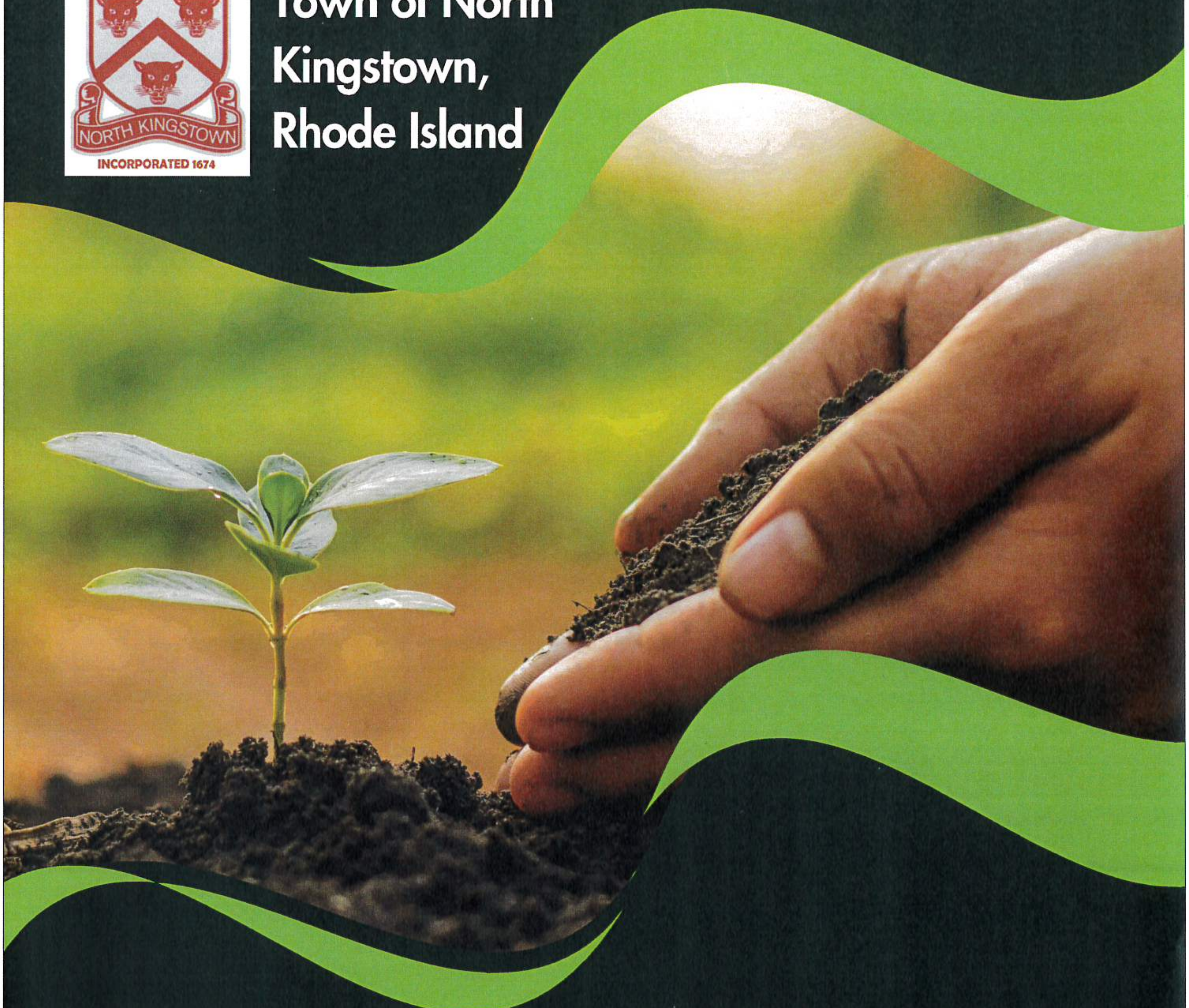
Town of North Kingstown, Rhode Island



SOIL HEALTH STEWARDS REPOSITORY

A collection of documentation sourced from the USDA and American Farmland Trust associated with the North Kingstown Planning Department Staff Soil Health Stewards Grant and training.

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TOWN OF NORTH KINGSTOWN

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NORTH KINGSTOWN
INCORPORATED 1674

The Town of North Kingstown was awarded a grant by the American Farmland Trust's (AFT) National Agricultural Land Network to participate in the Soil Health Stewards Training Program that took place in October 2023 in Fairlee, VT. As part of our participation in the training, the town through its Planning Department has been working on a Soil Health Stewards Action Plan to bolster the town's capacity to promote soil health practices and increase protection of farmland in town.

When developing the action plan, we considered many ways in which town staff can better connect with farmers and large landowners. One way to better engage with these communities is to share the information and resources we received as part of the training. We hope to provide a bridge between you and the extensive resources that are available on soil health.

This repository contains pamphlets covering many topics, including but not limited to strategies to promote good soil health, the economic impacts of adopting these strategies, and overall soil health management.

Some of the soil health management benefits that we want to share include:

- Improvement in field fertility through retention of organic matter.
- Reduction in the need for fertilizers and other applications.
- Increased aeration of the soil.
- Limiting erosion of fertile topsoil.
- Reduction in soil compaction, allowing more water to be absorbed and reducing irrigation.
- Increased ability of crops to withstand weather extremes from drought to excessive rain/flooding.

Healthy soils can improve both on-farm productivity and environmental health by preventing the loss of soil and nutrients to our waterways, protecting water quality and water quantity, and restoring soil biology and function. They are also critical to enabling farms to sequester carbon, reduce greenhouse gas emissions, and be more resilient to increasingly intense and erratic weather conditions. Soil health management includes various types of conservation tillage, including minimal-till, one focus of this program. Based on the experiences of large farms, these soil health actions have resulted in an increase in crop yields while reducing labor and expenses, benefitting farmers' bottom-line.

You can find more resources on soil health management at https://farmlandinfo.org. You can also contact Cassius Spears, State Resource Conservationist at the RI Natural Resources Conservation Service at cassius.spears@usda.gov.

We know members of the farming community have several interests to balance in their daily agricultural production. The goal of sharing these resources is to assist farmers in dealing with current challenges ranging from rising costs to climate unpredictability. Whether you choose to adopt these strategies, already use them, or just want to expand your knowledge of these practices, we hope this information will benefit you and your approach to managing the valuable soils on your property.

We encourage any feedback or questions you might have on this program. If you are already using some of these practices, we would welcome the opportunity to hear more about your experiences with them. If you have any questions regarding the soil health strategies or the town's conservation easement program, please feel free to contact Rebecca Lamond, at blamond@northkingstownri.gov or 268-1572. We look forward to hearing from you.

UNLOCK THE SECRETS IN THE SOIL
Basics & Benefits

Healthy, fully functioning soil is balanced to provide an environment that sustains and nourishes plants, soil microbes, and beneficial insects.

Managing for soil health is one of the most effective ways for farmers to increase crop productivity and profitability while improving the environment. Positive results are often realized within the first year, and last well into the future.

Soil Health

Soil is made up of air, water, decayed plant residue, organic matter from living and dead organisms, and minerals, such as sand, silt and clay. Increasing soil organic matter typically improves soil health since organic matter affects several critical soil functions. Healthy soils are also porous, which allows air and water to move freely through them. This balance ensures a suitable habitat for the myriad of soil organisms that support growing plants.

It's not difficult to improve soil health when utilizing the 4 soil health management principles. Here's how: **minimize disturbance** – for example, till the soil as little as possible; **maximize biodiversity** – for example, integrate livestock and grow as many different species of plants as possible through rotations and a diverse mixture of cover crops; **maximize living roots** – for example, by keeping living crops and cover crops in the soil as long as possible; and **maximize soil cover** – for example, by keeping the soil surface covered with residue year round.

Soil Health Benefits

Farmers who manage their land in ways that improve and sustain soil health benefit from optimized inputs, sustainable outputs and increased resiliency. Healthy soils benefit all producers regardless of the size or type of their operations. Healthy soils provide financial benefits for farmers, ranchers and gardeners, and environmental benefits that affect everyone.

Healthy soils lead to:

- **Increased Productivity** – Healthy soils typically have more organic matter and soil organisms which improve soil structure, aeration, water retention, drainage and nutrient availability. Organic matter provides and holds more nutrients in the soil until the plants need them.
- **Increased Profits** – Healthy soils may require fewer passes over fields because they are only minimally tilled and they aren't over-reliant upon excessive inputs to grow crops. Healthy soils can increase farmers' profit margins by reducing labor and expenses for fuel and optimizing inputs.
- **Natural Resource Protection** – Healthy soils hold more available water. The soil's water-holding capacity reduces runoff that can cause flooding, and increases the availability of water to plants during periods of stress. Good infiltration and less need for fertilizers and pesticides keep nutrients, sediment, and agrichemicals from loading into lakes, rivers, and streams. Groundwater is also protected because there is less leaching from healthy soils. Additionally, fewer trips across fields with farm machinery mean fewer emissions and better air quality.

Soil Health Management Systems

Implementing Soil Health Management Systems can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it. Soil Health Management Systems allow farmers to improve profitability because they spend less on fuel and energy while benefiting from the higher crop yields resulting from improved soil conditions.

More Information

To learn more about Soil Health Management Systems and the technical and financial assistance available visit **farmers.gov/conserve/soil-health** or contact your local NRCS office. To find your local NRCS office, visit **farmers.gov/service-center-locator**.

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UNLOCK THE SECRETS IN THE SOIL
Principles for High Functioning Soils

Soil Health Defined

Soil health is the continued capacity of a soil to function as a vital, living ecosystem that sustains plants, animals, and humans. Only living things can have "health," so viewing soil as a living, breathing ecosystem reflects a shift in the way we view and manage our nation's soils. Soil isn't an inert growing medium, but rather is the home of billions of bacteria, fungi, and other organisms that together create an intricate symbiotic ecosystem. This ecosystem can be managed to support the plants and animals, by providing nutrients, absorbing and retaining rainwater and snowmelt for use during dry periods, filtering and buffering water to remove potential pollutants, and providing habitat for the soil biological population to flourish and diversify to keep the ecosystem functioning well.

Key soil health management principles
These principles are represented in the circular diagram (Fig. 1) to emphasize their relationship as a continuum where each complements the others and also depends on the others.

- Minimize disturbance
- Maximize soil cover
- Maximize biodiversity
- Maximize presence of living roots

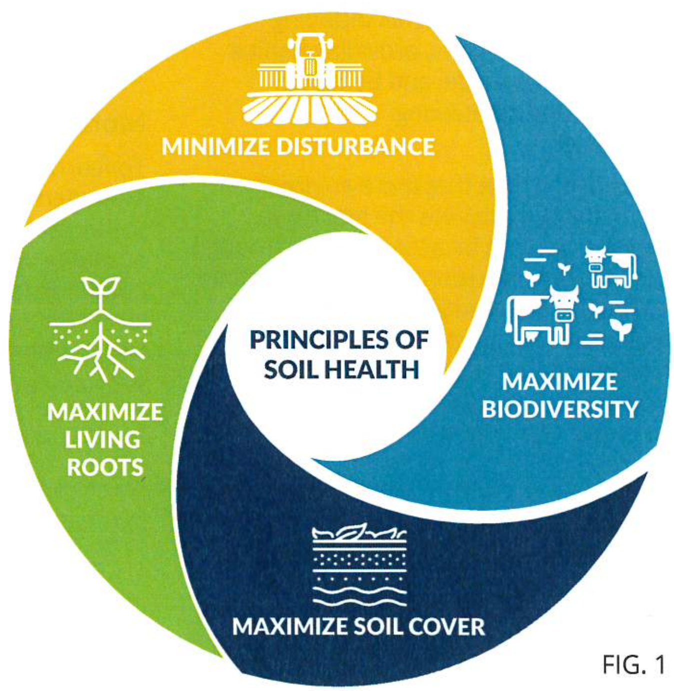

FIG. 1

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Protecting the Soil Habitat

The first two principles of soil health, minimizing disturbance and maximizing soil cover, focus on protection of the soil habitat. They maintain or increase stable soil aggregates and soil organic matter (SOM) and protect the fragile surface of the soil that is most susceptible to the degrading forces of wind and water.

SOM is highest at the soil surface and is critical for stabilizing soil aggregates. Maintaining SOM helps support additional soil functions including water infiltration and storage, nutrient-holding capacity and release, and habitat for soil life.

Feeding the Soil Organisms Inhabiting Soil

The second two principles, maximize presence of living roots and maximize biodiversity, focus on feeding the organisms inhabiting the soil. Maximizing the diversity of food (energy and carbon inputs) and aboveground biodiversity through increased plant, animal, or soil amendments to increase the diversity of soil animals and microorganisms. Diversity not only refers to food sources, but also aboveground diversification of plants and animals, as well as microbial diversification underground. Diversification stimulates a host of additional benefits including breaking disease cycles, providing habitat for pollinators, wildlife, and beneficial predators, and stimulating plant growth.

Increasing the time that there are living roots in the soil achieves the first three principles, and can be accomplished through crop rotations, inclusion of cover crops, and/or through dedicated grasslands (native or pasture). Mixing up which plants are grown during the year or over the course of multiple years may help to break disease/pest cycles. Maximizing biodiversity and living roots helps to stimulate belowground biological activity and increase biodiversity belowground as well as increase predator and pollinator populations aboveground. When these two principles are properly applied, soils not only maintain SOM but can build SOM and enhance nutrient cycling and overall plant growth (crop or forage).

Worm emerging from egg within the pore space of a well-aggregated soil.

Healthy, Functioning Soils Are Able to:

- Improve nutrient cycling
- Provide good aeration to promote plant root growth
- Improve farm and ranch profitability and resiliency
- Produce food, feed, fiber, fuel, and medicinal products at sustainable levels
- Reduce sedimentation and runoff
- Improve water storage and plant available water while protecting water quality
- Be resilient to drought, temperature extremes, fire, and flood
- Reduce disease and pest problems
- Store carbon in the form of soil organic matter

More Information

To learn more about Soil Health Management Systems and the technical and financial assistance available visit **farmers.gov/conserve/soil-health** or contact your local NRCS office. To find your local NRCS office, visit **farmers.gov/service-center-locator**.

SOIL DISTURBANCES

can occur in several different forms. Physical disturbances are those that occur by tillage or compaction from heavy machinery. Chemical disturbances are inputs such as fertilizer and pesticide applications particularly when they are over applied or misused. Lastly there are biological disturbances, such as over-grazing animals which can lead to compaction and reduction in perennial root systems as well as introduction of invasive species. Some other types of disturbance include the use of monocultures which can cause biological imbalances. All disturbance can affect soil functions.

SOIL COVER

consists of two main forms: 1) living plant material such as a growing crop, cover crop, or grassland; and 2) mulch, either as plant residues (e.g. crop redidues, bark chips, prunnings from trees and shrubs, thatch in grasslands, compost) or other suitable materials.

BIODIVERSITY

is the variety of life forms within a given ecosystem or farm field. The different life forms include all the plants, animals and microorganisms that are present. Each life form includes their own unique set of exudates, secretions or waste products that further contribute to increased diversity. Healthy management systems are full of biodiversity. Increases in diversity can be achieved through a variety of approaches, including plant diversity, (through the use of diversified crop rotations and cover crop mixes), integration of grazing animals (e.g. livestock) into the system. It includes animals living within the soils or microbial diversity, as well as direct additions with biological amendments. All four soil health management principles contribute to biodiversity.

LIVING ROOTS

in the soil provide secretions that help feed soil biology throughout the year. They provide carbohydrates and organic acids which are part of the diet of many life forms in the soil. The exudates help solubilize mineral nutrients for plants. Root hairs also assist with formation of aggregates by entangling and enmeshing soil.

UNLOCK YOUR FARM'S POTENTIAL
Dig a Little, Learn a Lot

unlock the SECRETS IN THE SOIL

Healthy, fully functioning soil is balanced to provide an environment that sustains and nourishes plants, soil organisms, and beneficial insects.

Soil is a living system, and healthy soil should look, smell, and feel alive. Healthy soil can increase production, increase profits, and protect natural resources, such as air and water. Dig in to your soil to discover what your soil can tell you about its health and production potential.

Dig in and see

Healthy soil is generally darker in color, crumbly, and porous. It is home to worms and other organisms that squirm, creep, hop, or crawl. Healthy soil provides the right amount of air, water, and organic matter for soil life to thrive and for plants to grow. Soil that is functioning at its full potential is full of the roots of the healthy and strong plants it supports. An unhealthy, poorly functioning soil is compacted or has poor structure, contains limited roots and soil life, and generally appears lighter in color.

Dig in and smell

Healthy soil has a sweet and earthy aroma. This is the scent of geosmin, a byproduct of soil microbes called actinomycetes. These microbes decompose the tough plant and animal residues in and on the soil and bring nitrogen from the air into the soil to feed plants.

An unhealthy, out-of-balance soil smells sour or metallic, or like kitchen cleaners.

Dig in and feel

Healthy soil is easy to dig into. It is soft, moist, and crumbly, and allows plants to grow their roots more freely and unimpeded. This crumbly or granular structure is ideal because porous, healthy soil holds water for plants to use when they need it. Its increased water-holding capacity reduces runoff that can cause erosion, and increases the availability of water to plants during droughts. An unhealthy, poorly functioning soil feels dry, looks crusty or cloddy, and does not crumble readily when pulled apart.

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Dig a Little. Learn a Lot.

Understanding how healthy soils look, smell, and feel are the first steps towards achieving soil health. Dig a little! If you find soil that is out of balance, NRCS can offer management tips to improve soil health.

Soil Health Management Systems

Implementing Soil Health Management Systems: a group of practices that positively impact soil health and tie into the soil health principles, can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it. Soil Health Management Systems can allow farmers to enjoy cost savings from reduced inputs as well as more consistent yields and increased crop resiliency resulting from improved soil conditions.

More Information

To learn more about Soil Health Management Systems and the technical and financial assistance available visit **farmers.gov/conserve/soil-health** or contact your local NRCS office. To find your local NRCS office, visit **farmers.gov/service-center-locator**.

UNLOCK YOUR FARM'S POTENTIAL
Discover the Cover

unlock the SECRETS IN THE SOIL

Diverse cover crop mixes increase the success of most agricultural systems.

Plant biodiversity helps to prevent disease and pest problems associated with monocultures. Using cover crops and increasing diversity within crop rotations improves soil health and soil function, reduces costs, and increases profitability. Diversity above ground improves diversity below ground, which helps create healthy productive soils.

Cover Crops

Cover crops are grasses, legumes, and forbs planted for seasonal vegetative cover. Well-managed cover crops can be an integral part of a cropping system. Cover crops can be managed to improve soil health, as they help to develop an environment that sustains and nourishes plants, soil life and beneficial insects.

- Cover crops can be planted any time of the year, typically following cash crops. Examples of cover crops include rye, wheat, triticale, oats, clovers and other legumes, turnips, radishes, sunflowers, buckwheat, etc. Planting several cover crop species together in a mixture can increase their impact on soil health. Each cover crop provides its own set of benefits, so it's important to choose the right cover crop mixture to meet management goals.

Cover Crop Benefits

- **Restoring Soil Health** – Cover crops help increase organic matter in the soil and improve overall soil health by adding living roots to the soil during more months of the year. Cover crops can improve water infiltration; for example, planting deep-tap rooted crops like forage radishes can create natural water passages. Also, fibrous rooted grass plants help break up compaction layers at the surface and allow water to percolate deeper in the soil. Legume cover crops serve as natural fertilizers while grasses scavenge nutrients that are often lost after harvest or during winter.

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- **Natural Resource Protection** – Along with crop residue above ground, cover crops protect the soil against erosive heavy rains and strong winds. Cover crops trap excess nitrogen, keeping it from leaching into groundwater or running off into surface water – releasing it later to feed growing crops.
- **Livestock Feed** – Cover crops can provide livestock producers with additional forage opportunities.
- **Wildlife Habitat** – Cover crops provide winter food, cover, and nesting sites for birds and other wildlife. During the growing season,flowering cover crops can provide food and habitat for pollinator and other beneficial insects.

Soil Health Management Systems

Implementing Soil Health Management Systems consisting of a group of practices like no-till or reduced till, cover crops, prescribed grazing, nutrient management, and pest management can lead to increased organic matter, reduced greenhouse gases, more soil organisms, reduced soil compaction, and improved nutrient storage and cycling. Healthy soils have greater aggregate stability and therefore absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it. Soil Health Management Systems can allow farmers to enjoy cost savings from reduced inputs as well as more consistent yields, increased crop quality, and increased resilience to weather extremes resulting from improved soil conditions.

More Information

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USDA United States Department of Agriculture

NATURAL RESOURCES CONSERVATION SERVICE

UNLOCK YOUR FARM'S POTENTIAL
Do Not Disturb

unlock the SECRETS IN THE SOIL

If soil health is your goal, till as little as possible.

Tillage can destroy soil organic matter and structure along with the habitat that soil organisms need. Tillage, especially during warmer months, reduces water infiltration, increases runoff and can make the soil less productive. Tillage disrupts the soil's natural biological cycles, damages the structure of the soil, and makes soil more susceptible to erosion. Transitioning to tillage systems that increase soil surface cover and limit soil disturbance and loosening is an effective approach to building a healthy soil.

Benefits of Reduced-Till/No-Till

- **Aiding in Plant Growth** – Soils managed with conservation tillage or no-till for several years contain more organic matter and moisture for plant use. Healthy soils cycle crop nutrients, support root growth, absorb water and sequester carbon more efficiently.
- **Reducing Soil Erosion** – Soil that is covered year-round with crops, crop residue, grass or cover crops is much less susceptible to erosion from wind and water. For cropping systems, practices like no-till keep soil undisturbed throughout the entire cropping season.
- **Saving Money** – Farmers can save money on fuel and labor by decreasing tillage operations. Improving nutrient cycling allows farmers to potentially reduce the amount of supplemental nutrients required to maintain yields, further reducing input costs.
- **Providing Wildlife Habitat** – Crop residue, grass and cover crops provide food and escape for wildlife.

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Production Inputs

Soils can be disturbed if inputs are not applied properly, potentially disrupting the delicate relationship between plants and soil organisms. Soil Health Management Systems help minimize that potential disturbance, while maximizing nutrient cycling, which can lead to greater profitability for producers.

Livestock Grazing

Improperly managed grazing can disturb the soil. There are several ways to graze livestock to reduce environmental impacts. For example, implementing a rotational grazing system instead of allowing livestock to continuously graze pasture allows pasture plants to rest and regrow.

Soil Health Management Systems

Implementing Soil Health Management Systems can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it. Soil Health Management Systems can allow farmers to enjoy cost savings from reduced inputs as well as more consistent yields, increased crop quality, and increased resilience resulting from improved soil conditions.

More Information

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HEALTHY, PRODUCTIVE SOILS
Checklist for Growers

Managing for soil health is one of the easiest and most effective ways for farmers to increase crop productivity and profitability while improving the environment.

Results are often realized immediately, and last well into the future. Using these four basic principles is the key to improving the health of your soil.

- Keep the soil covered as much as possible
- Disturb the soil as little as possible
- Keep plants growing throughout the year to feed the soil
- Diversify as much as possible using crop rotation and cover crops

Use the checklist on the back of this page to determine if you're using some or all of the core Soil Health Management System farming practices.

It is important to note that not all practices are applicable to all crops. Some operations will benefit from just one soil health practice while others may require additional practices for maximum benefit. But these core practices form the basis of a Soil Health Management System that can help you optimize your inputs, protect against drought, and increase production.

More Information

To learn more about Soil Health Management Systems and the technical and financial assistance available visit **farmers.gov/conserve/soil-health** or contact your local NRCS office. To find your local NRCS office, visit **farmers.gov/service-center-locator**.

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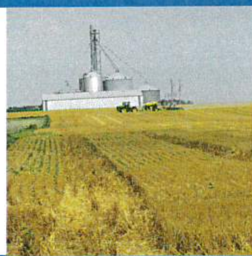
WHAT IS IT?		WHAT DOES IT DO?	HOW DOES IT HELP?
☐ **Conservation Crop Rotation** A planned sequence of crops grown on the same ground over a period of time (i.e. the rotation cycle).		• Increases nutrient cycling • Helps manage plant pests (weeds, insects, and diseases) • Reduces sheet, rill, and wind erosion • Holds soil moisture • Adds diversity so soil microbes can thrive	• Improves nutrient use efficiency • Decreases use of pesticides • Improves water quality • Conserves water • Improves plant production
☐ **Cover Crop** Grasses, legumes, and forbs planted for seasonal vegetative cover.		• Increases soil organic matter • Prevents soil erosion • Conserves soil moisture • Increases nutrient cycling • Provides nitrogen for plant use • Suppresses weeds • Reduces compaction • Feeds soil life • Reduces residual nutrient loss	• Improves crop production • Improves water quality • Conserves water • Improves nutrient use efficiency • Decreases use of pesticides • Improves water efficiency to crops • Improves water infiltration
☐ **No Till** Limiting soil disturbance to manage the amount, orientation and distribution of crop and plant residue on the soil surface year-round.		• Improves water holding capacity of soils • Increases organic matter • Reduces soil erosion • Reduces energy use • Decreases compaction • Reduces soil evaporation	• Improves water efficiency • Conserves water • Improves crop production • Improves water quality • Saves renewable resources • Improves air quality • Increases productivity
☐ **Reduced Tillage** Using tillage methods where the soil surface is disturbed but maintains a high level of crop residue on the surface.		• Reduces soil erosion from wind and rain • Increases soil moisture for plants • Reduces energy use • Increases soil organic matter • Reduces soil evaporation	• Improves water quality • Conserves water • Saves renewable resources • Improves air quality • Improves crop production
☐ **Mulching** Applying plant residues or other suitable materials to the land surface.		• Reduces erosion from wind and rain • Moderates soil temperatures • Increases soil organic matter • Controls weeds • Conserves soil moisture • Reduces dust	• Improves water quality • Improves plant productivity • Increases crop production • Reduces pesticide usage • Conserves water • Improves air quality
☐ **Nutrient Management** Manage rate, source, placement, and timing of plant nutrients and soil amendments while reducing environmental impacts.		• Increases plant nutrient uptake • Improves the physical, chemical, and biological properties of the soil • Budgets, supplies, and conserves nutrients for plant production • Reduces odors and nitrogen emissions • Reduces excess nutrient applications	• Improves water quality • Improves plant production • Improves air quality
☐ **Pest Management Conservation System** A system that combines an integrated pest management (IPM) decision-making process with natural resource conservation to address pest and environmental impacts.		• Reduces pesticide risks to water quality • Reduces threat of chemicals entering the air • Decreases pesticide risk to pollinators and other beneficial organisms • Increases soil organic matter • Increase soil organism diversity and activity	• Improves water quality • Improves air quality • Increases plant pollination • Increases plant productivity • Supports pollinators and other beneficial insects

11-way cover crop mix planted after wheat

ALL PHOTOS: KEVIN KEENAN

15' roller-crimper

UPDATED DECEMBER 2020

Soil Health Case Study

John and Jim Macauley, Macauley Farms LLC, NY

Introduction

John Macauley, his father Jim, and his brother Jeff operate their family's beef and crop farm in northwestern New York. Due to macroeconomic conditions in 2017, the Macauleys converted their dairy to beef and currently manage 80 cattle. The family owns all 1,106 acres of cropland they operate—200 are on river bottom, 339 are for hay and pasture, while the remaining 567 on rolling hills above the Genesee River are the focus of this study. John practices no-till and nutrient management on all 567 acres through a four-year rotation of one-year grain corn, two years of soybeans, and one year of wheat. He follows the wheat with cover crops, matching the acres, which varies season to season.

John found conventionally tilling his crops took too much time. He also wanted to save on equipment costs, reduce erosion, and improve soil tilth. In 2009, he received financial and technical assistance from his local USDA Natural Resources Conservation Service (NRCS) office through an Environmental Quality Incentives Program (EQIP) contract to begin no-tilling wheat. In the first year, the Macauleys struggled to get the grain drill set at the right depth. They experimented by adding weights but eventually decided to buy a bigger drill. By 2012, they expanded to no-till corn and now use no-till for all crops on the 567 acres.

Jeff, Jim, and John Macauley

In 2012, the Macauleys received another EQIP contract to add cover crops after wheat, hoping to reduce compaction, improve weed control between wheat and corn, and improve water infiltration. Planting cover crops following wheat harvest allows more time for cover crops to establish before winter. John currently plants a 12-way mix before corn and a seven-way mix before soybeans. In general, the mixes include oats, cereal rye, radishes, winter peas, and hairy vetch. Each year, John designs the cover crop seed mixes and rates to achieve his erosion and nitrogen (N) fertilization goals. John buys most of his cover crop seed locally but blends the mixes himself.

In 2014, John began planting his cash crop into the living cover crop and terminating the cover after planting. This practice, known as "planting green," allows the cover crop to grow longer, which means more biomass production, greater suppression of weeds and pathogens, and drier fields allowing earlier planting.

Prior to 2012, the Macauleys were putting all their nutrients, both organic and inorganic, on their fields at planting. John is happy with his current mid-season, split application of N on 254 acres of corn and wheat to complement the no-till program. Eventually, John hopes to lower his reliance on inorganic nutrients with the right cover crop mix.

Soil Health, Economic, Water Quality, and Climate Benefits

Partial budgeting was used to analyze the marginal benefits and costs of adopting no-till, cover crops, and nutrient management on the

Farm at a Glance

COUNTY: Livingston, NY

WATERSHED: Genesee River

CROPS: Grain corn, soybean, & wheat

FARM SIZE: 1,106 acres

SOILS: Clay, loamy, & gravelly soils on flat & rolling hills

SOIL HEALTH PRACTICES: No-till, cover crops, & nutrient management

15' no-till drill

USDA United States Department of Agriculture Natural Resources Conservation Service

American Farmland Trust

Macauley Farm. The study was limited to only those income and cost variables affected by the adoption of these practices. The table on page two presents a summary of these economic effects revealing that, due to the three soil health practices, John's net income increased by $44 per acre per year or by $25,036 annually on the 567-acre study area, achieving a 135% return on investment.

By eliminating three tillage passes with their switch to no-till, the Macauleys are saving around $72 per acre annually in machinery and labor expenses. John is also happy to not be picking rocks anymore, which were kicked up by tillage. He spends about $23 an acre each year on an additional herbicide application to manage weeds.

Despite significant upfront annual costs for cover crops ($53 per acre) and the labor and equipment to blend seed mixes ($1.72 per acre), John knows cover crops are worthwhile given they control weeds, reduce erosion, minimize compaction, increase infiltration, and increase the rate of organic matter build-up in his fields.

John recognizes how important split application of N can be for reducing nutrient runoff while optimizing crop fertilization needs. He has been able to maintain his yield and believes the extra $13 per-acre-per-year for split application is worth it. John enhances his knowledge of soil health practices by spending about 44 hours a year on learning the latest in no-till technologies and implementation at conferences and field days. John also watches YouTube videos to help him learn.

To estimate the water quality and climate benefits experienced on one of John's 13-acre fields, USDA's Nutrient Tracking Tool was used and found that the Macauley's use of no-till, cover crop mixes, and split application of commercial fertilizers reduced N, P, and sediment losses by 72, 90, and 99% respectively. On the same field, USDA's COMET-Farm Tool estimates a 69% reduction in total greenhouse gas emissions, which corresponds to taking ten cars off the road.

Closing Thoughts

John believes that continuing to find ways to improve his soil health will provide even greater returns in the future as he experiments with cover crop mixes to supply nutrients, thereby reducing reliance on inorganic N, P, and micronutrients. "I am focused on building my soil health and letting nature do some of the work for me. I may not be setting records for high yields, but at the end of the day, I've got more money in my pocket instead of shelling it all out upfront," says John.

Economic Effects of Soil Health Practices on Macauley Farms LLC, NY (2018)

Increases in Net Income			
Increase in Income			
ITEM	PER ACRE	ACRES	TOTAL
None Identified			$0
Total Increased Income			**$0**
Decrease in Cost			
ITEM	PER ACRE	ACRES	TOTAL
Machinery cost savings due to no-till (3 less passes/yr)	$72.28	567	$40,984
Ceased rock picking saving 12 hrs labor/yr	$0.27	567	$153
Weed control by cover crops saves 1 sprayer trip	$12.00	122	$1,464
Soil health practices reduce soil nutrient losses due to .51 tons/ac less erosion	$1.61	567	$914
Total Decreased Cost			**$43,515**
Annual Total Increased Net Income			**$43,515**
Total Acres in this Study Area			**567**
Annual Per Acre Increased Net Income			**$77**

Decreases in Net Income			
Decrease in Income			
ITEM	PER ACRE	ACRES	TOTAL
None Identified			$0
Total Decreased Income			**$0**
Increase in Cost			
ITEM	PER ACRE	ACRES	TOTAL
Increased herbicide cost due to no-till (1 more application)	$23.14	323	$7,475
Cover crop costs	$53.43	122	$6,518
1 day to mix cover seed (8 hrs labor)	$0.83	122	$102
Portable seed mixer & tote box	$0.89	122	$109
Increased machinery cost due to switch from single to split fertilizer	$12.60	254	$3,200
Residue & tillage mgt learning activities (44 hrs/yr)	$1.90	567	$1,074
Total Increased Cost			**$18,479**
Annual Total Decreased Net Income			**$18,479**
Total Acres in this Study Area			**567**
Annual Per Acre Decreased Net Income			**$33**

Annual Change in Total Net Income = $25,036

Annual Change in Per Acre Net Income = $44

Return on Investment = 135%

This table represents costs & benefits attributed to no-till, cover crops, & nutrient management over the 567-acre study area as reported by the farmer. • All values are in 2018 dollars • Prices used: Nitrogen: $.30/lb, Phosphate: $.39/lb, (Estimated Costs of Crop Production in Iowa—2018, ISU). • Sheet & rill erosion benefits are based on estimated N & P content of the soil & 2018 fertilizer prices. • Return on Investment is the ratio of Annual Change in Total Net Income to Annual Total Decreased Net Income expressed as a percent (i.e., net profit/cost of investment) • Financial assistance from NRCS was not included in the partial budget analysis as it is not an economic effect of soil health practices themselves. • For study methodology, see https://farmland.org/soilhealthcasestudies. For USDA's Nutrient Tracking Tool, see https://www.oem.usda.gov/nutrient-tracking-tool-ntt. For USDA's COMET-Farm Tool, see http://cometfarm.nrel.colostate.edu. • Rounding errors may result in minor discrepancies in calculated results. • This material is based on work supported by a 2018 USDA NRCS CIG grant: NR183A750008G008.

For more information about this study or to discuss soil health practices, please contact

• Aaron Ristow, American Farmland Trust, New York Agricultural Stewardship Program Manager, aristow@farmland.org, 315-748-5029
• USDA NRCS Livingston County Office, 11 Megan Drive, Suite 2, Geneseo, NY 14454, 585-243-0030 X 3

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Planting green with a 40-ft, 16-row corn planter

KEVIN KEENAN PHOTOS


Forrest adjusting planter

Soil Health Case Study

Forrest Watson, Mulligan Farm, NY

Can soil health practices be adopted while improving economic performance?

JULY 2022

USING DATA FROM NY DAIRY FARM BUSINESS SUMMARY

Farm at a Glance

COUNTY: Livingston, NY

WATERSHED: Genesee River

CROPS: Hay, corn silage/ grain, wheat

FARM SIZE: 2,618 acres; 1,275 milking cows plus 430 dry cows & heifers

SOILS: Loamy soils on gently sloping to steep rolling hills

SOIL HEALTH PRACTICES: No-till, strip-till, cover crops, crop rotation, nutrient management

Introduction


Forrest Watson

STEPHANIE CASTLE

Since 2008, Forrest Watson has farmed with his aunt and uncle, Lesa and Jeff, on their 1,500-head dairy in western New York. They farm 2,618 acres and practice an eight-year crop rotation: 1 year winter wheat (300 acres), 3 years alfalfa/grass (1,000 acres), and 4 years corn (1,318 acres), that is mostly corn silage. Occasionally other forage crops follow corn, such as triticale.

The farm constantly seeks to improve efficiencies and provide the best care for its animals, land, and employees. Forrest learns about soil health through participation in conferences and reading. As a result, Forrest has modified their crop rotation (e.g., increased wheat acreage), reduced tillage, adopted cover crops, and changed nutrient management strategies.

To improve soil health and productivity with fewer inputs, Forrest began experimenting with cover crops and no-till in 2015. He started no-till on just 75 acres of wheat but went "all-in" with cover crops. Today, Forrest plants a 6-way mix or a winter cereal following corn. In 2018, he began 'planting green'. On the remaining acres, alfalfa and wheat provide winter cover. Currently, all but 150 acres of corn are no-tilled and the rest are strip-tilled.

Forrest observes that the cover crops are improving the soil, enabling easier no-till drilling, which in turn, saves them time. "The feeling of needing to till due to compaction is virtually gone," says Forrest. "We're breaking up compaction with roots instead of iron." The farm received financial and technical assistance from the USDA Natural Resources Conservation Service to implement cover crops.*

Mulligan Farm works with consultants to implement a Comprehensive Nutrient Management Plan. Since 2008, Forrest has increased the frequency and intensity of their soil testing by introducing grid sampling, begun split applications of chemical fertilizers, and switched to drag hose and injection of their manure (versus spreading). These improvements optimized fertilizer application rates, timing, volume, and location.

Soil Health, Economic, Water Quality, and Climate Benefits

A marginal analysis was conducted using the Mulligan Farm's Cornell Dairy Farm Business Summary (DFBS) dataset[†] from 1998–2019 to answer the question, "Can soil health practices be adopted while improving economic performance?" We analyzed the benefits and costs before and after implementation of soil health practices. The study was limited to comparing only crop production income and cost variables that differed between the conventional "before" period (1998–2014) and the soil health "after" period (2015–2019). Variables taken from the Cornell DFBS survey include acres, yield, and production by crop, fertilizer and lime, seeds and plants, spray and other crop expenses, and various machinery expenses. The following results summarize the changes in these cost variables. We do not try to isolate specific changes due to soil health practices because the DFBS data do not breakdown the costs by crop or specific farm operations.

The DFBS data show Forrest was able to adopt soil health practices while improving economic performance as the farm's net income increased

Planting green

USDA United States Department of Agriculture Natural Resources Conservation Service

Great Lakes RESTORATION

American Farmland Trust

by $75/ac, or $196,350 annually, for the 2,618-acre study area, achieving a 129% return on investment. Forrest believes this increase in net income is due to multiple factors, including soil health practice adoption. In particular, the DFBS data highlight a modification in crop rotation with an increase in acres planted in higher-value wheat. Also, the data show higher average yields of both corn grain and wheat, which resulted in an increased value of crops harvested by $76/ac.

The farm decreased costs in the "machine hire, rent and lease" category by $27/ac, while increasing costs in the "machinery repair and farm vehicle" and "machinery ownership expenses (depreciation and interest)" categories by $2 and $10/ac, respectively. This overall cost-savings could be driven by the switch to no-till, which takes less time and improves efficiency.

The "seeds and plants" category increased by $8/ac. This category reflects all changes in seed expenses across all crops—cash crops, forage crops, and cover crops. These changes are driven both by the crop rotation modifications and introduction of cover crops between the periods.

The "fertilizer and lime" cost category decreased by $11/ac, while the "spray and other crop expenses" category increased by $38/ac. According to Forrest, he has reduced fertilizer applications due to better nutrient capture with cover crops and injecting instead of spreading manure.

In total, the difference in average costs was a $1/ac increase, while the value of crop production increased by $76/ac/yr. Yield resiliency also improved as the data show more consistent annual yields.

The USDA's COMET-Farm Tool was used to estimate water quality benefits and greenhouse gas emission changes. Analysis suggests that on one of Forrest's 35-acre fields from the study area, the farm's use of no-till, cover crops, and nutrient management reduced nitrogen, phosphorus, and sediment losses by 4%, 33%, and 60%, respectively, and resulted in a 252% reduction in total greenhouse gas emissions, which corresponds to taking two cars off the road.

Closing Thoughts

Commitment to using the most environmentally friendly practices guides crop production at Mulligan Farm. "You can't give up after the first little failure," says Forrest. Soil health practice adoption supports improved operational efficiencies. For example, less labor going to tillage allows labor to go to activities that provide additional value like cover crop establishment, double cropping, and nutrient management. Forrest has observed improvements in soil health, such as reduced soil compaction, and the DFBS data show more consistent and higher crop yields. Overall, Mulligan Farm has managed to improve economic performance while investing in soil health practices.

Economic Effects of Soil Health Practices on Mulligan Farm, NY (2019)

Using Survey Data from Cornell Dairy Farm Business Summary

Increases in Net Income			
Increase in Income			
ITEM	PER ACRE	ACRES	TOTAL
Increase in value of crops harvested	$76	2,618	$198,968
Total Increased Income			**$198,968**
Decrease in Cost			
DFBS EXPENSE CATEGORY	PER ACRE	ACRES	TOTAL
"Machinery hire, rent & lease"	$27	2,618	$70,686
"Fertilizer & lime"	$11	2,618	$28,798
"Fuels, oils & greases"	$19	2,618	$49,742
Total Decreased Cost			**$149,226**
Annual Total Increased Net Income			**$348,194**
Total Acres in this Study Area			**2,618**
Annual Per Acre Increased Net Income			**$133**

Decreases in Net Income			
Decrease in Income			
ITEM	PER ACRE	ACRES	TOTAL
None identified			$0
Total Decreased Income			**$0**
Increase in Cost			
DFBS EXPENSE CATEGORY	PER ACRE	ACRES	TOTAL
"Machinery repair & farm vehicle"	$2	2,618	$5,236
"Machinery ownership expenses (depreciation and interest)"	$10	2,618	$26,180
"Seeds & plants"	$8	2,618	$20,944
"Spray & other crop expenses"	$38	2,618	$99,484
Total Increased Cost			**$151,844**
Annual Total Decreased Net Income			**$151,844**
Total Acres in this Study Area			**2,618**
Annual Per Acre Decreased Net Income			**$58**

Annual Change in Total Net Income = $196, 350

Annual Change in Net Income Per Acre = $75

Return on Investment = 129%

†This table represents average costs and benefit data reported by Mulligan Farm annually to Cornell University Cooperative Extension through the NY Dairy Farm Business Summary survey. For this analysis, we analyzed crop production and expenses from 1998–2019 to estimate averages for yields and expenses for the pre- ('98 to '14) and post-soil health years ('15 to '19). • All values are expressed in real terms using USDA price indices, 2011 = 100. • Value of crop production prices: Forage: $164/ton (Source: New York NASS, various years). • For information about: (1) study methodology, review the working paper: nydairyadmin.cce.cornell.edu/uploads/doc_942.pdf; and (2) USDA's COMET-Farm Tool, see http://comet-farm.com/ • This material is supported by a 2019 Great Lakes Restoration Initiative Grant (#00E02807) & 2018 USDA NRCS CIG Grant (NR183A75008G008). *Mulligan Farm received financial support from the Environmental Quality Incentives Program (2004–'07, '15) and the Conservation Stewardship Program (2015–'20) for cover crops. This is not included in the analysis because cost-share is temporary and not received by all.

For more information about this study or to discuss soil health practices, please contact

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JULY 2019

Soil Health Case Study

Jay Swede, Gary Swede Farm LLC, NY

Farm at a Glance

COUNTY: Genesee County, NY

WATERSHED: Genesee River & the Great Lakes Basin

CROPS: Corn silage, grain corn, sweet corn, wheat, alfalfa & vegetables

FARM SIZE: 4,500 acres total, 1,500 dairy rotation

SOILS: Clay, loamy & gravely soils on flat & rolling hills

SOIL HEALTH PRACTICES: No-till, strip-till, cover crops & nutrient management

Introduction

Jay Swede, his father Gary, and his brother Ryan farm 4,500 acres of cropland on rolling terrain in northwestern New York. The farm splits the acreage among three rotations: grains, vegetables, and feed grown for a 2,000-cow dairy partnership. The rotations are moved throughout all 4,500 acres. Although they are using soil health practices on all crops, for simplicity's sake this study focuses on the 1,500-acre dairy rotation that includes 1-year sweet corn, 3-years alfalfa, 1-year corn silage or corn for grain.

In 2005, Jay tried strip-till to address soil compaction and erosion and to reduce costs. The Swedes began with 100 acres of sweet corn and grain corn but struggled getting the seed placed in the center of the strip. This led them to invest in autosteer in the second year and a satellite-based navigation system in the third year to guide the planter. In just a few years, they were strip-tilling all 1,500 acres in the dairy rotation.

Rye after corn silage has been a popular cover crop in New York, and the Swede farm was no exception. Jay moved to planting oats instead around the same time he switched tillage operations. Oats fit better into their new system and rye often got out of control in the spring, whereas oats die over the winter. However, oats can get too big, sealing the ground in the spring and keeping the soil excessively wet. Jay addressed this by reducing the seed population at planting and adding radishes and wheat to deal with erosion and compaction. Currently, Jay plants 450 acres of cover. He drills a blend of oats and radishes in two rows of strip-till strips, then goes back and drills the wheat in the other two rows.

Having the oats between wheat helps manage the large root mass of wheat, which can get in the way of cash crop seed placement.

When the Swedes joined the dairy partnership in 2010, they began applying manure through injection into the soil or top spreading onto the cover crops according to their Comprehensive Nutrient Management Plan. They are accounting for nitrogen and phosphorus in the manure, seeing better nutrient efficiencies due to injection, and putting less nitrogen on upfront by using a split application. More recently, they started using variable rate nutrient application and Adapt-N, a precision nitrogen recommendation tool for corn. Their yields have increased over the years as a result, despite using the same amount of nitrogen.

Soil Health, Economic, Water Quality, and Climate Benefits

Today, Jay uses strip-tillage, cover cropping, and nutrient management on his 600 acres of sweet corn and corn silage. He also uses reduced tillage on the 300 acres of alfalfa he plants each year. Because the alfalfa is in for three years, it makes up the remaining 900 acres in the dairy rotation. These changes have led to many benefits. According to farm records, Jay's sweet corn yields are up by over 31%, and corn silage yields have increased by more than 36% since 2005. Jay believes half of those increases (or about $72 per acre) are attributable to his soil health practices.

The Swedes eliminated three passes by strip-tilling their corn. This means less compaction,

USDA
United States Department of Agriculture
Natural Resources Conservation Service

American Farmland Trust

increased water infiltration, and savings in fuel, labor, and machinery maintenance. When combined with reduced tillage for his hay crop, Jay's savings average about $23 per acre. However, he spends about 10 hours each year setting up his corn planter to handle residue from the previous crop.

Despite sizable upfront costs for cover ($51 per acre), Jay thinks it's worth it because it reduces compaction and absorbs nutrients from fall applied manure. Cover also increases soil organic matter. This cost is offset by Jay's nutrient management activities that save him $41 per acre for purchases of phosphorus and potassium. Keeping the soil covered and minimizing tillage has also reduced erosion by nearly two tons per acre. The value of the nutrients in the soil saved is over $2 per acre (NRCS, 2009).

Jay enhances his knowledge of soil health practices by spending about 16 hours a year attending conferences and field days and meeting with ag consultants.

To estimate the water quality and climate benefits experienced on one of Jay's 25-acre fields, USDA's Nutrient Tracking Tool was used and found that Jay's use of strip-till, cover crops, and nutrient management reduced N, P, and sediment losses by 40, 92, and 96% respectively. On the same field, USDA's COMET-Farm Tool estimates that Jay's soil health practices resulted in a 560% reduction in total greenhouse gas emissions, which corresponds to taking three cars off the road.

Partial budgeting analysis was used to estimate the benefits and costs of adopting no-till and strip-till, cover crops, and nutrient management for the Swede Farm. The study limited its focus to variables affected by the adoption of these soil health practices. The table below presents a summary of these economic effects. Jay improved his bottom line by $55 per acre and by $82,257 on the 1,500 acres in this study by adopting the soil health practices.

Closing Thoughts

"In a recent wet year, the best corn was where the cover crops were," Jay says. While still learning, Jay feels that he has hit his stride with the soil health practices he's adopted and is seeing great results from relatively minor changes to his operations. "The second year we did strip-till, even though the corn was only 8" tall, we had roots going down about a foot." He says his ground is more "workable," and he has observed better infiltration and decreased runoff and erosion in his fields following heavy rains. He also believes he has improved his bottom line by reducing his operating costs, tightening up his management of nutrients, and producing higher yields.

Economic Effects of Soil Health Practices on Gary Swede Farm, LLC (2018)

Increases in Net Income			
Increase in Income			
ITEM	PER ACRE	ACRES	TOTAL
Yield Impact Due to Soil Health Practices	$71.95	600	$43,168
Total Increased Income			**$43,168**
Decrease in Cost			
ITEM	PER ACRE	ACRES	TOTAL
Reduced Machinery Cost due to Reduced Tillage	$23.43	1,500	$35,152
Nutrient Savings due to Nutrient Mngmnt.	$40.65	600	$24,390
Value of Decreased Erosion due to Soil Health Practices	$2.25	1,500	$3,369
Total Decreased Cost			**$62,911**
Total Increased Net Income			$106,079
Total Acres in the Study Area			1,500
Per Acre Increased Net Income			$71

Decreases in Net Income			
Decrease in Income			
ITEM	PER ACRE	ACRES	TOTAL
None Identified			$0
Total Decreased Income			**$0**
Increase in Cost			
ITEM	PER ACRE	ACRES	TOTAL
Cost of Setting up Planter to Handle Residue	$0.72	600	$432
Cover Crop Costs	$51.00	450	$22,950
Residue and Tillage Mgmt. Learning Activities	$0.07	1,500	$98
Cover Crops Learning Activities	$0.22	450	$98
Nutrient Management Learning Activities	$0.16	1,500	$244
Total Increased Cost			**$23,822**
Annual Total Decreased Net Income			$23,822
Total Acres in this Study Area			1,500
Annual Per Acre Decreased Net Income			$16

Annual Change in Total Net Income = $82,257

Annual Change in Per Acre Net Income = $55

This table represents costs and benefits over the entire study area (1,500 acres) as reported by the farmer.

All values are in 2018 dollars.

Crop prices used in the analysis: Corn: $3.55/Bu, Sweet Corn: $75/Ton. Sources: Crop Values 2018 Summary, USDA, NASS (Corn), Jay Swede (Sweet Corn).

Fertilizer prices used in the analysis: Phosphate: $.39/LB, Potash: $.27/LB. Source: Estimated Costs of Crop Production in Iowa—2018

Sheet and rill erosion benefits are based on estimated nitrogen and phosphorus content of the soil and 2018 fertilizer prices. Source: NRCS Interim Final Benefit-Cost Analysis for the Environmental Quality Incentives Program, 2009.

For information about study methodology, see http://farmland.org/soilhealthcasestudies. For information about USDA's Nutrient Tracking Tool, see https://www.oem.usda.gov/nutrient-tracking-tool-ntt. For information about USDA's COMET-Farm Tool, see http://cometfarm.nrel.colostate.edu/. This material is based on work supported by a USDA NRCS CIG grant: NR183A750008G008.

Jay has been receiving technical and financial assistance through a Conservation Stewardship Program (CSP) contract (2016 to 2020). This support allowed Jay to experiment with new cover crop mixes and new nutrient management split application techniques on a few hundred acres. The CSP income is not included in the analysis given the mismatch in years and acres between the contract and the study. Readers can assume that during the contract years, Jay received additional net income from CSP.

For more information about this study or to discuss soil health practices, please contact

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Meghan in one of her pastures

R. DROBIS

Table Rock Farm

Soil Health Case Study

Meghan Hauser, Table Rock Farm, NY

Can economic performance improve with adoption of soil health practices?

AUGUST 2022

USING DATA FROM NY DAIRY FARM BUSINESS SUMMARY

Farm at a Glance

COUNTY: Wyoming, NY

WATERSHED: Genesee River

CROPS: Hay, corn silage, peas, triticale

FARM SIZE: 1,800 acres; 1,150 milking cows plus 950 dry cows & heifers

SOILS: Fine-loamy on gentle to steep rolling hills

SOIL HEALTH PRACTICES: Cover crops, minimal tillage, nutrient management, diversified crop rotation

Introduction

Fourth generation farmer Meghan Hauser manages Table Rock Farm's 1,150-head dairy alongside long-time crop specialist, Jeffrey Jordan, and a dedicated team of 35 employees. Meghan and her family own 1,008 acres of their 1,800 crop acres where they implement a 6-year rotation of 3 years corn silage and 3 years alfalfa hay.

For as long as Meghan remembers, Table Rock Farm has planted a rye cover crop after corn to, "protect against runoff." The farm has tried inter-seeding and broadcasting rye, to now using a drill to plant a rye and oat mix, which coincided with a seed tender purchase in 2016. They include radishes in the mix when they can get into the field early. In 2012, the farm switched to a shorter-season corn to allow earlier planting of cover crops. Recently, the farm has been experimenting with "planting green," or planting into a living cover crop.

In 2002, they began following a Comprehensive Nutrient Management Plan (CNMP) to optimize nutrient placement and timing. Jeffrey started planting 60 acres of peas in 2005 then added 150 acres of triticale in 2017 (both planted between corn harvest and alfalfa planting) to diversify their crop rotation, protect the soil, and grow additional feed.

In 2001, Jeffrey encouraged the farm to reduce tillage to increase soil organic matter, water infiltration and storage, and to improve cover crop establishment. They sold their plow and began using a zone-builder subsoiler to break up compaction with minimal surface disruption. Rather than purchasing a no-till drill, Jeffrey made modifications to their conventional drill over time to work in minimally tilled soil. Jeff now minimally tills all owned acres, using the subsoiler on newly acquired land and areas, such as headlands, where compaction is an issue. Recently, they have experimented with other minimal tillage tools such as a roller harrow to break clods or a speed tiller to reduce surface compaction while facilitating better seed to soil contact when planting triticale. Farm operation efficiency has improved since reducing tillage, says Jeffrey, as time, labor, and equipment are allocated to other activities.

Meghan Hauser

R. DROBIS

After selling their plow, Meghan says they noticed immediate improvements to soil health, especially reduced erosion. "After several summer torrential downpours, we didn't have any washouts," Meghan notes, "[and] the ground stayed in place." And, nowadays, Jeffrey observes that, "in the summer you can feel the softness of the soil under your feet while before it felt like concrete… [and] we have earthworms now!"

Soil Health, Economic, Water Quality, and Climate Benefits

A marginal analysis was conducted using Table Rock Farm's Cornell University Dairy Farm Business Summary (DFBS) data† from 1993 to 2020 to answer the question, "Can economic performance improve with adoption of soil health practices?" The analysis compares the average value of crops produced and crop production costs between the "before" period ('93–'00) and "after" period ('01–'20), which Meghan selected to reflect the change from their former system (conventional tillage with rye cover crop) to their current system (minimal tillage, cover crop mix, diversified crop rotation, and a CNMP). We recognize that during both periods the farm changed their field operations for soil health reasons, such as planting cover crops in the

Corn planted green, growing through a cover of oats, rye, and tillage radish

M. HAUSER

early '90s, but Meghan chose 2001 as the start of their current system as that was the year they stopped plowing their fields and soon after implemented a CNMP.

Variables from the DFBS data include acres and yield by crop, fertilizers and lime, seeds and plants, spray and other crop expenses, and various machinery expenses. The table below summarizes any changes in these variables. Note, we do not attribute specific practices to cost changes because the DFBS data do not breakdown costs by crop or specific farm operations.

The DFBS data show that Table Rock Farm was able to adopt soil health practices, alongside other changes in their field operations, while improving economic performance as the farm's net income increased by $79/ac, or $142,848/yr, for the 1,800-acre study area, achieving a 125% return on investment.

The value of crops produced (price x yield) increased by an average of $111/ac and, importantly, is more consistent year-to-year.* There are decreases in costs as well. The "fertilizers and lime" expense category decreased by $7/ac, which Meghan believes is from improving soil health and reducing synthetic fertilizer use by accounting for nutrients in applied manure. Additionally, "spray and other crop expenses" decreased by $25/ac. Jeffrey commented that, "we are spraying less," thanks to greater weed suppression and more resilient crops.

The farm experienced an increase in "fuel, oil, and grease," "machinery repairs and farm vehicles," and "machine hire, rent, and lease" cost categories by $32, $13, and $10 per acre, respectively. Those increases in costs cannot be attributed to any one change based on the DFBS data, but Meghan believes the addition of newly leased land (almost double from "before" to "after" period), which required clearing, installing drainage, and manure applications contributed to these increases. Additionally, the farm experienced a $7/ac increase in "seeds and plants," which they believe reflects purchasing improved seed varieties. Overall, despite these increases in costs, the benefits outweigh the costs according to the DFBS data.

AFT used USDA's Nutrient Tracking Tool and COMET-Farm Tool to estimate Table Rock Farm's use of minimal tillage, cover crop mixes, diversifying their crop rotation, and nutrient management on a 21-acre field and found that they reduced their nitrogen, phosphorus, and sediment losses by 33%, 75%, and 90%, respectively, and reduced their GHG emissions by 165%, corresponding to taking 2 cars off the road.

Closing Thoughts

The team at Table Rock Farm combined soil health practices to achieve their land stewardship mission to improve the land while being profitable, and, according to this analysis, Table Rock Farm's investment in soil health practices coincides with improved economic and environmental performance.

Economic Effects of Soil Health Practices on Table Rock Farm, NY (2011 Prices)

Using 1993–2020 Survey Data from Cornell University's Dairy Farm Business Summary

Increases in Net Income

ITEM	PER ACRE	ACRES	TOTAL
Increase in Income			
Increased value of crops produced (price x yield x acres)	$111	1,800	$200,556
Total Increased Income			**$200,556**
Decrease in Cost			
DFBS EXPENSE CATEGORY	PER ACRE	ACRES	TOTAL
"Fertilizer & lime"	$7	1,800	$12,060
"Spray & other crop expenses"	$25	1,800	$44,100
Total Decreased Cost			**$56,160**
Annual Total Increased Net Income			**$256,716**
Total Acres in this Study Area			**1,800**
Annual Per Acre Increased Net Income			**$143**

Decreases in Net Income

ITEM	PER ACRE	ACRES	TOTAL
Decrease in Income			
None identified			$0
Total Decreased Income			**$0**
Increase in Cost			
DFBS EXPENSE CATEGORY	PER ACRE	ACRES	TOTAL
"Seeds & plants"	$7	1,800	$13,032
"Fuel, oil, & grease"	$32	1,800	$57,798
"Machinery repairs & farm vehicle"[1]	$13	1,800	$24,228
"Machine hire, rent, & lease"[2]	$10	1,800	$18,810
Total Increased Cost			**$113,868**
Annual Total Decreased Net Income			**$113,868**
Total Acres in this Study Area			**1,800**
Annual Per Acre Decreased Net Income			**$63**

Annual Change in Total Net Income = $142,848

Annual Change in Net Income Per Acre = $79

Return on Investment = 125%

*Please see the working paper (link below) for more on the increased consistency in the total value of production. †This analysis uses cost and benefit data reported by Table Rock Farm annually from 1993 to 2020 to Cornell University Cooperative Extension through the NY Dairy Farm Business Summary survey. We calculated average yields and expenses "before" ('93-'00) and "after" ('01-'20) adoption of minimal till, diversified crop rotation, a cover crop mix, and a nutrient management plan. [1]"Machinery repairs & farm vehicle" do not include milk parlor repair costs. To exclude these costs, the 1993-2000 milk parlor repair costs were estimated as not provided in DFBS survey those years (for methodology, see working paper linked below). [2] Machinery depreciation and interest costs are not included in this analysis because they are fixed costs, and not applicable. • All values are expressed in real terms using USDA price indices, 2011 = 100. • Prices by crop used from years 1993-2020 (USDA, New York NASS Prices Received, 1993-2020). • For information about: (1) study methodology, see working paper: bit.ly/CCEDFBSWorkingPaperTRF, (2) USDA's Nutrient Tracking Tool, see https://ntt.tiaer.tarleton.edu/welcomes, and (3) USDA's COMET-Farm Tool, see comet-farm.com • This analysis is supported by a 2019 GLRI grant (00E02807).

For more information about this study or to discuss soil health practices, please contact

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Corn after cover crops on the left = resilient! No cover crops on the right = stressed!

RIGHT IMAGE: MICHAEL SWISHER


Healthy soil with vetch roots

JANUARY 2024

Soil Health Case Study

Bob Waring, Brandon Farm, VA

Brandon Farms is a third-generation row crop farm located in Essex County, Virginia, along the Rappahannock River, a tributary to the Chesapeake Bay. Bob Waring Jr. manages the farm with his father, Rob, growing 1 year of corn grain and 2 years of soybeans across 450 acres, 100 of which they own. They have implemented no-till since the 1990s. For this study, we analyze their more recent adoption of cover crops and nutrient management on 300 acres, as the other 150 acres are managed using different practices.


DAWN HOWETH

Bob Waring with his family

Bob works as a nutrient management specialist for the Virginia Department of Conservation and Recreation. "Conservation is part of my job, but it's also part of my life," he says. After a back injury from an 11-foot fall in 2013, Bob recognized that by eating correctly, his body was able to withstand that stress and heal. He began applying that philosophy to his farm, believing that "plants are better able to withstand drought, insect pressure, and disease if they get nutrition through natural sources like cover crops."

Bob and Rob began experimenting with cover crops as early as 2010, with help from state and federal cover crop cost-share programs.[1] In 2016, Bob partnered with Virginia Tech and Precision Sustainable Agriculture to implement a long-term field trial, with a side-by-side comparison of cover crops and no cover crops. They are comparing different nitrogen amounts and discovering application timing through extensive soil sampling, discovering that with cover crops, they can reduce synthetic nutrients applied. "Nutrients are staying in the soil that would have been lost to leaching," says Bob. "Cover crops are harvesting potash, nitrogen, and sulfur for release to the next crop."

Based on learnings from this trial, Bob has expanded his nutrient management practices. Bob now completes a Soil Test for Biological Activity (STBA) to determine nitrogen levels in the soil. He also tests soil for pH, nutrients, and organic matter and measures cover crop biomass and leaf tissue nutrients every year on every field. Previously, he used just one representative standard soil test per crop.

Bob and Rob are constantly fine-tuning how best to offset fertilizer costs in crop production with cover crops. They currently use high biomass, single-species cover crops—planting vetch before corn and black oats before soybeans—but are experimenting with cover crop mixes. Bob plants corn and soybeans into green cover, rolling vetch but not oats, as the soybeans didn't mind either way.

Soil Health, Economic, Water Quality, and Climate Benefits

Partial budgeting analysis was used to estimate the marginal benefits and costs of cover crops and nutrient management on Brandon Farms. The study was limited to only those income and cost variables affected by the adoption of these soil health practices. The table on page 2 presents a summary of these economic effects, revealing that, due to the two soil health practices, Brandon Farms' net income increased by $55/ac/yr, or by $16,439/yr, on the 300-acre study area, achieving a 70% return on investment.

The largest increase in net income was due to yield increases from the adoption of cover crops and nutrient management. Using Bob's yield monitor and crop insurance records, we attribute 50% of his corn and soybean yield increases to the adoption of cover crops and change in nutrient management. We calculated a 43 bu/ac of corn and 9 bu/ac of soybean increase in yield when comparing average yield before and after adoption of cover crop and nutrient management. Bob adds,

Farm at a Glance

COUNTY: Essex, VA

WATERSHED: Rappahannock River, Chesapeake Bay

CROPS: Corn & soybeans

FARM SIZE: 450 acres (300-acre study area)

SOILS: Sandy loam 0–2%

SOIL HEALTH PRACTICES: Cover crops & nutrient management

Corn emerging into terminated vetch

Bob Waring, Brandon Farms, Essex County, VA

"I think we are getting a lot more resiliency, which is translating into better and more consistent yields."

Additional increases in net income are attributed to decreases in cost. With the adoption of cover crops, pesticide application costs have been reduced by $16/ac, as Bob no longer applies an insecticide on soybeans and has reduced his herbicide costs on corn. The largest savings that Brandon Farms attributes to cover crops and nutrient management is a $37/ac reduction in fertilizer applications. On corn, they reduced nitrogen inputs by 85 lbs/ac, reduced phosphorous inputs by 25 lbs/ac, and reduced potassium inputs by 20 lbs/ac. For soybeans, they reduced their phosphorous inputs by 15 lbs/ac and potassium inputs by 5 lbs/ac. Additionally, with the pH buffering effects of the cover crops, they have reduced lime applications to one ton every 6 years, instead of every 3 years, for an annualized savings of $8/ac/yr.

The largest cost incurred by the farm is for cover crops at about $63/ac/yr, or a total of $18,950/yr, including seed, establishment, and management. This cost estimate does not include termination because a pre-plant herbicide spray was already part of the farm's no-till system. The chemical costs for burndown are $13/ac for corn and $7/ac for soybeans. Another cost increase is the additional soil, tissue, and grid sampling costs, which total $7/ac/yr.

Bob is a lifelong learner and estimates he spends 100 hours annually on learning activities related to soil health practices valued at $2,618/yr. This estimate does not include the additional time that Bob spends at work learning about and presenting on nutrient management to help other Virginia farmers.

AFT used USDA's Nutrient Tracking Tool to evaluate Bob's use of nutrient management and cover crop practices on a 77-acre field and found that the practices reduced N, P, and sediment losses by 84%, 76%, and 93%, respectively. The USDA's COMET-Planner Tool estimates that Bob's soil health practices resulted in a reduction of 129 metric tons of CO_2-equivalents/yr, corresponding to taking 29 cars off the road for one year.

Closing Thoughts

As a soil health advocate and innovator, Bob is now an executive member of the Southern Cover Crops Council and the Innovation Roundtable, a farmer-led group of soil health leaders. Bob's passion is palpable in his presentations. As he puts it, "I grew up on the river. My heart is in saving the waterways and being a good steward of the land."

WRITERS: *Kent Bohnhoff & Ellen Yeatman, American Farmland Trust*

Economic Effects of Soil Health Practices on Brandon Farms (2021 Prices)[2]

Increases in Net Income			
Increase in Income			
ITEM	PER ACRE	ACRES	TOTAL
Yield increase of 15% for corn and 10% for soybeans	$71	300	$21,289
Total Increased Income			**$21,289**
Decrease in Cost			
ITEM	PER ACRE	ACRES	TOTAL
Reduction in pesticides due to cover crops (reduced weed pressure on corn & stopped insecticides on soybeans)	$16	300	$4,917
Reduction in N, P, & K on corn and P & K on soybeans	$37	300	$11,210
Lime application reduced by 50% due to nutrient management	$8	300	$2,502
Total Decreased Cost			**$18,629**
Annual Total Increased Net Income			**$39,918**
Total Acres in this Study Area			**300**
Annual Per Acre Increased Net Income			**$133**

Decreases in Net Income			
Decrease in Income			
ITEM	PER ACRE	ACRES	TOTAL
None identified			$0
Total Decreased Income			**$0**
Increase in Cost			
ITEM	PER ACRE	ACRES	TOTAL
Cover crop costs for vetch before corn and black oats before soybeans	$63	300	$18,950
Soil Test for Biological Activity (STBA) on every field once a year	$3	300	$801
Increased nutrient testing costs due to soil, tissue, & cover biomass sampling on every field	$2	300	$510
Grid sampling in lime application years and applying lime on grid	$2	300	$600
Learning activities (100 hrs/yr)			$2,618
Total Increased Cost			**$23,479**
Annual Total Decreased Net Income			**$23,479**
Total Acres in this Study Area			**300**
Annual Per Acre Decreased Net Income			**$78**

Annual Change in Total Net Income = $16,439
Annual Change in Net Income Per Acre = $55
Return on Investment = 70%

[1] Bob received $75/ac ($10,157/yr) through the NRCS EQIP program (2014-2016) and $40/ac ($10,000/yr) from the Virginia Department of Agriculture (1999-2023) for cover crops; and $37/ac ($9,323/yr) through EQIP (2014-2016) for nutrient management. This is not included in the analysis because cost-share is temporary and not received by all.

[2] This table represents estimated average costs and benefits attributed to adopting cover crops and nutrient management over the 300-acre study area, as reported by Bob Waring.

- Rounding of per acre values may result in minor discrepancies in totals.
- All values are in 2021 dollars.
- 2021 standard prices: Corn Grain $5.45/bu, Soybeans $13/bu (USDA NASS, Crop values: 2021 Summary); Nitrogen: $0.72/lb, Phosphate: $0.62/lb, Potash: $0.56/lb (ISU, 2022, Ag Decision Maker.)
- Machinery costs include the cost of custom hire, labor, depreciation, interest, insurance, housing, repairs, and fuel (Univ. of IL at UC, 2021, Farm Business Management Machinery Cost Estimates: Field Operations.)
- For information about (1) study methodology, see farmland.org/soilhealthcasestudies; (2) USDA's NTT, see ntt.tiaer.tarleton.edu; and (3) USDA's COMET-Planner Tool, see comet-planner.com.

For more information about this study or to discuss soil health practices, please contact:
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To read more case studies, visit farmland.org/soilhealthcasestudies

United States Department of Agriculture
Natural Resources Conservation Service

Farming in the 21st Century
a practical approach to improve Soil Health

What is Soil Health? Why Should I Care?

A simple definition of soil health is *the capacity of a soil to function*. How well is your soil functioning to infiltrate water and cycle nutrients to support growing plants?

Soil works for you, if you work for the soil. Management practices that improve soil health increase productivity and profitability immediately and into the future. A fully functioning soil produces the maximum amount of products at the least cost. Maximizing soil health is essential to maximizing profitability. Soil will not work for you if you abuse it.

Soil is a living factory of macroscopic and microscopic workers who need food to eat and places to live to do their work. Amazingly, there are more individual organisms in a teaspoon of soil than there are people on earth; thus, the soil and its processes are controlled by these organisms. The living 'soil factory' is powered primarily by sunlight.

Farms and ranches are provided with soil, water, and sunlight. The challenge is to feed the soil, harvest sunlight and farm sustainably to make a living now and in the future. Tillage, fertilizer, livestock, pesticides, and other management tools can be used to improve soil health, or they can significantly damage soil health if not applied correctly.

Managing for soil health (improved soil function) is mostly a matter of maintaining suitable habitat for the myriad of creatures that comprise the soil food web. This can be accomplished by disturbing the soil as little as possible, growing as many different species of plants as practical, keeping living plants in the soil as often as possible, and keeping the soil covered all the time.

Manage More by Disturbing Soil Less

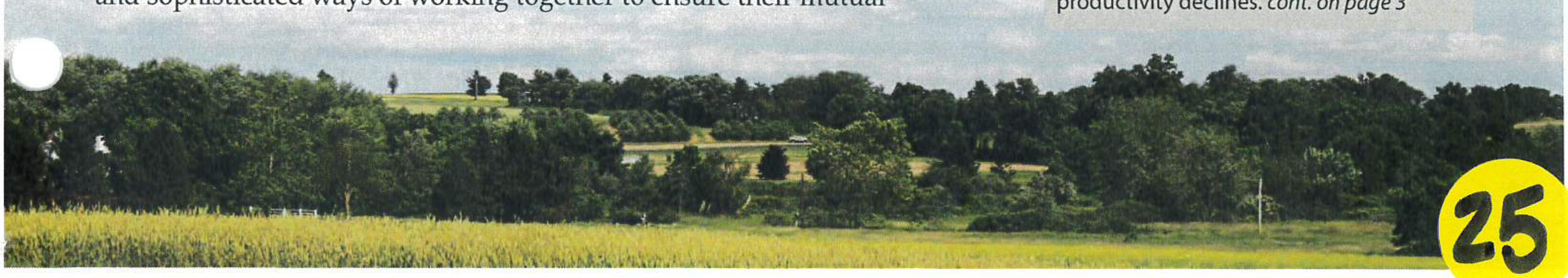
Tilling the soil is the equivalent of an earthquake, hurricane, tornado, and forest fire occurring simultaneously to the world of soil organisms. Physical soil disturbance, such as tillage with a plow, disk, or chisel plow, that results in bare or compacted soil is destructive and disruptive to soil microbes and creates a hostile, instead of hospitable, place for them to live and work. Simply stated, tillage is bad for the soil.

The soil may also be disturbed chemically or biologically through the misuse of inputs, such as fertilizers and pesticides. What happens when we supply inputs to the soil? Soil and all the organisms that live and grow in it have been cycling plant nutrients for a very long time without any human intervention. Consequently, soil and plants have very efficient and sophisticated ways of working together to ensure their mutual

Working in the Factory

The soil factory functions on the same principles as any other factory. For example, suppose you were to build and operate a factory to manufacture pickup trucks. How would you run the factory to produce the greatest number of high quality pickup trucks at the lowest cost each year? First, you might construct a building to provide a good working environment for your workers. Next, you might provide the means for your workers to live in a nice home, have enough food to eat, and enjoy other benefits to allow them to come to work and be at top productivity each day. Finally, you might find ways to maximize the use of energy and raw materials so nothing is wasted or hindered during the production of pickup trucks. Sounds good... a suitable factory filled with productive workers not wasting any energy.

What if our imaginary pickup truck factory were suddenly hit by a tornado and an earthquake, and then it caught fire!? How many high quality pickup trucks could be produced the next day, week, month, or year? Injured (or dead) workers in a damaged factory would probably not be able to produce as many pickups as healthy workers in a well-built factory operating at peak efficiency. This is the scene that is created when soil is physically disturbed by tillage. Soil structure and habitat for soil organisms is destroyed, water infiltration is reduced, runoff is increased, soil erodes, and productivity declines. *cont. on page 3*



sustainability. When we add chemical inputs to the soil, we need to understand and respect existing soil and plant relationships, or we might actually be setting the system up to be inefficient, or worse, to fail altogether.

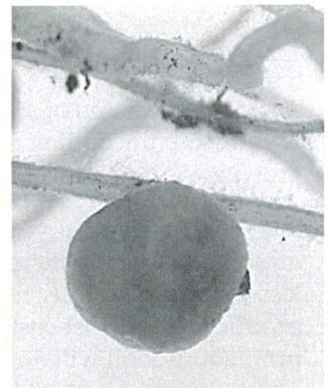
If crop nutrients are applied to the soil in excess, plants will not develop associations with soil organisms that help them acquire water and nutrients. After the "party is over" and the synthetic fertilizer is gone, the plants are left "high and dry" with few to no soil factory workers to help them access water and nutrients for the remainder of the growing season. The plants then give up valuable energy (sugars) in an attempt to make connections with microbes mid-way through the growing season when the plant should be putting that energy into flowering and seed development to produce a harvestable yield. By applying excess fertilizer, particularly nitrogen or phosphorus, we create plants that are very inefficient as they try to function without the support system of the soil with which they evolved.

By reducing nutrient inputs, we can take advantage of the nutrient cycles in the soil to supply crop nutrients and allow plants to make essential associations with soil organisms. This ensures that plants are able to achieve their full potential, and the soil is allowed to perform all of its desired functions to its full potential. If we acknowledge the complex life in the soil and work with it instead of disturbing it, we will harness a tremendous engine for biological production (growing crops).

The 'soil factory' workers can be most productive when they have a good working environment with an ample supply of energy. When they are most productive, the farmer is most profitable.

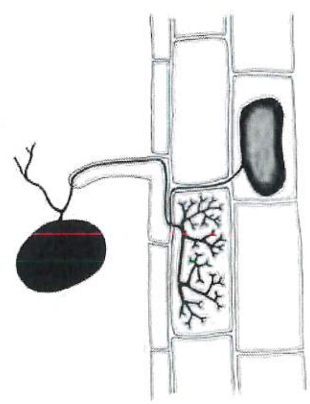
Symbiosis and Mutualism

- One of the many beneficial relationships between plants and soil organisms is the acquisition of nitrogen from the atmosphere by a variety of organisms, including bacteria (rhizobia) that live symbiotically with leguminous plants, such as beans, clover and vetch. When these organisms die, or the plants they associate with shed leaves, shoots, stems, or roots, this material becomes part of the soil along with the nitrogen it contains.



Rhizobia bacteria fix atmospheric nitrogen into ammonium after becoming established in root nodules of leguminous plants.

- Another example involves a group of fungi (arbuscular mycorrhizae) that extend the plant root system out into the soil, forming 'pipelines' to acquire nutrients and water that the plant roots themselves cannot access. As with the bacteria that fix nitrogen, the fungi are given sugar energy from the plant to keep the association working.



Arbuscular mycorrhizae fungi live inside plant roots and help plants capture nutrients from the soil.

Images courtesy of Dr. James Nardi, University of Illinois at Urbana-Champaign.

Photo left: In association with rhizobia bacteria, legumes, such as crimson clover (foreground), convert atmospheric nitrogen into ammonia.

Diversify with Crop Diversity

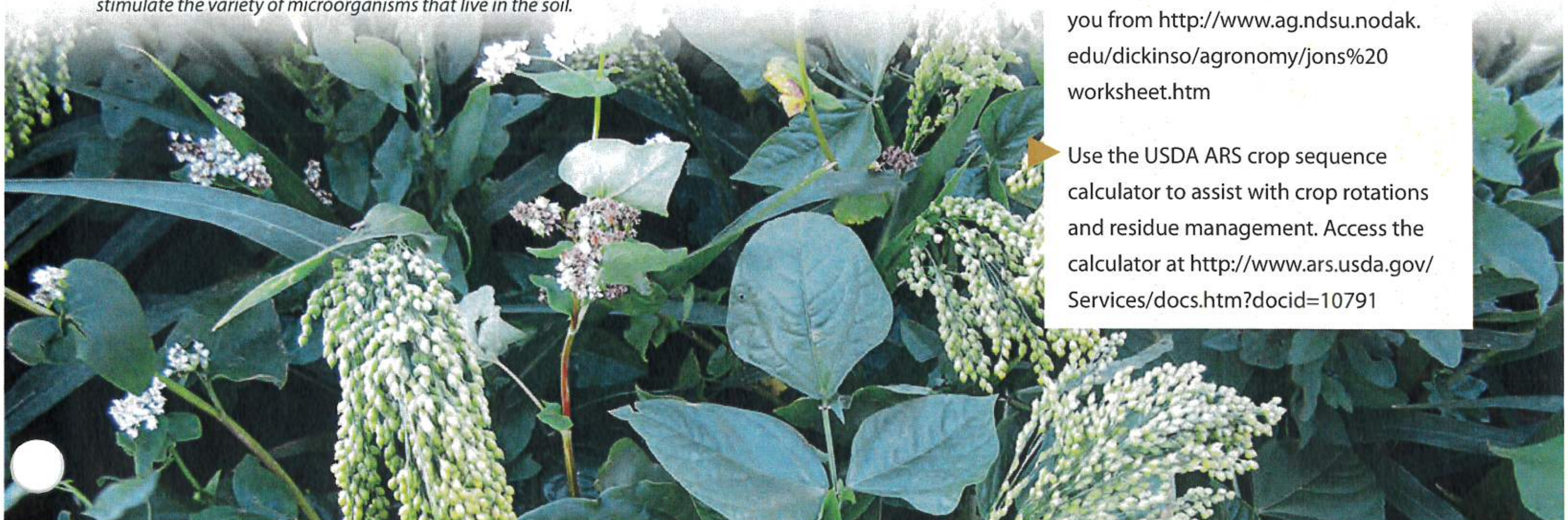
A living functioning soil depends on an efficient flow of light energy originating from the sun. Using chlorophyll to absorb sunlight energy, green plants transform atmospheric carbon dioxide and water into carbohydrates (starches, sugars, lignin, cellulose) in a process known as photosynthesis. The sun's light energy is stored in these carbon compounds, which provide the building blocks for plant roots, stems, leaves, and seeds.

There are two primary mechanisms for carbon to get into the soil and feed the organisms in the soil food web. The first mechanism involves the association between plants and particular types of microbes, in which sugars made by the plant are released from their roots and traded to microbes for nutrients that support plant growth. The second mechanism is by soil life eating dead plant material, such as leaves, stems, and roots, and subsequently releasing carbon into the soil in their waste products or as they die and decompose. In these ways, carbon that was once in the atmosphere is transferred into the soil as organic matter.

Soil microorganisms are responsible for decomposing organic matter and releasing plant available nutrients. A diversity of plant carbohydrates is required to support the assortment of soil microorganisms that live in the soil. To achieve this level of diversity, different plants must be grown. The key to improving soil health is that food and energy chains and webs consists of several types of plants or animals, not just one or two. A guiding principle is that diversity above ground (plants) equals diversity below ground (the soil food web). Growing a diverse rotation of crops is an excellent way to increase the diversity of the soil food web.

Biodiversity is ultimately the key to success of any agricultural system. Lack of biodiversity severely limits the potential of any cropping system and disease and pest problems are increased. A diverse and fully functioning soil food web provides for nutrient, energy, and water cycling that allows a soil to express its full potential. Increasing the diversity of a crop rotation and cover crops increases soil health and soil function, reduces input costs, and increases profitability.

This cover crop mixture of buckwheat, cowpeas, soybeans, and millet provides the soil system with diversity in rooting depth, root structure, organic exudates, and biomass quality, creating different habitat niches to stimulate the variety of microorganisms that live in the soil.



Working in the Factory

...cont.

In a factory making pickup trucks, there is an assembly line for building and installing the engine and another one for the electrical system. The workers in these lines have different needs to complete their tasks. Likewise, the soil factory contains assembly lines of skilled workers that turn raw materials into carbon, oxygen, nitrogen, phosphorus, micronutrients, and water that plants need. These assembly lines require a vast population of diverse workers in order to function properly; and these diverse workers require diversity in their food supply... throughout the year and under optimum soil conditions.

Crop Diversity Tools

- Read *The Power Behind Crop Rotations: A Guide for Producers* by Dr. Dwayne Beck, South Dakota State University, Dakota Lakes Research Farm. Look for it and the Crop Rotation Intensity and Diversity tool at http://www.dakotalakes.com/crop_rotations.htm
- Download a spreadsheet to make diversity and intensity calculations for you from http://www.ag.ndsu.nodak.edu/dickinso/agronomy/jons%20worksheet.htm
- Use the USDA ARS crop sequence calculator to assist with crop rotations and residue management. Access the calculator at http://www.ars.usda.gov/Services/docs.htm?docid=10791

Grow Living Roots Throughout the Year... to feed soil organisms

The soil food web is a complex association of organisms responsible for breaking down crop residues and cycling plant-available nutrients in the soil. Every organism has something that it eats...or something that eats it. There are many sources of food in the soil that feed the soil food web, but there is no better food than the sugars exuded by living roots.

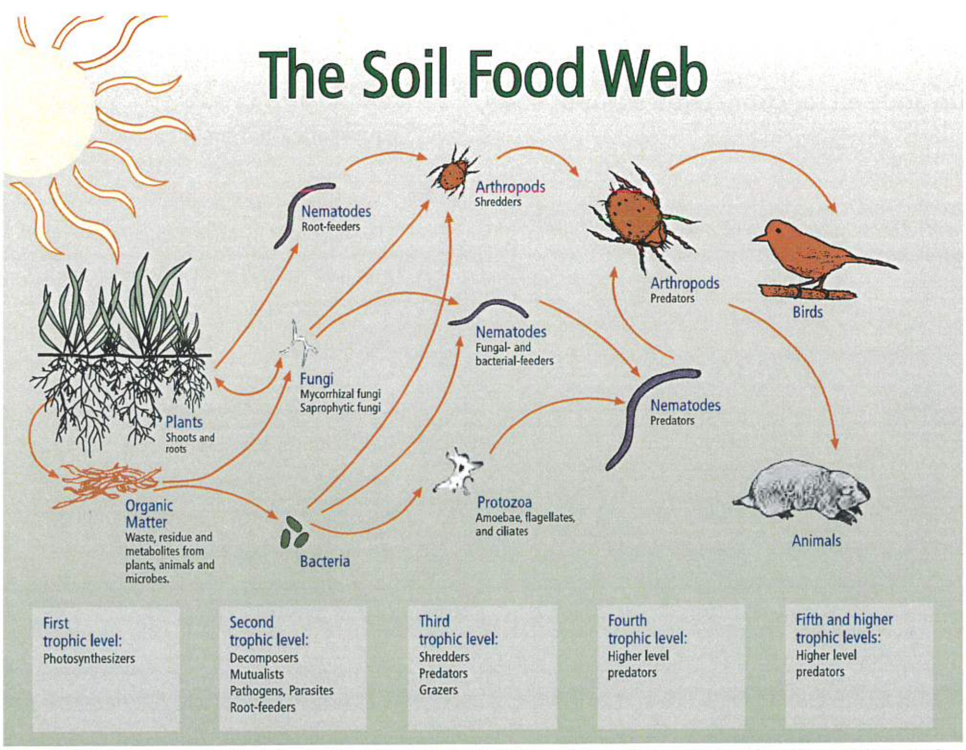
Living plants maintain a rhizosphere, an area of concentrated microbial activity close to the root. The rhizosphere is the most active part of the soil factory because it is where the most easy to eat food is available, and it is where peak nutrient and water cycling occurs. Microbial food is exuded by plant roots to attract and feed microbes that provide nutrients (and other compounds) at the root-soil interface where the plant can take them up. Since living roots provide the easiest source of food for soil microbes, growing long season crops or a cover crop following a short season crop, feeds the foundation species of the soil food web as much as possible during the growing season.

When carbon is not available from living roots, nutrient and water cycling occur at a much slower rate. The process is slower because the microbes involved have to do more work, often allocating parts of tasks to many other organisms and transporting the resources further.

Soil organisms feed on sugar from living plant roots first. Next, they feed on dead plant roots, followed by above-ground crop residues, such as straw, chaff, husks, stalks, flowers, and leaves. Lastly, they feed on the humic organic matter in the soil.

Dead plant roots and crop residues have to be shredded by soil microarthropods, such as mites, springtails, woodlice, earwigs, beetles, and ants. Crop residues have to be transported from the soil surface to living plant roots through long lines of multiple organisms. The humic organic matter has to be processed by a wide variety of organisms before the nutrients locked up in such material are available to the plant.

Healthy soil is dependent upon how well the soil food web is fed. Providing plenty of easily accessible food to soil microbes helps them cycle nutrients that plants need to grow. Sugars from living plant roots, recently dead plant roots, crop residues, and soil organic matter all feed the many and varied members of the soil food web. While the mission statement of the Natural Resources Conservation Service is *helping people help the land*, a farmer's mission statement might be *helping microbes help the plants* by providing soil microbes with the best soil habitat possible, including food.



From Soil Biology Primer [online]. Available: soils.usda.gov/sqi/concepts/soil_biology/biology.html [September 2010].

The soil food web is the community of organisms living all or part of their lives in the soil. The food web diagram shows a series of conversions of energy and nutrients as one organism eats another. The food web is fueled by plants and other organisms that use the sun's light energy to fix carbon dioxide from the atmosphere. Most other soil organisms get energy and carbon by consuming the organic compounds found in plants, other organisms, and waste by-products. As organisms decompose complex materials, or consume other organisms, nutrients are converted from one form to another, and are made available to plants and to other soil organisms.

Keep the Soil Covered as Much as Possible

Soil cover conserves moisture, intercepts raindrops to reduce their destructive impact, suppresses weed growth, and provides habitat for members of the soil food web that spend at least some of their time above ground. This is true regardless of land use (cropland, hayland, pasture, or range). If improving soil health is your goal, you should not see the soil very often.

Soil should always be covered by growing plants and/or their residues and, it should rarely be visible from above. Soil cover cannot be taken for granted. Even in a no-till system, there are times when soil cover may be lacking because of crop harvest methods, amounts of residue produced, and low carbon:nitrogen ratios of some crop residues that make them decompose quickly.

Soil cover protects soil aggregates from 'taking a beating' from the force of falling raindrops. Even a healthy soil with water-stable aggregates (held together by biological glues) that can withstand wetting by the rain may not be able to withstand a 'pounding' from raindrops. When water-stable soil aggregates are covered by crop residues or living plants, they are protected from disintegration by the hammering energy of raindrops. When soil aggregates remain intact at the soil surface, water infiltrates the soil and is available to plant roots.

A mulch of crop residues on the soil surface suppresses weeds early in the growing season giving the intended crop an advantage. This is particularly the case with a rolled cover crop that may cover the entire soil surface at once. They also keep the soil cool and moist which provides favorable habitat for many organisms that begin residue decomposition by shredding residues into smaller pieces. If these "shredders" have good residue habitat they can increase residue decomposition, and therefore nutrient cycling, by up to 25%.

Keeping the soil covered while allowing crop residues to decompose (so their nutrients can be cycled back into the soil) can be a bit of a balancing act. Producers must give careful consideration to their crop rotation (including any cover crops) and residue management if they are to keep the soil covered and fed at the same time.

Did You Know?

The High Plains subregion of the Great Plains is characterized as semiarid, shortgrass prairie. Extreme temperature changes and high winds characteristic of the area can have drastic and devastating effects on exposed soil. In the High Plains, more than 65% of the soil must remain covered to limit evaporation of water. In this rainfall limited area (average rainfall is 10 - 20 inches), maintaining soil cover is an important management strategy for profitable agricultural production. Bare soil heats up quickly in direct sunlight; and the hotter it gets, the faster water evaporates from it. This not only wastes water, but leaves salts behind at the soil surface. Residue cover also limits the drying effect of the wind and traps snow during the winter.

Soil should be covered with living plants or residue at all times, realizing that high quality residue from legumes decomposes relatively quickly. Pictured: hairy vetch.

Residue cover protects soil from the impact of raindrops, keeps it cool and moist for soil organisms, and suppresses weed growth. Pictured: rye rolled down with a cultipacker creates a blanket of residue.

Turnip (above) and forage radish (below) cover crops provide a lot of above and below ground biomass; and their "bio-drilling" action penetrates compacted layers to improve soil health.

Soil Health for Your Farm, Ranch... for You!

Managing for Soil Health must begin by changing the way you think about Soil.

The key to building soil health is to first understand that soil is a biological system. Soil health is improved by disturbing the soil less, growing the greatest diversity of crops (in rotation and as diverse mixtures of cover crops), maintaining living roots in the soil as much as possible (with crops and cover crops), and keeping the soil covered with residue at all times.

Drills, planters, seed, fertilizer, pesticides, livestock, fences, water, farm implements, etc. are all tools that can be used to manage the soil habitat for the benefit of living members of the soil food web.

Organisms in the soil food web cycle crop nutrients and release organic glues that increase soil aggregate stability. Soil aggregates provide these organisms with protected habitat. Stable soil aggregates are critical for water infiltration and gas exchange, both of which are essential to crop production.

Many soils have a water infiltration problem that causes a water runoff problem. If soil health is improved, the structure of the soil results in greater water infiltration, less runoff, less or no erosion, and reduced incidence of flooding and sedimentation.

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United States Department of Agriculture
Natural Resources Conservation Service

Farming in the 21st Century
a practical approach to improve Soil Health

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Soil is a living factory of macroscopic and microscopic workers who need food to eat and places to live to do their work.

There are more individual organisms in a teaspoon of soil than there are people on earth; thus, the soil is controlled by these organisms.

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Managing for soil health (improved soil function) is mostly a matter of maintaining suitable habitat for the myriad of creatures that comprise the soil food web.

Managing for soil health can be accomplished by disturbing the soil as little as possible, growing as many different species of plants as practical, keeping living plants in the soil as often as possible, and keeping the soil covered all the time.

Manage More by Disturbing Soil Less

Tilling the soil is the equivalent of an earthquake, hurricane, tornado, and forest fire occurring simultaneously to the world of soil organisms. Simply stated, tillage is bad for the soil.

Physical soil disturbance, such as tillage with a plow, disk, or chisel plow, that results in bare or compacted soil is destructive and disruptive to soil microbes and creates a hostile, instead of hospitable, place for them to live and work.

The soil may also be disturbed chemically or biologically through the misuse of inputs, such as fertilizers and pesticides. This disrupts the symbiotic relationship between fungi, microorganisms and crop roots.

By reducing nutrient inputs, we can take advantage of the nutrient cycles in the soil to supply crop nutrients and allow plants to make essential associations with soil organisms.

Diversify with Crop Diversity

Sugars made by plants are released from their roots into the soil and traded to soil microbes for nutrients to support plant growth.

The key to improving soil health is assuring that the food and energy chains and webs includes as many different plants or animals as practical.

Biodiversity is ultimately the key to success of any agricultural system. Lack of biodiversity severely limits the potential of any cropping system and disease and pest problems are increased.

A diverse and fully functioning soil food web provides for nutrient, energy, and water cycling that allows a soil to express its full potential.

Above ground diversity = Below ground diversity
(plants) (soil food web)

Grow Living Roots Throughout the Year

There are many sources of food in the soil that feed the soil food web, but there is no better food than the sugars exuded by living roots.

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Healthy soil is dependent upon how well the soil food web is fed. Providing plenty of easily accessible food to soil microbes helps them cycle nutrients that plants need to grow.

Keep the Soil Covered as Much as Possible

Soil should always be covered by growing plants and/or their residues, and soil should rarely be visible from above. This is true regardless of land use (cropland, hayland, pasture, or range).

Soil cover protects soil aggregates from 'taking a beating' from the force of falling raindrops. Even a healthy soil with water-stable aggregates (held together by biological glues) that can withstand wetting by the rain may not be able to withstand a 'pounding' from raindrops.

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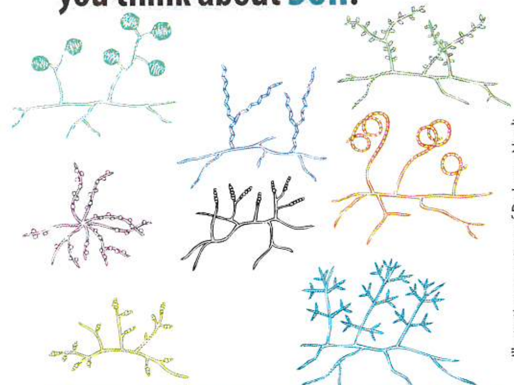
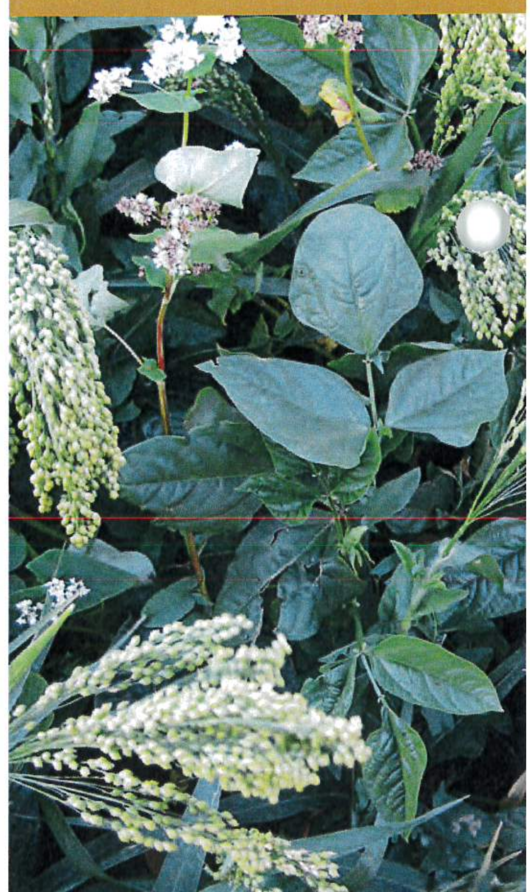
Drills, planters, seed, fertilizer, pesticides, livestock, fences, water, farm implements, etc. are all tools that can be used to manage the soil habitat for the benefit of living members of the soil food web.

Many soils have a water infiltration problem that causes a water runoff problem. If soil health is improved, the structure of the soil results in greater water infiltration, less runoff, less or no erosion, and reduced incidence of flooding and sedimentation.

Managing for Soil Health must begin by changing the way you think about Soil.



Illustrations courtesy of Dr. James Nardi, University of Illinois at Urbana-Champaign.



diversify with crop diversity

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Developed by the National Soil Health and Sustainability Team with contributions from North Dakota NRCS

Soil Health Stewards Action Plan: NORTH KINGSTOWN, RHODE ISLAND

Proposed Touchpoint	Proposed Action	Tasks for Completion	Proposed Timeline	Action(s) Taken (required)	Date (optional)	Action is Ongoing - Or One Time (required)	Approximate number of farmers, landowners, staff reached (required)	Approximate number of acres impacted (if you can delineate FRPP and non FRPP acres impacted, that would be awesome) (required)	Reflections of your experience (optional)
Conservation Commission	Share information about soil health.	Place soil health on an agenda of the commission. Provide training materials and resource information for the commission.	Nov-23	Presented training materials to the commission and shared resources on soil health.	9-Nov-23	One time	7 commission members	n/a	The commssion was very receptive and interested in soil health and this promted them to ask for more information. It is expected that this will be considered more in their recommendations moving forward.
Land Conservancy of North Kingstown and Narrow River Land Trust	Share information about soil health.	Share soil health training materials and resource information with both organizations; notify them of available soil health trainings	Jan-24	Becky has a contact with the land conservancy and is reaching out to them.	Current	Ongoing	Multiple staff	n/a	
Planning Commission	Share information about soil health.	Place soil health on an agenda of the commission. Provide training materials and resource information for the commission.	21-Nov-23	Presented training materials to the commission and shared resources on soil health.	21-Nov-23	One time	5 commission members	n/a	The commssion found the opportunity beneficial and was interested in the information presented.
Economic Development Advisory Board	Share information about the economics of soil health.	Place soil health on an agenda of the commission. Provide training materials and resource information for the commission.	Jan-24	We have had discussions with our Economic Development Principal Planner and staff liason for the EDAB. We feel it will be beneficial for board members to hear about the economic benefits of soil health practices. It will be presented to them at a meeting in the near future.	TBD	One time	7 board members	n/a	
.andowners with existing easements and potential easement holders	Share information about soil health.	Share soil health training materials and resource information with landowners: a. meet with landowners on site as appropriate b. web site repository c. targeted mailing	Feb-March 2024	Informational letters and fact sheets mailed. About 95 mailings sent to North Kingstown farmers, land owners and easement holders. The website has been updated to include information from the training, worksheets and resources. We are currently discussing meeting with landowners.	April 24, 2024 - Mailing May- Website update	Mailing and website - one time, Meeting with landowners - ongoing	Over 95 residents	n/a	We have not gotten feedback from the residents we sent mailings to, however we are glad we were able to gather information on who this information would be most helpful to and be able to share it with them. We hope it is considered and provided our contact information as well as a contact at NRCS should anyone have questions.
Residents of North Kingstown	Share information about soil health.	Share soil health training materials and resource information via a. municipal web site; b. information at the Planning Department counter; c. Allies Feed, Farm & Pet; and d. North Kingstown Free Library reference department.	Apr-24	Gathered fact sheets for repository. Brochures with information were available in the Planning Department. All brochures have been claimed. Documents have been shared with the llibrary and are available in the repository. We have collected the documents needed to share with Allie's. We are working on coordinating with them to get it there.	Completed over time	One time and ongoing	50+ residents	n/a	The brochures that were available in the Planning Department were gone very quikcly. The information has been on the Planning Department webpage which gets frequent visitors.
Area residents	Share information about soil health.	Attend local markets/fair/events; have soil health information available to distribute and communicate information to attendees	Summer 2024	Had a table at the Washington County Fair from 9 AM- 6 PM. Spoke with multiple residents from different areas of Rhode Island and had soil health documents and case studies to hand out. We also had the penetrometer available for people to try.	Fair: 16-Aug-24	One time at least, open to more.	10 to 15 attendees	n/a	Residents at the fair had some questions and we shared information with them about our opportunity to take part in the soil health stewards training. Many people were interested in the amount of preserved land we have in town.They were pleasantly surprised how much is preserved (about 8,000 acres).