# Lessons Learned from Assessing On-Farm Composting Operations in Connecticut

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For the 2024 Connecticut Compost Conference
March 14th, 2024

# USDA NRCS Conservation Innovation Grants

- NRCS works with farms to help conserve natural resources (primarily helping to improve soil and water quality)
- NRCS uses conservation practices that they have developed for these soil and water quality efforts
- The NRCS (formerly the Soil Conservation Service, or SCS) was developed in response to the Dust Bowl
- Early practices included strip cropping, crop rotation, diversions, etc. to help reduce soil erosion
- NRCS provides farms grants (referred to as “cost shares”) to help farms implement NRCS practices

# USDA NRCS Conservation Innovation Grants

- Conservation Innovation Grants are research/pilot project-oriented grants designed to potentially develop new practices that farms could use to further the goal of protection natural resources
- Northern Tilth, LLC is a Technical Service Provider (TSP) working with farmers that are cooperating with the NRCS.  Currently Northern Tilth is a certified TSP for developing Nutrient Management Plans, Soil Health Management Plans and Grazing Management Plans
- Northern Tilth has received four CIGs, one each for the states of Vermont, New Hampshire, Maine and Connecticut working on phosphorus reduction practices, reducing PFAS plant uptake on PFAS-impacted fields and composting

# Northern Tilth - CT - USDA NRCS Conservation Innovation Grants

- Current CT NRCS grant is investigating the effectiveness of providing technical support to farms with On-Farm Composting operations to help improve the outcomes of these operations, especially in relation to protecting soil and water quality
- A successful outcome (other than providing assistance to the farms participating in this CIG) would be a cost-share practice that NRCS would provide to farms to have TSPs provide this kind of composting technical assistance
- For this project, Northern Tilth found six Connecticut farms with on-farm composting operations, at various levels of experience and refinement, to work with over two field seasons to improve composting operations.
- Work included a thorough on-site assessment (with Dr. Bill Seekins from the University of Maine's Compost School) with extensive interviews and testing of compost and compost feedstocks. Northern Tilth then provided recommendations for improving operations and has been following regularly with site visits, monitoring logs and continued analyses.

# Organic Matter Transformations; Fate of Carbon

*Approximately 2/3 carbon in biomass → $CO_2$*

Photosynthesis captures $CO_2$ from the atmosphere and converts it to biomass

$6\ CO_2 + 12\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$

Plants die, we poop and create other organic matter-based by-products→ non-living biomass ends up on and in the soil (when it does not go to a landfill)

Organic C
(energy source)

Microbial Biomass

**Stable Soil Carbon**

# Impact of Processing Organic Wastes on Carbon

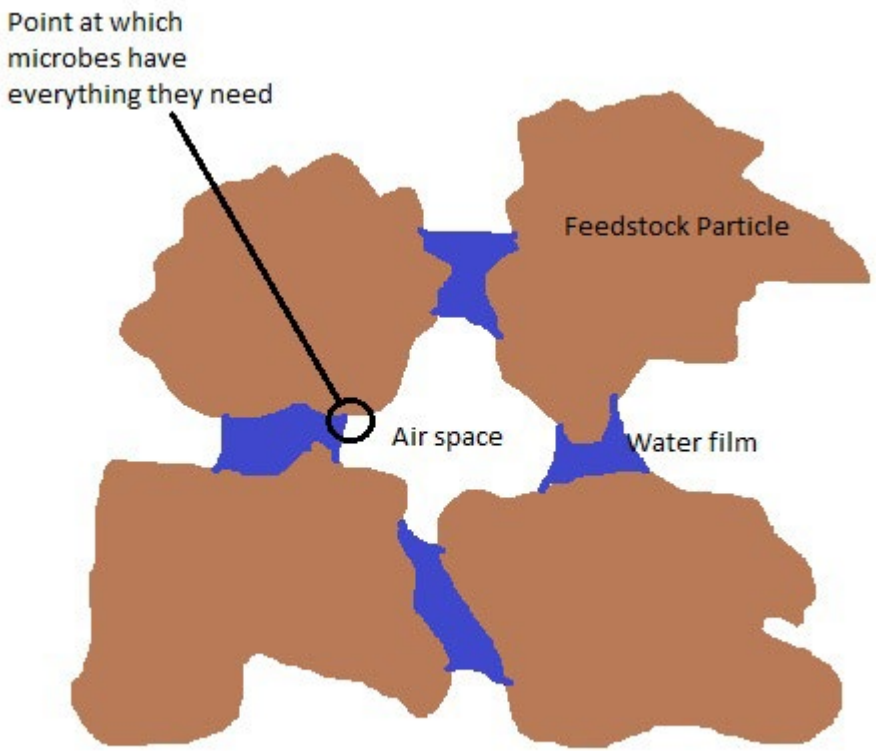
- Land application of unprocessed organic waste → microbial oxidation in soil → approximately 2/3 carbon leaves the soil as $CO_2$

- Composting → microbial oxidation, $CO_2$ evolution, and conversion to stable carbon occurs prior applying to the land, but ultimately carbon storage in soil from initial feedstocks is likely similar to direct land application

- Anaerobic digestion → conversion of some readily available organic carbon to methane occurs prior applying to the land → captured some energy in the organic carbon bonds, but ultimately the amount sequestered is likely similar to that from direct land application

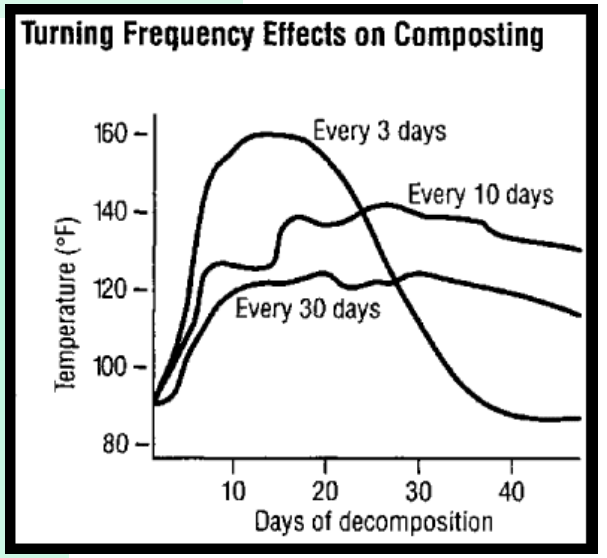
- Pyrolysis → conversion of organic carbon to graphite-like structure → when applied to soil potential to increase % carbon sequestered in soil

# Composting Basics - Managing the Microbes




- In order to drive the conversion of fresh organic matter to mature compost, microbes have the same basic requirements we do:
  - Oxygen
  - Water
  - Food – the correct ratio of Carbon to Nitrogen
- Additionally, microbes need these factors to be in correct range:
  - pH
  - Temperature
  - Volatile solids

# Managing the Microbes – Moisture & Oxygen



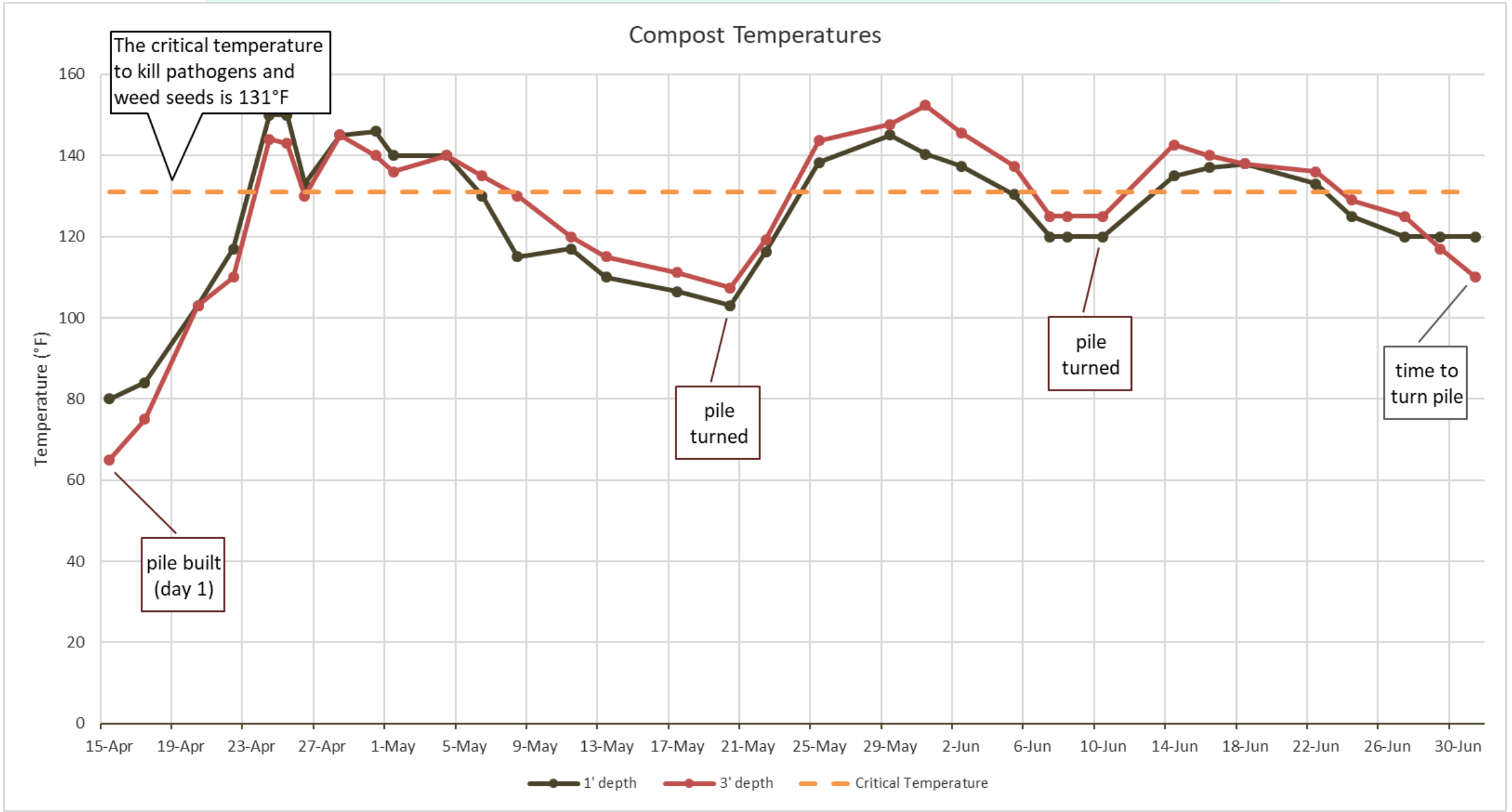

- Moisture
  - 50-60% is optimal moisture content for compost piles
  - Squeeze test
- Oxygen
  - 5-10% is optimal oxygen content of the pile (air is 20%)
    - Too little, microbes can't breathe.  Too much air, the pile is too porous.
  - Particle size – a mix is best
  - Bulk density
  - Turning
  - Can tell if pile is getting enough oxygen based on temperature

# Managing the Microbes – Carbon & Nitrogen

## Microbes need the correct balance of carbon & nitrogen in their diet

- Ratio of 20:1 to 30:1 is ideal
  - If too much carbon, the process will proceed very slowly
  - If too much nitrogen, ammonia will be lost in the process
- Correct ratio achieved by mixing feedstocks
  - High carbon examples:  hay, sawdust, leaves
  - High nitrogen examples:  manure, food waste, green grass

# Temperature Monitoring and Windrow Composting



# Trial and Error

- Compost theory will only get you so far
- Composting is a sometimes mystifying alchemy of biology, chemistry and physical properties
- Your own experience with compost recipe development and pile management from trial and error can be as valuable, if not more so, than what you can learn in books, classes or from me.
- When blending new recipes to help troubleshoot problems, make big changes, as opposed to subtle ones, in order to help determine the root cause of your problems.
    - For instance, if you have a 2:1 blend of wood chips to chicken manure and you suspect the porosity is too low, try a small batch of 4:1, instead of trying 2.5:1. Even if this won't be your long-term recipe, if it works it will give you information about what you need to change.

# What is the goal of your operation?

## Material Management

Managing a wet material

Facilitating spreading of heterogeneous material

Pathogen reduction for use in food production

Managing mortalities at livestock operations

Avoiding nitrogen tie-up in a carbonaceous material

# What is the goal of your composting operation?

High quality compost product for general distribution, either bagged or in bulk

Photo from BioCycle Magazine

# What is the goal of your operation?

- Economic models for composting vary greatly
  - **Tip fee-based**
  - **Finished product sales-based**
  - **Many are a hybrid of the two**

# Farm 1

- Beef operation
- Newly constructed NRCS bedded pack with compost bins at far end
- Original idea for farm to compost bedded manure and scrape alley manure in bins
- **Findings and Recommendations**
  - Without aeration, three sided bins are not a good setup for composting
    - No air going through the piles
  - Farm was most interested in managing manure; manure is applied on surrounding cropland → no need for composting

# Is composting the best option to achieve your goals?

Nitrogen and Phosphorus Balance in Organics

Chicken manure, for example

- 21# plant-available N per wet ton
- 38# plant-available $P_2O_5$ per wet ton
- Most crops use approximately 1 unit $P_2O_5$ for every 2 units of nitrogen

- During the composting process, phosphorus content does not change significantly, but plant-available nitrogen is reduced, consequently, the imbalance between nitrogen and phosphorus relative to crop uptake is exacerbated.
- From the standpoint of replacing fertilizer, nitrogen is a more critical need than phosphorus

# Farm 2


- Horse Boarding and Training Center
- Recently constructed 3-bin covered, aerated static pile NRCS-build system (this is a Cadillac for an NRCS composting project)
- Goal was to better manage bedded horse manure


# Farm 2

- **Findings and Recommendations**
  - Compost feedstocks were too dry for ideal composting conditions
  - Carbon to nitrogen ratio was a little higher than ideal
  - Easily achieved high temperatures, but the finished compost was not thoroughly broken down
  - Aeration timer was set to kick on only when compost temperatures got over 160 $^{o}$F
  - Added moisture to piles and added some supplemental nitrogen
  - Changed aeration timer to pulse on a regular basis
  - Improved composting, but significant additional input of labor
  - Because the composting operation and sales of the finished compost is not a priority for the farm (true with many farms), it may be the case that this material would be a good feedstock for a nearby composting facility

# Farm 3

- Piggery and food waste collection operation
- Historical fit between collecting food waste and raising pigs
- Large composting mass, turned at front end, but slow cooking after the first few months
- Farm already has a thriving market for their finished compost


# Farm 3

- **Findings and Recommendations**
  - **Good current blends → getting up to temperature quickly**
  - **Need more diligence on maintaining high temperatures when composting pig manure**
  - **Incorporating soil from earthen pad into compost, is slowing down the composting process**
  - **Investigating the switch to a windrow composting operation on a concrete or asphalt pad in order to improve aeration and reduce the amount of soil unintentionally introduced to the compost**

# Farm 4

- Diversified Livestock, Vegetable Operation and many other farm-related activities
- Windrow composting of bedded manure (beef, hogs, goats, chickens), mixed with leaves and  wood chips (from local landscaping operations, food waste and biomass from vegetable operation




# Farm 4

- **Findings and Recommendations**
  - **Compost windrows not coming up to temperature**
  - **Mixing of soil with the bedded manure has been the biggest constraint.**
    - **Manure is collected by scraping off of earthen surfaces**
    - **The unintentionally added soil increases bulk density which impedes air movement through the piles and slows down biological activity**
  - **Built trial piles, tweaking the current recipe to improve aeration (lower bulk density) and provided instructions for turning schedule based on temperature monitoring**
  - **This farm will be building a bedded pack for the animals which will reduce soil incorporation into the compost feedstocks**


# Farm 5

- Medium-sized dairy operation
- Long-term composters with a very good market for the finished compost
- Selling in bulk and bagging, with a compost delivery service
- Inputs include primarily bedded dairy manure and leaf and yard waste from surrounding towns


# Farm 5

- **Findings and Recommendations**
  - **Already making very high quality compost**
  - **Feedstock mix is good**
  - **Could improve turn-around time, which will reduce space requirements, by temperature monitoring and turning schedule based on fluctuating pile temperatures**

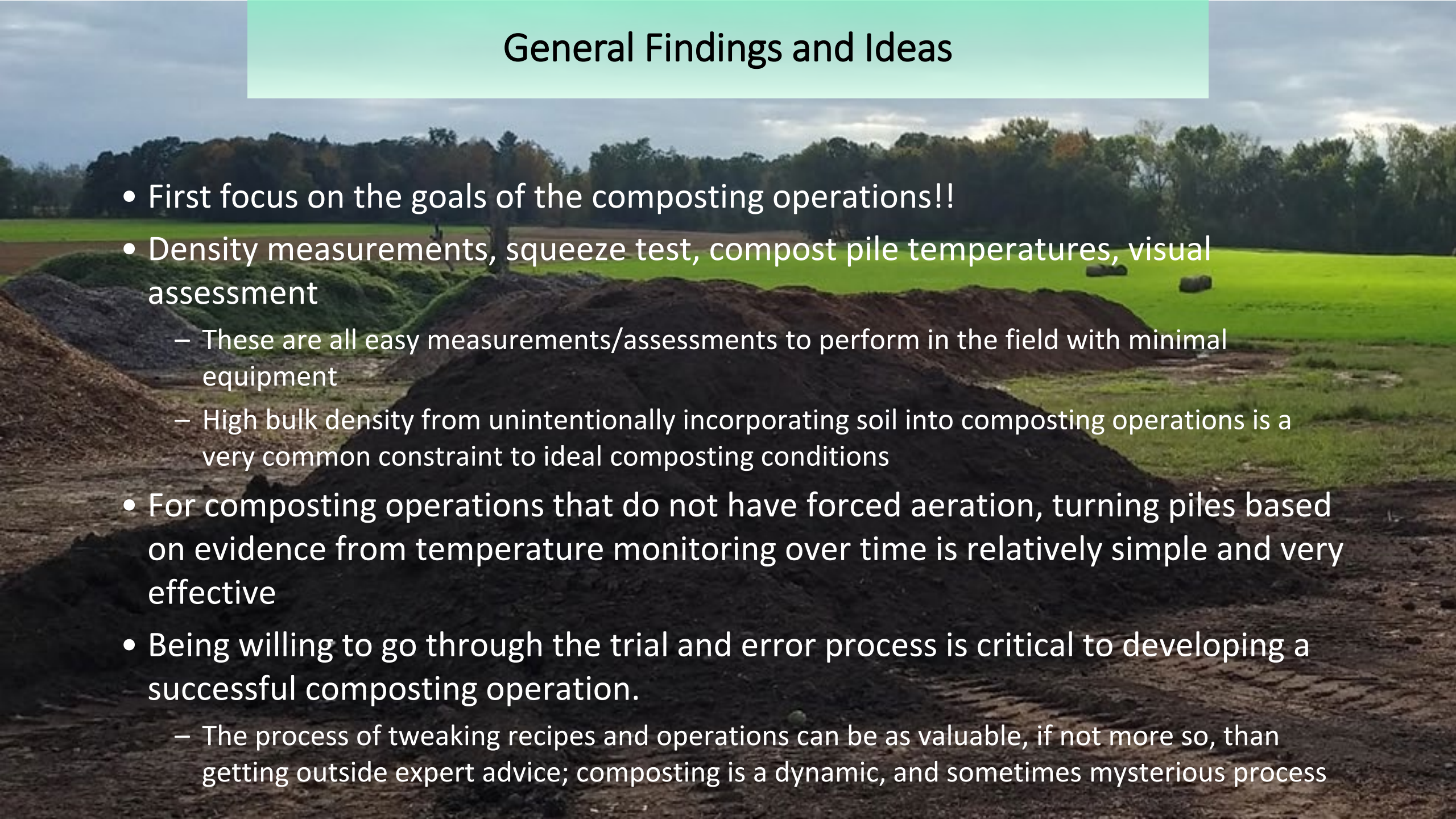
# Farm 6

- Large family-run dairy managing mortalities through composting, which is currently considered the most environmentally sound method for mortality management
- Mortality compost area, as is often the case, was located in a remote area on the farm and received minimal management
- While the composting was working to manage mortalities, the process took a long time and was causing some resource concerns downslope of the piles.


# Farm 6

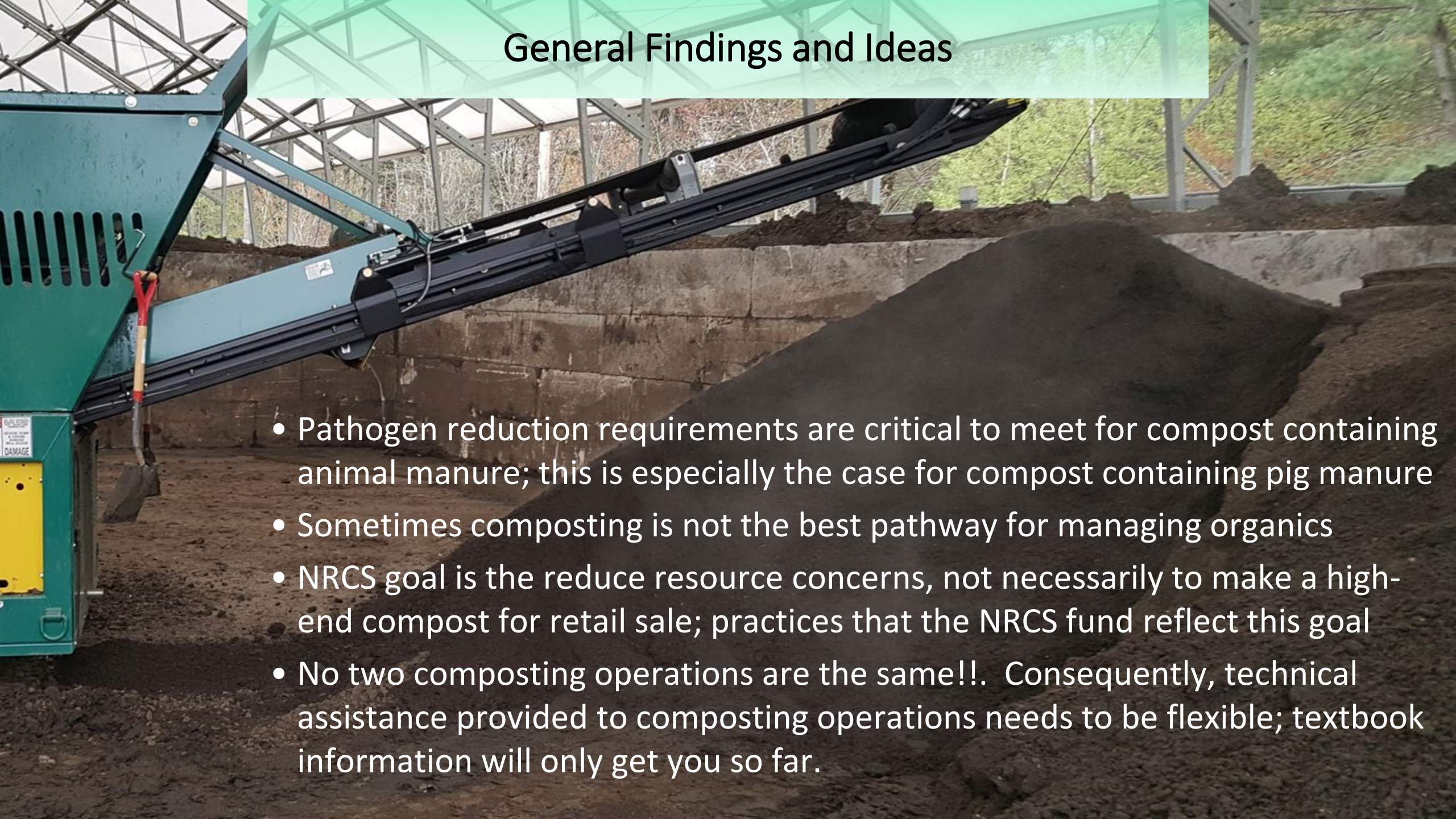
- **Findings and Recommendations**
  - **Recommended moving the location of the piles to reduce resource concerns and tweak the recipe to provide a better moisture and C:N balance**
  - **Based on the success of the changes, and based on further trial and error by the farm has significantly grown the composting operation and is now selling a very high quality, finished compost in bulk**

# General Findings and Ideas



- First focus on the goals of the composting operations!!
- Density measurements, squeeze test, compost pile temperatures, visual assessment
  - These are all easy measurements/assessments to perform in the field with minimal equipment
  - High bulk density from unintentionally incorporating soil into composting operations is a very common constraint to ideal composting conditions
- For composting operations that do not have forced aeration, turning piles based on evidence from temperature monitoring over time is relatively simple and very effective
- Being willing to go through the trial and error process is critical to developing a successful composting operation.
  - The process of tweaking recipes and operations can be as valuable, if not more so, than getting outside expert advice; composting is a dynamic, and sometimes mysterious process

# General Findings and Ideas



- Pathogen reduction requirements are critical to meet for compost containing animal manure; this is especially the case for compost containing pig manure
- Sometimes composting is not the best pathway for managing organics
- NRCS goal is the reduce resource concerns, not necessarily to make a high-end compost for retail sale; practices that the NRCS fund reflect this goal
- No two composting operations are the same!!. Consequently, technical assistance provided to composting operations needs to be flexible; textbook information will only get you so far.


***Big Thank you to all participating farms and the CT NRCS!!!***

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