit and vegetable production occupies 23% of cropland, an area similar to total dairy-related cropland. While dairy-related cropland supports limited numbers of crops, vegetable and fruit-related cropland produces dozens of different crops with unique production systems. Advancing regenerative practices across these diverse cropping systems within both the fruit and vegetable industries in New England requires accessible, specialized technical assistance to support farmers in meeting production needs while improving on-farm practices.

FIGURE 6: NEW ENGLAND CROPLAND USAGE



Top ten crops by acreage planted (excluding hayland and corn silage). USDA NASS, 2020.

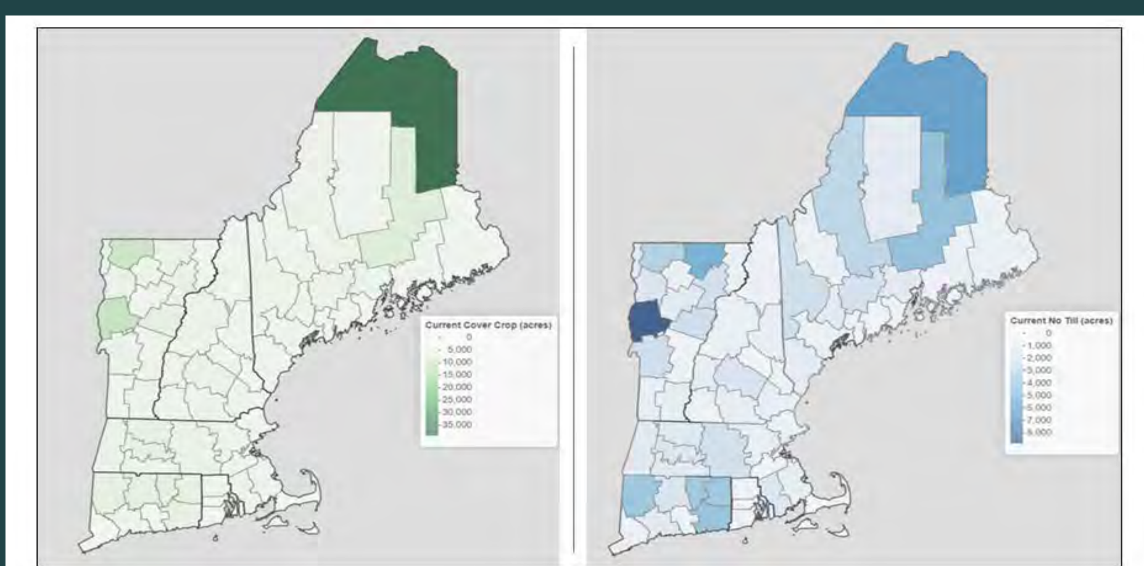
CURRENT ADOPTION OF REGENERATIVE PRACTICES IN NEW ENGLAND

New England producers have adopted some regenerative practices (see Table 2) at a higher rate than other parts of the country, with cover crops being the most highly implemented conservation practice regardless of farm size or agricultural product. New England has a higher rate of cover crop implementation at 10% of cropland acres, as compared to the national rate of 3.9%. This is in part due to the widespread adoption of planting cover crops after harvest of corn silage, which is a staple feed crop for our regional dairy industry.

Overall, large farms (>180 acres) in New England (which include most dairy farms) have the highest rate of implementation across all practices. This is because transitioning to no-till or adopting cover crops is easier for farming operations focused on only a few crops, than it is for smaller operations, for whom the barriers to adoption can be technically challenging and economically harder to overcome. Regardless of farm size, however, there is significant potential for increased adoption of cover crops across the region.

As for reduced tillage, or no-till practices, New England farmers have implemented these at similar rates as cover crops. However, compared to the national average for implementation of no-till and reduced tillage practices at 37% and 35% respectively, the New England implementation rates of 5.9% and 6.3% are dramatically lower. Across New England adoption of no-till practices are concentrated in a few counties as is depicted in Figure 7 (below). The county-by-county adoption rates of both cover crops and no-till shows meaningful adoption is found in only a few counties, indicating significant room for increased adoption across most

FIGURE 7: COVER CROP (LEFT) AND NO-TILL (RIGHT) ADOPTION LEVELS BY ACREAGE (MOORE ET AL., 2019).



of the region. For each New England farm, the adoption of specific regenerative agricultural practices will be driven by its production system, location-specific soil and land characteristics, and natural resource concerns, as well as access to technical assistance, and ability to fund costs associated with the adoption of new practices. States would be well-served by gathering their own-state level data, rather than relying on the USDA Ag Census, to better evaluate and understand factors that impact the wide range of adoption across their own counties.

Even with this striking lack of conservation practices across most counties in New England, the climate mitigation impact of existing cover crops and reduced or no-tillage adoption is still significant. These two practices alone mitigate more than 72,000 MTCO2e annually. This is roughly the same amount of carbon dioxide that burning more than 8 million gallons of gasoline would emit annually (see Table 2).

Table 2: Current Adoption Levels and Climate Mitigation Impact of Cover Crop and No-till Adoption in New England

State	Total Cropland (acres)	Reported Adoption (% acreage)		Combined Annual GHG Mitigation	
		Cover Crop	No-Till/Red. Till	$MTCO_2e$	Gallons of Gasoline avoided
Connecticut	148609	15	18	11300	1.28M
Maine	472508	12	11	22500	2.54M
Massachusetts	171496	10	11	8200	0.92M
New Hampshire	107996	8	8	3900	0.44M
Rhode Island	17654	13	8	800	0.1M
Vermont	479680	9	13	25300	2.84M
New England	**1397943**	**10**	**12**	**72000**	**8.11M**

Source USDA NASS, 2017

CHALLENGES TO ADOPTING REGENERATIVE AGRICULTURE

While there are compelling reasons to adopt regenerative agriculture practices, including potential climate and other environmental benefits, there are also challenges that make implementation difficult when transitioning to and working to sustain an adopted practice (Carlisle, 2016). This section describes some of these challenges, and the following policy section provides a discussion of some state and federal policies that can help producers overcome these challenges.

Adoption of regenerative agricultural practices occurs along a spectrum of transformation, starting with the shifting or altering of a specific practice, to adopting additional practices, and finally to more fully transforming a system of production. While larger system transformations are what is needed over time for robust climate and societal benefits, they also entail more challenges for adoption, particularly when considering how these practices may challenge traditional systems and goals of production (e.g., shifting to more diverse crops, reduced focus on yield). Introducing or shifting to specific, sustainable practices that include regenerative agriculture, can more easily be accomplished within existing systems of production and is an important first step toward transforming our farming systems. However, we can harness even greater impact through holistic, systemic transformations to regenerative agriculture. Systemic change such as this calls for strong local, state, and federal commitment and support, even as policy and technical support for the shifting practices are implemented or maintained.

BARRIERS TO IMPLEMENTATION AND MEASUREMENT

The adoption of new regenerative practices can also be costly, financially risky, and difficult to finance. Specifically, farmers may need to rent or purchase specialized equipment, including no-till transplanters or roller crimpers that terminate cover crops prior to planting main crops. Farms may also need to invest in additional labor to undertake new practices. Additionally, when making a transition from conventional to regenerative practices, farmers may experience a period of transition with lower crop yields. These costs are often well worth it in the long run, but the initial investment is significant barrier for farm operations with slim profit margins and limited liquid assets. In New England, two-thirds of farms sell less than $10,000 in goods annually (USDA NASS, 2021). To mitigate the farmer's financial risk, the USDA, along with state agencies, must provide the technical and financial assistance required to mitigate risk for the transitioning farmers and to ensure that new practices work together to achieve net environmental and agronomic benefits.

FIGURE 8: CHALLENGES TO IMPLEMENTING AND SUSTAINING PRACTICES

The transition to regenerative practices can also be labor-intensive. The time and labor commitments from the farm to both learn about and implement regenerative agricultural practices are referred to as operational challenges. Operational challenges typically arise when the regenerative practices require substantially different equipment (such as a no-till transplanter) or techniques different than those farmers have learned to use. Technical assistance is invaluable for learning, troubleshooting, and implementing regenerative practices and overcoming the associated operational challenges (Carlisle, 2016).

Even when technical assistance from government and academic institutions is available, transition to regenerative practices may be slow due to the cultural patterns of knowledge exchange in the farming community, as many farmers prefer to learn from other farmers[3]. For this reason, farmers that have developed strong working relationships with researchers and technical support providers to implement regenerative agriculture practices are invaluable actors in local agricultural knowledge networks, because they are uniquely able to translate and contextualize technical guidance, funding opportunities, and research findings for their peers. Whenever possible, farm support agencies and academic institutions should invest in collaborative relationships with these regenerative farming champions and direct funding allocated for education, outreach, and technical support towards those farmers as key local educators and technical support providers.

Once the practices are in place, both farmers and technical service providers face the challenge of measuring and verifying environmental impacts. To guide financial investment in regenerative agriculture and build the trust of farmers, land stewards, and policymakers, we need simple and reliable ways to measure, report, and verify the greenhouse gas impacts of adopting regenerative practices. Measurement methods that rely on direct measurement in the field and others that rely on modeling and estimation are evolving rapidly and becoming more accessible to the farmer (Nayak et al., 2019). Policymakers must support technical assistance and knowledge sharing so that farmers can integrate new technologies that document the impacts they are making on the farm.

Alongside these challenges, the perceived risk associated with the adoption of new practices may dissuade farmers from transitioning, even when the potential benefits are significant. This is an all-too-common occurrence, easily rectified with local technical and financial support. Together these barriers underscore the importance of smart state and federal policies that support farmers with funding and technical assistance to make this transition.

FUTURE FARMLAND SECURITY AND ACCESS

Now is a critical time in agriculture to implement system-level changes. New and beginning farmers are entry points to making these changes. Today more than 1/3 of farmers are 65+ and as such, farmland will change hands in the next 10 years, a prime opportunity to influence system-level production changes (AFT, n.d.). Further still, in considering the shifting demographics of farmers and potential transfers of land, it is important to note that regenerative agriculture has already been well-practiced in indigenous and Black farming and land caretaking communities. Yet there exists a staggering racial disparity when it comes to agricultural land ownership and stewardship, stemming from historical and ongoing oppression (Horst & Marion, 2019). Supporting transformative farming at this crucial juncture is critical and supporting BIPOC farmers (while being mindful and open to rectifying past and ongoing injustices) is one important part of this transformational process. Farmland prices have soared in the past decade, thanks in part to unprecedented interest on the part of wealthy investors. While the resulting land access dilemma is common among new farmers, it is especially keen for farmers of color. This is particularly salient as the potential to exacerbate inequalities and problematic power dynamics is significant when considering incentives as one potential pathway to incentivize the adoption of regenerative agriculture.

3. Independent research by American Farmland Trust and NOFA/Mass has revealed that other farmers are the leading source for producers seeking information on soil health practices. AFT's Massachusetts Soil Health Producer Survey asked farmers where they get information on soil health practices. Farmers could choose all options that applied. 69% responded that they get information from "other farmers I know," and 58% from "farmer-led sessions at conferences," while 63% get information from online sources, 51% from trade publications and books, and only 41% from specialist-led sessions at conferences and 40% from Extension workshops.

CLIMATE MITIGATION IMPACTS OF REGENERATIVE AGRICULTURE

To understand the possible climate mitigation impacts of regenerative agriculture practices in New England, AFT modeled the greenhouse gas equivalent impacts of four key practices:

COVER CROP	NO TILL AND REDUCED TILL	PRESCRIBED GRAZING	NUTRIENT MANAGEMENT

Using COMET-Planner, we provide the current levels, acreage, and GHG mitigation impacts of specific practices provided at the New England regional level. We selected the four modeled practices due to their relevance to New England agriculture and the availability of adoption and climate impact data. Although estimating impacts is a valuable step towards understanding the environmental benefits of higher adoption of regenerative agriculture in New England, it is important to understand the limitation to modeling such complex systems. Additional detail regarding the climate impacts of cover crops and no-till are also available in AFT's Combatting Climate Change on US Cropland report. The methodology used in this paper can be found in Appendix A. For each practice, we maintained the same adjustments within the practices for all four scenarios (e.g., the percent of legumes within the cover crop). We offer a range of adoption scenarios and associated estimated climate impacts.

Along with climate impacts, these practices may bring other co-benefits, including cleaner air and water, enhanced biodiversity, and improved climate resilience. Cleaner water due to reduced runoff and erosion is an important co-benefit that can also be modeled. To illustrate the potential water quality benefits of cover cropping and no-till, we used the U.S. Environmental Protection Agency's (EPA) Spreadsheet Tool for Estimating Pollutant Load (STEPL) (USEPA, n.d.) to generate high level generalized estimates of nitrogen (N), phosphorous (P), and sediment load reductions due to the adoption of regenerative practices on New England's cropland.

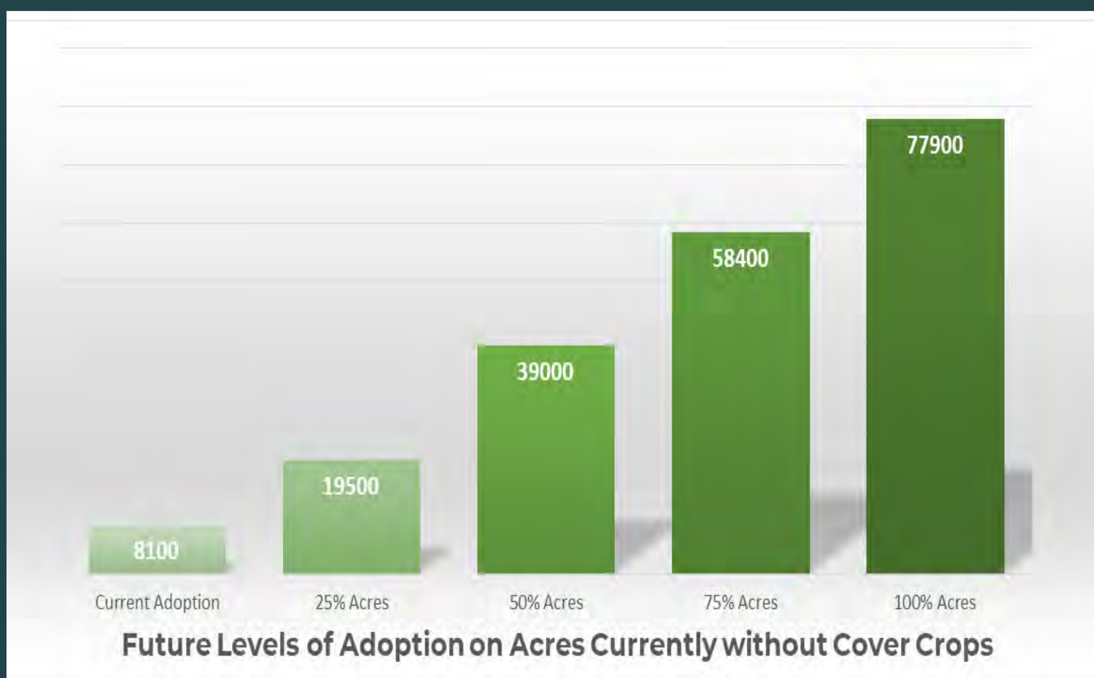
PLANTING COVER CROPS

The 10% adoption rate of cover crops across New England, is currently responsible for the mitigation of approximately 8100 MTCO2e annually, which is the equivalent to the emissions from 910,000 gallons of gasoline consumed. In Figure 8 (below), the current adoption level of cover crops is presented alongside four potential increased levels of adoption of 25, 50, 75, and 100% cover crop usage on cropland. If New England were to meet the 25% adoption level, the potential climate mitigation would increase to 19,500 MTCO2e annually (equivalent to 2.2 million gallons of gasoline). Under a future scenario where 100% of cropland acres also plant cover crops, the impact would increase to upwards of 77,900 MTCO2e annually (equivalent to 8.8 million gallons of gasoline, the carbon sequestered by 95,000 acres of forest, or equivalent to the removal of 17,000 passenger vehicles from the road annually).

For all the future scenarios of increasing more acres of cover cropping in New England, not surprisingly, most of the change is occurring in Maine due to its higher farmland acreage. Vermont, Massachusetts, and Connecticut follow with medium potential for increases in acreage for cover cropping. This is explicitly due to the relative amount of farmland in each state as well as the differences in soil characteristics that impact the mitigation potential of cover crops.

FIGURE 9: MITIGATION POTENTIAL OF COVER CROP ADOPTION

Estimated annual mitigation potential in $MTCO_2e$ /year



CO-BENEFITS OF ADOPTING COVER CROPS TO NEW ENGLAND

Planting cover crops between main crop growing seasons provides an opportunity to increase carbon sequestration and improve soil health across New England. However, in a region like New England, where farms are never far from a stream, river, lake, or the coast, the water quality impacts of adopting cover crops are also important to consider. With regional issues of water quality, including the critical need to improve the water quality of Lake Champlain and the Long Island Sound, increasing cover cropping can help to decrease topsoil erosion and increase the uptake of excess soil nutrients – resulting in reduced nutrient loading in our surface waters and improved water quality. Cover cropping practices may help minimize soil compaction and maintain or increase soil quality, organic matter content, and plant-available moisture, all of which increase resilience to drought. Increasing cover cropping may help to suppress excessive weed pressures and break pest cycles, potentially reducing reliance on pesticides (Zimnicki et al., 2020). With regards to regional economic concerns, increasing cover cropping may help reduce reliance on off-farm inputs by decreasing the need for fertilizer, and/or creating forage for livestock that may be able to be sold as an extra crop, depending on the cover crop and production system. Table 3 (below) shows the reduced nutrient load entering local surface waters due to cover crop adoption as modeled using STEPL (USEPA, n.d.). Currently, the use of cover crops in New England prevents 4,900 tons of sediment from entering our waterways, instead it remains on cropland, retaining associated nutrients and organic matter vital to crop growth.

Table 3: Water Quality Impacts of Cover Crop Adoption in New England: Nutrient Loading Reduction Potential

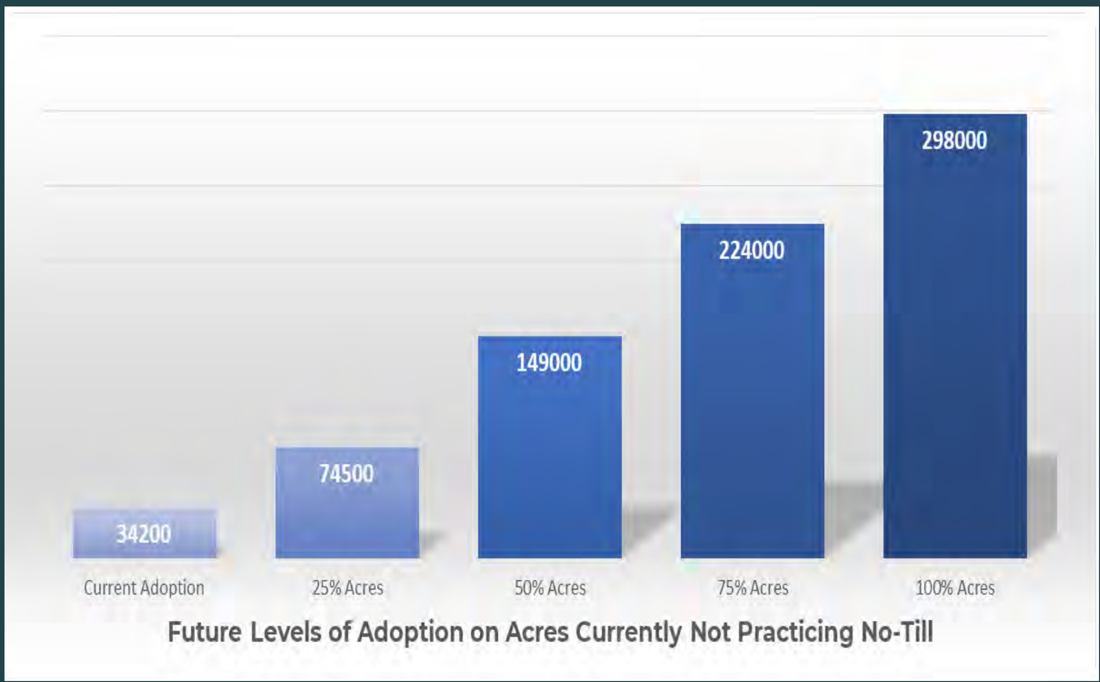
Adoption Level % Total Acres	**Nitrogen** (lb/yr)	**Phosphorus** (lb/yr)	**Sediment** (ton/yr)
Current	66,600	8,700	4,900
25%	79,400	10,400	5,800
50%	159,000	20,700	11,500
75%	238,000	31,100	17,300
100%	317,000	41,400	23,100

Source USDA NASS, 2017

TRANSITIONING INTENSIVE TILLAGE PRACTICES TO NO-TILL

Currently, only 12% of New England cropland is reported as using either no-till or reduced till. Together, the current level of implementation of those two practices mitigate more than 34,000 MTCO2e, which is the equivalent to 3.8 million gallons of gasoline consumed. In Figure 9 (below), the current adoption level of cover crops is presented alongside four potential increased levels of adoption of 25, 50, 75, and 100% cover crop usage on cropland. If New England were to meet the 25% adoption level by advancing no-till practices on an additional 13% of available cropland, the potential climate mitigation would increase to 74,500 MTCO2e (equivalent to 8.4 million gallons of gasoline). Under a future the scenario where 100% of cropland acres are using no-till, the impact grows to 298,000 MTCO2e annually (equivalent to 33.5 million gallons of gasoline consumed, the carbon sequestered in 365,000 acres of U.S. forest, or removing 65,000 passenger vehicles from the road each year). In comparison, if instead 100% of cropland acres adopted reduced-till, the climate mitigation potential is reduced to 170,000 MTCO2e annually. Transitioning to no-till is approximately 35% more effective at reducing GHG emissions than transitioning to reduced till. For example, the climate mitigation potential of reduced till for 100% cropland acre adoption is 170,000 MTCO2e annually (compared to 298,00 MTCO2e for no-till). In cropping systems where no-till practices are not easily integrated, reduced till still has a large climate mitigation potential. A more likely scenario of advancement will include a combination of both reduced tillage and no-till and result in climate mitigation impacts that lie somewhere between the two values.

FIGURE 10: MITIGATION POTENTIAL OF INCREASED NO-TILL ADOPTION
Estimated annual mitigation potential in $MTCO_2e$ /year



CO-BENEFITS RELATIVE TO NEW ENGLAND

Beyond carbon sequestration and GHG emission reductions, no-till and reduced tillage practices help to decrease erosion by leaving the soil surface intact and undisturbed. By reducing the number of passes that farm equipment must make over each field, no-till and reduced till can lower both the labor and fuel costs. With regional instances of drought increasing, no-till and reduced tillage practices help maintain or increase soil quality, organic matter content, and increase plant-available moisture. This decreases stormwater run-off, decreases erosion, and reduces agricultural run-off into regional surface and groundwaters. Current and future water quality impacts of adopting no-till are presented in Table 4 (below). The significant reduction in soil erosion that accompanies no-till results in dramatic decreases in nutrient and sediment loading of New England's waterways.

Table 4: Water Quality Impacts of No-Till Adoption in New England: Nutrient Loading Reduction Potential			
Adoption Level % Total Acres	**Nitrogen** (lb/yr)	**Phosphorus** (lb/yr)	**Sediment** (ton/yr)
Current	4,000	20,600	10,600
25%	16,700	85,800	44,000
50%	33,300	172,000	88,000
75%	50,000	257,000	132,000
100%	66,600	343,000	176,000

Source USDA NASS, 2017

ADOPT PRESCRIBED GRAZING AND DECREASE DEPENDANCE ON FEED CROPS

In New England, just over 5,000 farms (16%) practiced rotational or managed intensive grazing in 2017 compared with just over 6,000 in 2012, amounting to a 15% decline. The highest rates of this practice were observed in Vermont (23%) though the state still experienced a decline over the five-year period (-13%). Southern New England reported the lowest rates at roughly 12% of all farms practicing rotational grazing each, with the highest five-year decline in Rhode Island (-37%). According to 2017 Ag Census data, intensive grazing and pastureland is more prevalent among smaller farms, though a potentially substantial amount of acreage is not disclosed from Southern New England states. The skewed use of prescribed grazing may have to do with the significant amount of infrastructure that large farms would need to adopt this practice. Larger farms would likely require wells to provide water access in more remote fields, as well as significant amounts of fencing. Additionally, smaller producers with less acreage may have more knowledge of their field quality and have a more intimate understanding of their pastures, providing more security in transition to prescribed grazing.

Under the scenario of 25% of New England's pastureland acres in prescribed grazing, the potential climate mitigation potential is 1,600 MTCO2e annually, whereas under the final scenario of 100% potential acres, it's 6,500 MTCO2e annually, the emissions equivalent of 730,000 gallons of gasoline consumed (see Figure 10). While the impact of transitioning current pasture practices to prescribed grazing may be lower than that of no-till and cover crop adoption, the cumulative impact from transitioning more livestock to grazing-based feed practices can be significant.

FIGURE 11: MITIGATION POTENTIAL OF INCREASED ADOPTION OF PRESCRIBED GRAZING ON PASTURELAND
Estimated annual mitigation potential in $MTCO_2e$ /year

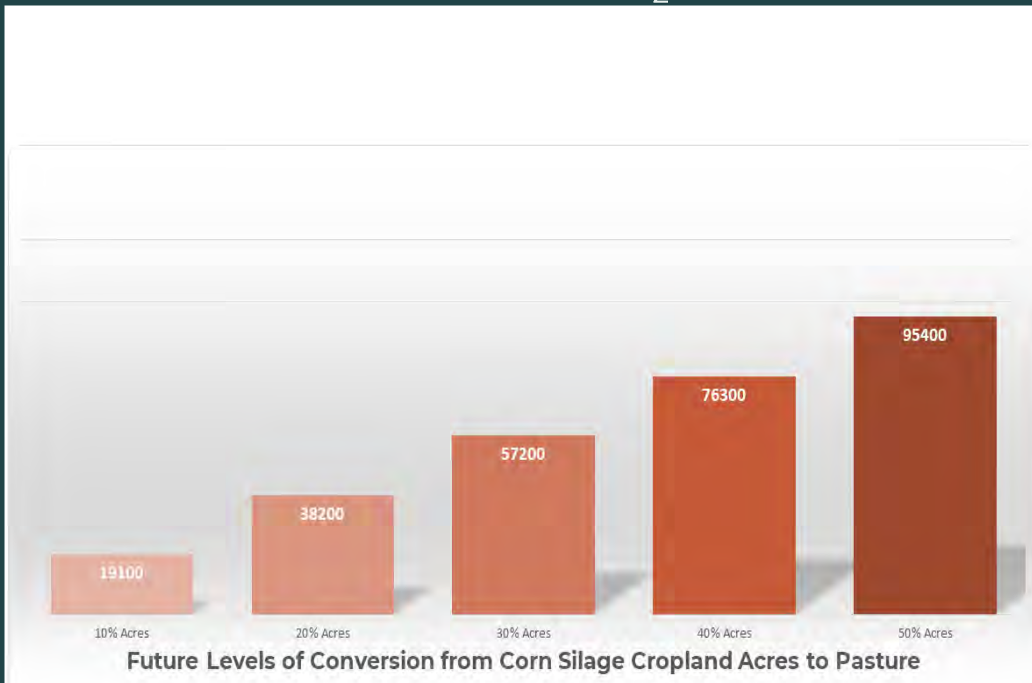
Corn silage is a staple feed source for dairy livestock operations. Lowering the dependance on field crops such as silage corn and increasing the use of grazing-based feed practices across New England can be more impactful than adopting both cover crops and no-till on cropland (on an acre-by-acre comparison). Corn silage is a management-intensive crop with high nutrient demands. In 2017, 151,000 acres of cropland were dedicated to silage corn across New England.

If just 20% of those acres were converted to grazing, the mitigation potential would be approximately 38,200 MTCO2e. Acre for acre, this practice's climate mitigation potential is three times that of transitioning intensively tilled cropland to no-till, but conversion of cropland to pasture can require multiple growing seasons to properly establish pasture grasses and such a transition must be made with significant planning and technical support. Figure 11 (above) shows the future impacts of incremental conversion of cropland that is currently used in silage corn production to pasture, through the planting of forage grasses.

CO-BENEFITS RELATIVE TO NEW ENGLAND

With regional issues of water quality, increasing the practices of prescribed grazing—particularly with water quality in mind—could help to reduce soil erosion and improve surface and/or subsurface water quality and quantity and thus improve riparian and watershed function. Increasing the practices of prescribed grazing may help improve desired species composition and vigor of plant communities, which can help improve the quantity and quality of forage for grazing and browsing animals' health and productivity even under drought conditions. Prescribed grazing

FIGURE 12: MITIGATION POTENTIAL OF CONVERTING ACRES PLANTED WITH CORN SILAGE TO PASTURE
Estimated annual mitigation potential in $MTCO_2e$ /year



may help to enhance wildlife habitat providing more bird, bee, and other beneficial insect habitat at a time of intense species decline. Prescribed grazing can also help reduce reliance on off-farm inputs for feed, while also encouraging communities and consumers alike to support grass-based food produced in New England for reasons ranging from animal welfare to climate mitigation.

IMPROVE NUTRIENT MANAGEMENT BY REPLACING SYNTHETIC FERTILIZER WITH DAIRY MANURE

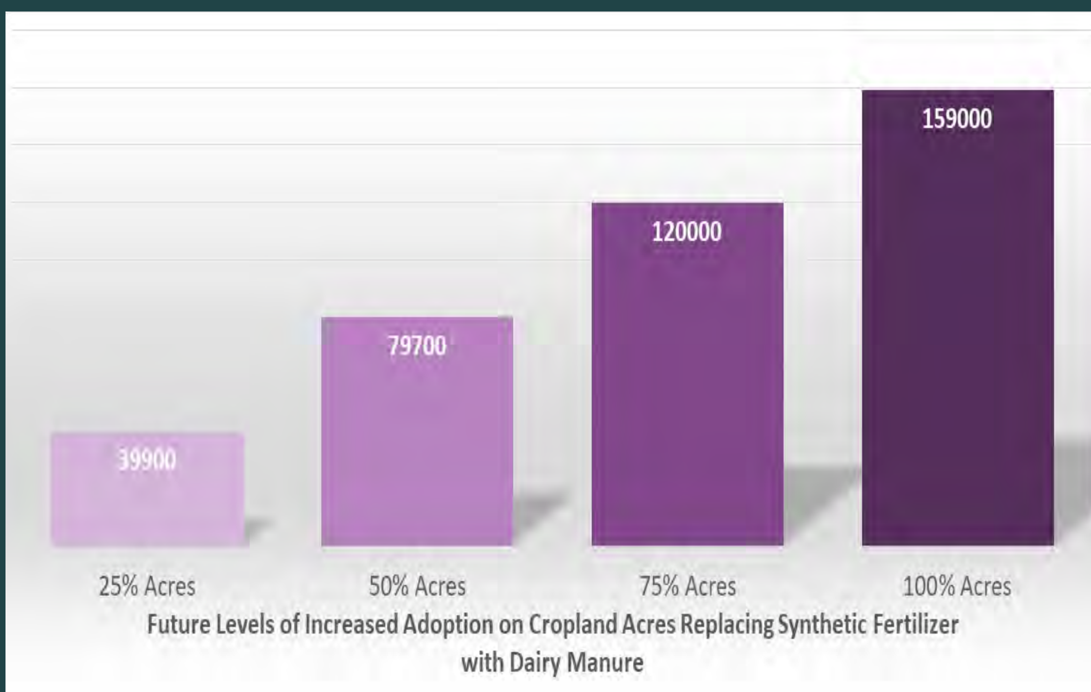
Soil management is by far the largest source of GHG emissions (excluding on-farm fuel and energy use) and within that, synthetic fertilizer use accounts for more than 36% of all direct N2O emissions. The climate impact of replacing synthetic fertilizer with dairy manure as a part of nutrient management planning (NMP) in New England will differ depending on whether these changes are occurring in pasture lands (where little or no inorganic fertilizer is used) or in crop lands (where inorganic fertilizer is used predominantly). For this reason, our analysis estimates impacts of adoption on cropland only.

Under the first scenario of 25% of potential acres in replacement of synthetic fertilizer with dairy manure in croplands, the potential climate mitigation for all of New England is approximately 40,000 MTCO2e annually, whereas under the final scenario of 100% potential acres, it is 159,000 MTCO2e annually (equivalent to 17.9 million gallons of gasoline consumed, the carbon sequestered by 194,000 acres of U.S. forest each year, or 35,000 passenger vehicles driven for a year).

CO-BENEFITS RELATIVE TO NEW ENGLAND

Transitioning away from synthetic fertilizer to dairy manure can help to minimize agricultural nonpoint source pollution of surface and groundwater resources—particularly, and only if, manure is applied in determined amounts relative to the needs of the crops at the appropriate time of year. This transition can also help maintain or improve the physical, chemical, and biological condition of soil, which may support improved water usage. Increasing the transition from synthetic fertilizer to dairy manure in the right amounts may also help to protect air quality by reducing excessive nitrogen emissions (ammonia, oxides of nitrogen). With regards to regional economic concerns, increasing the transition from synthetic fertilizer to dairy manure may help reduce reliance on off-farm inputs while also using waste generated by a large proportion of farms in New England (Niles & Wiltshire, 2019).

FIGURE 13: MITIGATION POTENTIAL OF INCREASED NUTRIENT MANAGEMENT
Estimated annual mitigation potential in $MTCO_2e$ /year



INTEGRATE TREES USING RIPARIAN BUFFERS AND AGROFORESTRY

Increasing woody plantings on farmland with riparian buffers and agroforestry practices, provides higher climate mitigation impacts per acre than the adoption of regenerative cropland-based agricultural practices. Though the acre-for-acre impact is greater, these practices are likely to be implemented at a much smaller scale and on farms with fewer acres. This is particularly salient in New England, where farm sizes are smaller, and each farm may have the potential to plant an acre of woody biomass in riparian buffer strips, which may carry far more climate mitigation potential than shifting the practices on the rest of the cropland or pastureland acres.

In comparison to cropland practices such as adopting no-till or cover crops, planting 1 acre of trees or other woody biomass in New England, can have the same climate mitigation potential as transitioning 14 acres of cropland to no-till or planting 37 acres of cover crops (Schoeneberger et al., 2012; Swan et al., 2015). Importantly, tree and other woody biomass plantings may also increase co-benefits more substantially. Permanent plantings such as riparian buffers and the planting of trees for agroforestry reduce erosion and stabilize steep slopes and streambanks, resulting in improved water quality, additional wildlife and pollinator food and habitat, improved habitat for fish and livestock, and increased diversification of plant and microbial communities.

Environmental regulations often mandate significant buffer zones of at least 100 ft between agricultural land and wetlands, resulting in significant acreage set aside to protect water quality. Purposefully planting even wider riparian buffer areas can be costly, especially when planting bush or tree species. However, the climate mitigation and water quality protection benefits are significant. Woody riparian plantings offer an opportunity to maximize environmental impacts of that land, removing roughly 21 pounds of nitrogen per acre each year and about 4 pounds of phosphorus per acre each year (USEPA, 2003).

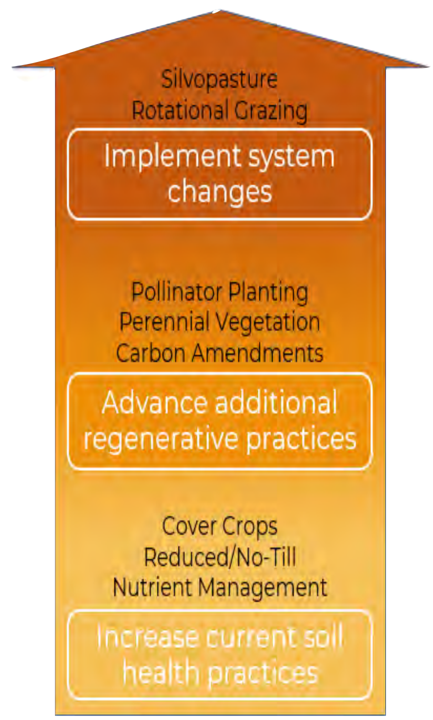
Restoration of a riparian area with native tree plantings, clearing of invasive vegetation, and the use of fascines of willow and dogwood species to control erosion. Credit: Arthur's Point Farm, Ghent, NY.

The cost of planting trees and other woody biomass plantings is a considerable hurdle for farmers but may also provide an opportunity to diversify on-farm, revenue streams. According to the Massachusetts Department of Environmental Protection, planting forest buffer can cost anywhere from $200-729 per acre (MDEP, n.d.). However, regionally compatible fruit, berry, and other edible plantings offer the potential for an additional and diversified revenue stream. The U.S. Forest Service has guidance and recommendations for including edible tree crops including paw-paw, hazelnuts, and black walnut trees, which can sell for more than $9/lb. (USDA NAC, 2015). One acre of black walnut trees can produce 1,000 lbs. annually, providing a substantial return on investment. So, while this is an expensive practice to implement, there is significant potential for additional revenue as a value-add crop.

PRIORITIZE SYSTEM-LEVEL CHANGES

Within the shifting of practices *on cropland*, adopting no-till is the practice with the highest climate mitigation potential per acre of implementation, in accordance with COMET-Planner estimations, followed by cover crop and replacing synthetic fertilizer with dairy manure. In New England, we have a lower percent of adoption of reduced tillage practices than the rest of the country, so this is an area that needs significant focus to overcome localized knowledge barriers. Continuing to focus on cover crop, where New England has a higher percent adoption than the rest of the country, remains an important focus as well, particularly if policies and activities can simply be extended to increase adoption. Where cropland that is highly degraded is a source of agricultural run-off and pollutant loading of our surface waters, a focused effort to support the conversion of cropland to pasture through the planting of pasture grasses can have significant climate and water quality benefits.

FIGURE 14: GREATER ADOPTION CHALLENGES NECESSITATE INCREASED FINANCIAL AND TECHNICAL ASSISTANCE



Individually, the above regenerative agriculture practices can all contribute to strengthening the role of New England agriculture in combatting climate change as they improve farmland resiliency and viability for the farmers adopting these practices. Shifting management practices (transitioning to no-till or prescribed grazing) and integrating additional practices (planting cover crops and integrating trees) should be considered together. Together, the adoption of regenerative agriculture practices can encourage system-level changes, generating far greater climate mitigation impacts and supporting a viable future for New England agriculture.

POLICY OPTIONS TO INCREASE ADOPTION OF REGENERATIVE AGRICULTURE IN NEW ENGLAND

Equipment costs, technical support, yield uncertainty, and labor are a few of the significant challenges facing producers in the New England region as they adopt regenerative agricultural practices, yet there are myriad ways both the USDA and New England states can leverage policy tools to help producers overcome them.

Most of the federal programs that enable, or hinder farmers' adoption of regenerative practices are authorized as part of the farm bill, a package of legislation that is passed approximately every five years. The current farm bill, the Agricultural Act of 2018, runs through 2023. The provisions of the farm bill are wide-ranging, from policies that facilitate access to healthy foods for low-income families to policies that support rural development. Title II of the farm bill authorizes the USDA's conservation programs, through which farmers and landowners can access funding to voluntarily address natural resource concerns on their lands. These programs are primarily run by the Natural Resources Conservation Service (NRCS) and address environmental issues from reducing erosion to increasing wildlife habitat to improving water supply. Many of the regenerative practices described in this report are already recognized as NRCS conservation practices; the farm bill and its conservation programs can be an important means by which farmers can overcome financial and operational barriers to their adoption.

IMPROVE EXISTING USDA CONSERVATION PROGRAMS, AUTHORIZED THROUGH THE FARM BILL, TO BETTER SUPPORT PRODUCERS' TRANSITION TO REGENERATIVE PRACTICES:

- The USDA should ensure that conservation programs do not fund extractive practices.
- The federal government can also reduce financial barriers facing producers by making adjustments to the USDA's insurance programs, such as reducing insurance premiums or providing rebates for producers who incorporate the regenerative practices analyzed in this report.
- The USDA should reduce the amounts producers have to pay as cost-share amounts under EQIP and other programs. Payment rates for regenerative practices should also be increased.
- The USDA should also provide compensation for the administrative burdens of applying for assistance, for example by compensating producers for the time they spend completing NRCS paperwork.
- To incentivize practices with lasting environmental benefits, the USDA should create a permanent easement program in the Conservation Reserve Program (CRP) to avoid the reversal of any carbon sequestration benefits. Another option would be to ensure that land that is leaving the CRP program is afterwards managed using regenerative practices, in order to avoid undoing the carbon sequestration benefits.
- In its funding allocations through conservation programs such as EQIP and the Conservation Stewardship Program (CSP), the USDA should prioritize incentivizing transformative and system-level changes through permanent, sustainable practices over annual practices.

- The USDA must provide funding to facilitate robust technical assistance for producers seeking to transition to regenerative practices, including the whole-farm management and conservation planning recommended by this report.
- The USDA should provide additional funding for the Cooperative Extension System (CES) and to increasing cooperative partnerships with organizations that can provide assistance on regenerative practices, including region-specific advice and research.
- The USDA should also fund programs through which producers using regenerative practices could share knowledge with nearby producers, compensating producers for their time.

INVEST IN RESEARCH THAT DEVELOPS REGIONAL EXPERTISE AND KNOWLEDGE BASED UPON REGIONAL VARIABILITIES IN SOIL AND CLIMATE CONDITIONS, AS WELL AS THE VARIABILITIES IN FARM SIZE AND REGIONAL INFRASTRUCTURE.

- The USDA should expand its Climate Hub model (USDA, n.d.), which develops and delivers region-specific information and technologies to producers. The USDA should also provide additional funding for the Sustainable Agriculture and Research Education (SARE) program.
- The USDA must provide resources for better regional calibration of its the carbon modeling programs, preferably by providing additional funding for this research at land-grant institutions.
- The USDA and State agencies must support technical assistance and knowledge sharing so that farmers can integrate new technologies that document the impacts they are making on the farm.

REDUCE THE FINANCIAL BARRIERS PRODUCERS FACE TRYING TO TRANSITION TO SUSTAINABLE PRACTICES AT THE STATE LEVEL.

- States can provide soil health equipment grants and can set up programs to loan equipment related to regenerative agriculture, such as no-till drills, interseeders, and roller-crimpers. As discussed in Barriers to Implementation and Measurement, the high cost of this equipment limits the ability of producers to transition to and sustain regenerative practices.
- States and communities can develop farmland protection strategies to ensure that existing farmland is protected and support beginning farmers to ensure that farmland remains in use as the current generation retires.
- States can incentivize the adoption of regenerative agriculture through current use taxation laws by increasing the tax savings for farms that have adopted conservation practices on the farm.
- States would be well-served by gathering their own-state level data, rather than relying on the USDA Ag Census, to better evaluate and understand factors that impact the wide range of adoption across their own counties.
- States can support infrastructure development that helps small producers using regenerative practices access food aggregation centers, hubs, and coops.

CONCLUSION

Although New England farms are far smaller than other regions of the country, the potential climate impact of transitioning to regenerative agriculture is significant. When 25% of potential acres have each previously detailed practice implemented (cover crops, no-till, prescribed grazing, converting silage corn cropland to pasture, and replacing inorganic fertilizer with dairy manure), the GHG mitigation potential for that achievable scenario is more than 183,000 MTCO2e annually. This is the equivalent of mitigating the emissions from more than 20.5 million gallons of gasoline consumed, the emissions from approximately 40,000 vehicles, or the emissions from more than 33,000 homes' electricity use for one year.

To meet the ambitious and necessary climate goals set by New England states, as well as to prepare farmers and the food system for the impacts of climate change, regenerative agriculture practices must be more widely adopted in place of conventional practices that contribute to GHG emissions on farmland. The specific soil and farming characteristics of New England make it a region where policies supporting regenerative agriculture can have a significant impact. The need for such policies is imperative as New England also strives to increase local food production, protect threatened farmland from permanent development, and support the next generation of farmers as a third of the region's farmers retire in the next decade.

Farmers face uncertainty each growing season – producing food is dependent on external factors that are out of the farmer's control. Those farmers willing to adopt regenerative practices are then taking additional risks, stepping away from their previous way of doing things. To expect New England's farmers to take on this additional risk, without the financial and technical support necessary to mitigate some of this risk, is unfair. Farmers can be one of our nation's greatest allies in fighting climate change. To transform the agricultural system, a fair and effective approach values the potential food system, climate, and ecosystem benefits by honoring and attempting to mitigate the risks and hard realities that farmers face. Prioritizing funding for current programs that assist farmers in their transition to regenerative agriculture, using public and private funding, can provide the support necessary for farmers to move past the barriers to adoption and move towards a regenerative food system.

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APPENDIX A - METHODOLOGY

In this report we used a combination of data from the National Ag Statistics (USDA NASS, 2020) and CARPE to provide the current agricultural activity data for New England by state, and COMET-planner for emissions estimates (both through the COMET-planner tool and through CARPE, which draws from COMET-Planner). COMET-Planner recently revised the emissions estimation approach to fully aligning GHG reduction estimates with COMET-Farm and the USDA entity-scale GHG inventory methods (USEPA, 2021). This tool generates estimates for greenhouse gas emissions and carbon sequestration for the following sources (sources relevant for this report's conservation practices are in bold): **SOIL CARBON, WOODY BIOMASS CARBON, CO_2 EMISSIONS** from biomass burning, liming, **UREA FERTILIZATION, AND DRAINED ORGANIC SOILS**, CO emissions from biomass burning, **N_2O EMISSIONS FROM SOILS (INCLUDING FERTILIZERS)**, biomass burning, **AND DRAINED ORGANIC SOILS, CH_4 EMISSIONS FROM SOIL,** wetland rice cultivation and biomass burning.

LEVEL OF ACCURACY: COMET-Planner provides both the mean estimate and the maximum and minimum values for net GHG emissions. These together can demonstrate how emission estimates vary over a range of soil, weather, and agricultural management conditions within each major land resource area and as the tool states: "Estimates are not meant to apply to any specific site conditions but rather represent the range of expected values to be found over the multi-county region and reflect the assumptions stated." Tables with the mean estimate coefficients for relevant practices to this report are available on COMET-Planner. It is worth noting that as climates shift regionally (e.g., with temperature and precipitation shifts) the mitigation effects of conservation practices will shift in concert. Most models use historical averages, however with the increased changes, the historic average may not be valid as a baseline for projecting forward. Moving baselines need to be addressed in future models/assessments, particularly when accurately quantifying mitigation is the objective.

POTENTIAL SOURCES OF ERROR: could include either or both (1) errors associated with the agricultural activities, such as the number of acres under any given agricultural production (e.g. grazed lands) and/or the number of acres that any given regenerative agricultural practice is implemented on (e.g. holistically managed grazing) and (2) errors associated with the climate mitigation estimates, such as the change in the amount of GHG emissions that a certain regenerative practice might entail and/or the amount of carbon that is sequestered by a given practice.

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