

SESSION III  
...  
**Managing  
Soil Nutrients**

*What will be covered in Session III:*

**Minimizing Environmental Risks  
Through Nutrient Management**

LESSON 1: Managing the Plant and Soil Ecosystem

LESSON 2: Potential Environmental Risks on Your Farm

LESSON 3: N- or P-Based Management and Manure Spreading Restrictions

**Terms to Learn**

- mineralization
- tith
- compaction
- farm nutrient balance
- dominant soil
- nitrogen leaching index
- N- or P-based management
- manure spreading restriction

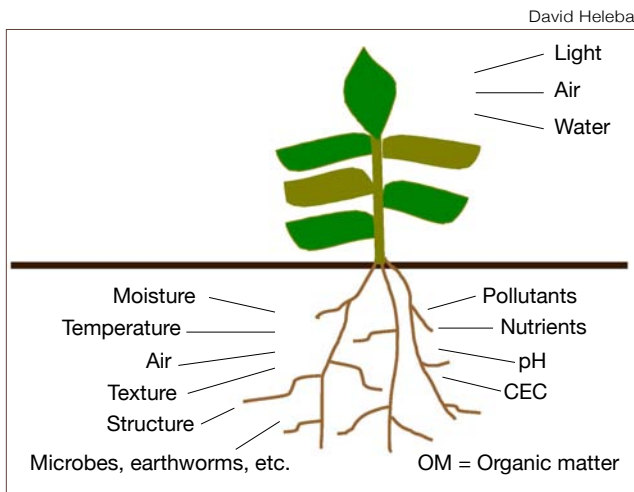
**Exercises**

1. Farm Nutrient Balance
2. Risk Assessment Worksheet
3. Checklist

## LESSON III-1

### Managing the Plant and Soil Ecosystem

**P**lants and soil form a complex ecosystem. In terms of nutrient management we have focused primarily on managing individual nutrients such as nitrogen, phosphorus, and potassium. It is important that farmers understand that soil fertility management goes beyond just managing these nutrients. This lesson will help give you a broader understanding of soil fertility as it exists within the context of the plant and soil ecosystem.



*There are many variables integrally involved in sustaining a plant.*

Soil fertility is defined as the ability of a soil to provide a physical, chemical, and biological environment for plants that is health-sustaining. In order for farmers to maintain soil fertility there are six basic principles to achieve:

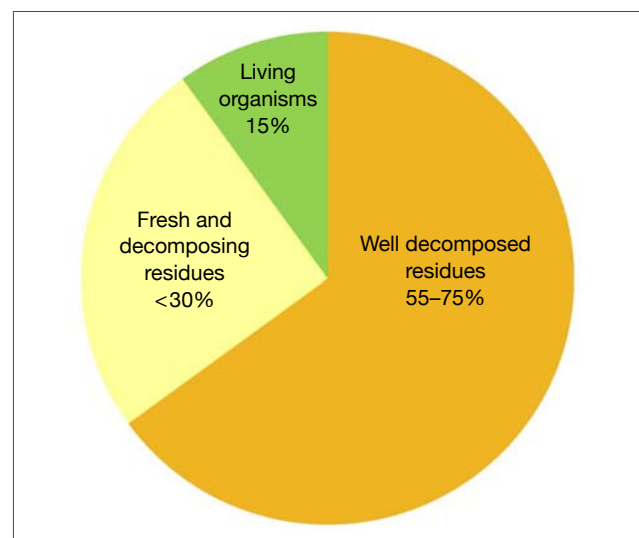
- Soil organic matter levels
- Biological activity
- Soil tilth
- Minimal or no erosion
- Proper soil pH
- A balance of nutrients

We will describe these principles of soil fertility and demonstrate how they are critical to supporting the plant and soil ecosystem.

### What's the Big Deal About Organic Matter?

Soil fertility and many of its principles are profoundly influenced by soil organic matter (SOM). Soil organic matter is the portion of soil that is derived from decomposing plants and animals. For example, when you plow down a grass field, the leaves and roots become part of the SOM. The soil organic matter is composed of several different fractions including the living organisms, the fresh residues, and the decomposed residues.

**Living Organisms.** Living organisms make up about 15% of the soil organic matter. The living portion of soil includes earthworms, insects, bacteria, fungi, plant roots, and animals such as voles and moles. These organisms help break down freshly added plant residues, manures, and other organic debris. In the process of breaking down the debris, the organisms obtain energy and nutrients and release nutrients that become available for plant uptake. This process of nutrient release is called *mineralization*. These organisms also play a role in soil aggregation and disease suppression. These functions will be addressed later.



*Composition of soil organic matter.*

**Fresh and Decomposing Residues.** The fresh and decomposing residues are another fraction of the SOM. In most soils these residues consist of 30% or less of the organic matter. Fresh residues include partially decomposed once-living organisms. These residues are generally no more than three years old. Again, as these fresh residues are decomposed by living organisms the nutrients in the fresh residues are digested. In the process, some nutrients are released to surrounding living organisms (mineralization). The relative speed of decomposition of these materials is related to the carbon to nitrogen ratio of the fresh residues added to the soil. Residues that have a high carbon to nitrogen ratio (C:N) can be slow to decompose. This is because the microorganisms require additional nitrogen to decompose the high carbon materials. Often times these amendments will result in the microorganisms “tying-up” nitrogen that would have otherwise been available to the crop. Generally, residues with a C:N ratio of 20:1 or less have enough available nitrogen for rapid decomposition. In addition, the decomposition of fresh residues will also contribute to improving soil tilth.



*Decomposing organic residues provide food for soil organisms.*

**Well Decomposed Residues.** The well decomposed residues make up the majority of the soil organic matter (75 to 80%). As you might have guessed, the well decomposed residues were at one time living organisms. These residues have been thoroughly decomposed to unrecognizable carbon compounds. Essentially, these compounds are no

longer considered food for the living organisms in the soil. This fraction of organic matter carries a negative charge and is considered essential for other soil functions including the cation exchange capacity. These residues are anywhere from five to thousands of years old.

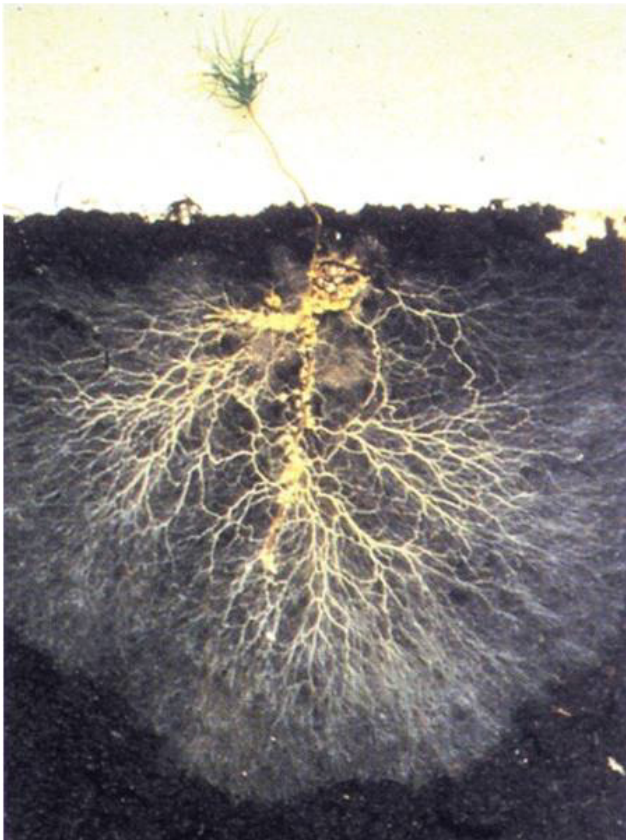
### Fertility Principle 1 — Maintaining Soil Organic Matter Levels

It is critical to maintain sufficient levels of organic matter in the soil. This can be a difficult task for some farms and requires a diversified approach. Essentially, organic matter can be maintained through additions of a variety of types of organic matter while simultaneously decreasing losses of organic matter from the system. On dairy farms the primary organic matter addition is manure. Other organic matter additions can occur from cover crops and crop residues. Even farms with a readily available source of organic matter must work to reduce losses of organic matter from the cropped fields. For example, crop rotations that include perennial hay crops will reduce organic matter losses. Hay crops keep the soil from eroding and also do not require tillage. Aggressive and continuous tillage will reduce organic matter levels in soil. Lastly, it is important to remember that applying organic matter also adds nutrients to the soil. Therefore we must add organic matter in a manner as to not over-apply nutrients such as phosphorus. The SOM has a significant influence on several of the other physical and biological aspects of soil fertility.

### Fertility Principle 2 — Maintaining Soil Biological Activity

The second principle of soil fertility is to maintain biological diversity in the soil. The soil food web consists of a multitude of organisms that range in size but rely heavily on each other for survival. A biologically diverse soil can have up to 100,000 different types of living organisms.

The biology in the soil has many important functions that make it possible to have healthy plants and clean water. The primary activity of most soil organisms is to grow and reproduce. Soil organisms depend on interactions with each other to survive.



*Mycorrhizae are symbiotic associations between fungi and plant roots. The mycorrhizal fungus colonizes plant roots and allows the plant access to more nutrients.*

The by-products that come from roots and fresh residues feed the soil organisms. In turn, the soil organisms will support plant health as they decompose organic matter, cycle nutrients, hold nutrients, degrade pollutants, improve soil structure, and control populations of crop pests. Earthworms, for example, break down large pieces of plant residues into smaller pieces for other soil organisms. Earthworms also burrow through soil providing lots of air channels for root growth. Lastly, earthworms secrete a mucigel as they burrow through the soils. This mucigel is one of the ingredients that help the soil bind together.

### Fertility Principle 3 — Maintaining Soil Tilth

The next fertility principle is to maintain soil *tilth*. Soils in good physical condition are considered to have good tilth. This means the soil is porous and allows easy infiltration of water and penetration of roots. The pore space is created by aggregated soil. Soil aggregates are formed when soil particles (sand, silt, clay) become glued together with organic matter, soil organisms, and plant roots. The glue that holds all of this together come from the plants’

## CARING FOR YOUR SOIL LIVESTOCK

To increase and maintain the diversity of organisms in the soil we must take care of the soil “livestock.” Similar to feeding our cows, soil organisms require energy, protein, water, oxygen, and a proper habitat. We can provide these key diet ingredients by adding a diversity of organic residues. It is probably obvious from the previous section that adding fresh organic residues to the soil will feed the soil life. However, different soil organisms require slightly different foodstuffs. For example, fungi are common decomposers of plant residues because they generally have large amounts of hard-to-decompose carbon. Bacteria are generally more abundant on green litter of younger plants because they con-



*Earthworms are one of the most visible soil organisms and are often used as indicators of a healthy soil.* Credit: US Composting Council

tain more simple carbon compounds. The bacteria and fungi are only able to access plant residues after shredder organisms, such as earthworms, break residues into smaller chunks.

Oxygen and air space can be provided by implementing practices that foster good tilth. Soil organisms do not grow well in compacted soils that contain little air space. Growing a variety of plants species can also

create diversity of soil life. The plant roots of different organisms attract different microorganisms. The take home message is to treat your soil livestock like you would your own animals. Think about what practices will not only provide adequate food, but a healthy home for the animals that lie beneath your feet.

roots and soil microorganisms. These aggregates come in all shapes, sizes, and levels of stability. The placement of aggregates in the soil ecosystem forms the soil structure. The space between the aggregates allows room for air and water. Therefore these soils have fewer issues with erosion and runoff. These porous soils also have ample air space. Roots and microbes require oxygen and open exploration of the soil for optimum growth. The ample pore space allows plant roots to explore the soil and access nutrients freely. Stable aggregates are preferred as they can resist stress that might afflict the soil. For example, a soil that is well aggregated can resist rainfall, harsh tillage, and compaction.

The problems start when these aggregates are broken and remaining soil particles are squished together. We refer to this as **compaction**. Once the pore space is eliminated it is difficult for roots to grow properly and for microbes to survive. Compaction also keeps the soils water logged, resulting in anaerobic losses of nutrients. Essentially, nutrient cycling is severely limited without proper pore space.

There are three types of compaction that we observe on farms: surface, plow layer, and subsoil compaction. Surface compaction is common in annually cropped fields. Surface crusting occurs when soil is unprotected by surface residue, and raindrops disperse the aggregates by smearing them together into a thin layer of soil. Surface compaction can inhibit the germination of crops and increase the chance of erosion runoff.

Plow layer compaction is also common in our fields. The causes of plow layer compaction are ero-



*Soil compaction is a common problem in Vermont fields.*

sion, reduced SOM levels, and heavy field equipment. Fields that are too wet for tillage are prone to this type of compaction.

Subsoil compaction occurs below the normally tilled surface layer. Subsoil is easily compacted because it is commonly wetter and more dense than the topsoil. This compaction occurs when a tillage implement applies pressure to the subsoil or when heavy equipment with poor weight distribution is run over the surface of the soil. Compaction is always most severe on wet soils.

Certainly the goal of a farmer should be to implement practices that maintain and improve soil tilth. Maintaining soil tilth first requires the addition of various types of organic matter to the soil. This organic matter increases the biological activity of the soil, resulting in the glues that form aggregates. These aggregates create ample pore space to allow for root, air, and water movement in the soil. Organic matter additions can help reduce the chance of surface and plow layer compaction. It is also important to maintain soil tilth through tillage. Tillage can be a detriment to soil tilth but also can be beneficial in alleviating soil compaction. Reduced tillage can increase SOM and reduce traffic on the fields. It is important to work the soil when it is at proper moisture. One rule of thumb is to roll some soil into a ball and drop it on the ground. If it breaks apart when dropped it is a signal that the soil is dry enough to be worked.

### **Fertility Principle 4 — Preventing Erosion**

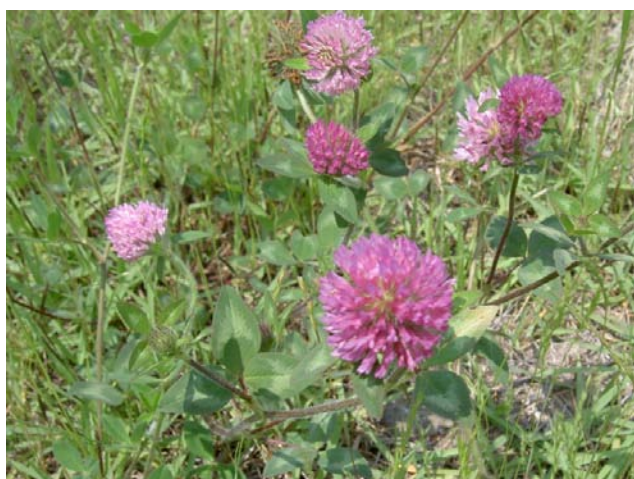
When managing fertility it is important to reduce nutrient losses to the environment. Erosion is a principle mechanism by which valuable topsoil is lost from agricultural fields. Eroding soil generally has nutrients attached to it. As this soil is moved and deposited, valuable nutrients and organic matter are removed from crop fields. It is important to reduce or eliminate erosion to keep nutrients and organic matter on the field. Ways to reduce erosion from agricultural fields include reducing the speed of water or wind and keeping the soil in a condition that will resist the impact of rain and wind.

There are many practices that can be implemented to control erosion that will not hinder plant

productivity. First, keep the soil covered with plant material as much as possible. For example, there is a greater chance of losing soil from a row crop than from a perennial grass crop. The grass crop holds the soil in place and the leaves can provide more coverage of the bare soil. In row crop systems, cover crops can be grown to protect the soil from erosion during the fall and winter months. Reduced tillage can also reduce erosion. When the soil is turned with a moldboard plow more bare soil is exposed, making it susceptible to erosion. Reduced or no-tillage options will leave more plant residue on the soil surface. However, in the case of corn silage, where the whole plant is removed, there is minimal residue, even with no-tillage. Cover cropping will need to be implemented in order to have enough residue to protect against erosion. The residue can absorb the impact of rain droplets and improve soil infiltration. In general, soils with higher levels of organic matter and good structure are less prone to erosion. The organic matter helps to create good soil tilth. These soils are better able to absorb rainfall because they have more pore spaces to allow for water flow through the soil.

### Fertility Principle 5 — Maintaining a Proper Soil pH

Next we must remember to maintain the soil pH. It remains true that spending money on lime is probably the biggest bang for your fertilizer buck. A neutral soil is at a pH of 7. An acidic soil would fall



*Legumes such as this red clover are an important part of a crop rotation.*

### CREATING BIODIVERSITY

It is important to increase biodiversity above and below ground. Above-ground biodiversity can both enhance soil characteristics and help control pest populations. When crops are grown in monoculture there is a better chance of significant pest outbreaks. The living organisms above ground can play an important role in pest management. To encourage beneficial insects above ground we must provide them with a diversity of food and a proper home. Generally these requirements can be met by making sure that there is more than one crop growing in an area. This can be done by planting biological or ecological islands; habitat and food for beneficial organisms; biostrips, flower strips, beetle banks, strip insectary intercropping, vegetative corridors, or hedge rows. It can also be accomplished by planting a diversity of crops on the farm. Lastly, the judicious and careful use of pesticides is important to minimize harm to beneficial organisms.



*Hedgerows provide habitat for many beneficial insects that help control pests.*

below 7 and an alkaline pH would rise above 7. The pH can highly influence the nutrient availability in the soil. Most crops prefer a pH between 6.0 and 6.8. Some crops such as alfalfa prefer a pH of 6.8. This crop will perform poorly when the pH falls below 6. Some of this sensitivity is due to the fact that legumes generally form an association with a special type of bacteria. The bacteria have the ability to fix atmospheric N into plant-available N. These bacteria require a soil pH of 6.0 to survive. Molybdenum, which is necessary for nitrogen fixation in legumes, is more available at a more basic pH.

## Fertility Principle 6 — Maintaining a Balance of Nutrients

The last principle of soil fertility is to balance the nutrients needed by plants while reducing their impact on the environment. This probably sounds familiar, as it is the primary goal of nutrient management. The goal is to provide what the crops require while being careful not to over-apply various nutrients. This is difficult to achieve, especially when manure is used as a nutrient source. We want to make sure that nutrients added to the soil do not become environmental hazards.

Hopefully from this session you have learned that there are many factors that affect soil fertility. It is not as easy as just maintaining N-P-K. Careful management of the soil's biological, physical, and chemical properties will provide optimum crop production.

### CHARACTERISTICS OF HEALTHY SOIL

Farmers usually know when a soil is healthy by its ability to grow healthy crops. Healthy soils have the following characteristics:

- Good soil tilth
- Sufficient depth
- Sufficient but not an excessive supply of nutrients
- Small populations of plant pathogens and insect pests
- Good soil drainage
- Large populations of beneficial organisms
- Low weed pressure
- No chemicals or toxins that may harm the crop
- Resistance to degradation
- Resilience when unfavorable conditions occur

## THE CORNELL SOIL HEALTH TEST

While traditional soil tests measure the chemical properties of soil such as pH and nutrient levels, it is well accepted that biological and physical properties also play an important role in soil's ability to grow crops. This more holistic approach to looking at soil has been called "soil health." Soil health (or soil quality) can be defined as the capacity of a soil to function within ecosystem and land use boundaries, to sustain productivity, maintain environmental quality, and promote plant and animal health (Doran and Parkin, 1994).

Since 2001, Cornell University has been developing a test to measure soil health. Twelve indicators of biological, physical, and chemical soil properties are used to make a comprehensive assessment. Some

of these indicators include: available water capacity (a measure of the ability of crops to store water between rains), aggregate stability (a measure of how well soil aggregates hold together in rain and resist surface crusting), and active carbon (a measure of the soil organic matter fraction that is available as a food source for microorganisms). The test results show how your soil compares with more than a thousand soil samples that have been submitted from the northeastern United States.

The procedure for submitting a soil sample for the Cornell soil health test is somewhat different than for traditional soil tests. First of all, the sample should be taken in the spring before the ground is tilled. If you are

interested in submitting a sample from your farm, you will need to borrow a special piece of equipment called a penetrometer (or soil compaction meter) as measuring field compaction is part of the test. Biological properties are very sensitive to changes in temperature, thus, the sample must be kept refrigerated until it is submitted. It is important to follow the sampling instructions carefully or to get help from someone with experience taking soil health samples in order to obtain meaningful results.

Because of the wide array of tests that are performed on each sample, the soil health test is more expensive than a standard chemical soil test. The current cost of a soil health test is \$45 per sample (2008 price). Because of the cost, it is most economical to target specific "problem areas" on the farm for sampling and compare them with "good areas." The test will identify constraints on plant growth that exist for a particular soil, but will require interpretation to determine the best management strategies for dealing with constraints.

For more information on the Cornell soil health test, visit the following website: [www.hort.cornell.edu/soil-health](http://www.hort.cornell.edu/soil-health).

CORNELL SOIL HEALTH TEST REPORT				
FARM NAME/FARMER:		SAMPLE ID: E415	DATE: 5/15/2007	
ADDRESS:		E-MAIL:	PHONE:	
FIELD/TREATMENT: RIVER FIELD		AGENT: Heather Darby - UVM Extension	SLOPE: 0-2%	
TILLAGE:		DRAINAGE: EXCELLENT	SOIL SERIES:	
CROPS: GRT/GRT/GRT		SOIL TEXTURE: SANDY	ONDAWA FINE SANDY LOAM	
INDICATORS	VALUE	RATING	CONSTRAINT	PERCENTILE RATING*
PHYSICAL	Aggregate Stability (%)	45.2	10.0	
	Available Water Capacity (m/m)	0.16	7.0	
	Surface Hardness (psi)	233	1.0	rooting, water transmission
	Subsurface Hardness (psi)	280	4.0	
BIOLOGICAL	Organic Matter (%)	1.6	1.0	energy storage, C sequestration, water retention
	Active Carbon (ppm)	370	1.0	soil biological activity
	Potentially Mineralizable Nitrogen (µgN/gdwsoil/week)	7.1	6.0	
	Root Health Rating (1-9)	2.5	9.0	
CHEMICAL	pH (see CNAL Report)	6.6	10.0	
	Extractable Phosphorus (see CNAL Report)	4.0	5.0	
	Extractable Potassium (see CNAL Report)	35	3.0	
	Minor Elements (see CNAL Report)		10.0	
OVERALL QUALITY SCORE (OUT OF 100)		MEDIUM		55.8
Ratings on this report are based on generalized crop production standards for New York. For crop specific nutrient interpretation and recommendation, see the attached chemical test report.				

The Cornell soil health report uses a stoplight system to show how your soil compares with other soils of similar texture. Red indicates problem areas.

## EXERCISE III-1

### Farm Nutrient Balance

**N**ext we will calculate crop nutrient removal rates in order to determine if there is enough crop need for the amount of manure nutrients produced on your farm. You will be using Table 19 which can be found on page 66.

In the example below, the farm grows 150 acres of corn grain and has an average yield of 120 bushels per acre. From Table 19, we can find the nutrient removal rate (or nutrient need) per bushel of grain corn (nitrogen 0.75 lbs./bushel, phosphorus 0.4 lbs./bushel, potassium 0.3 lbs./bushel). Note that the units are different for different crops. The total nutrient need for each crop grown on the farm will be automatically calculated and totaled. In Session II you calculated the nutrients that are available from manure, and those values will automatically fill in the "Manure Supplies" row.

Now we will look at the most important part of the worksheet — the balance. If the number is positive, this means that you have enough crop need to account for the nutrients in your manure. If the number is negative, it will show up in red and this indicates that you have too much manure for your land base. You will need to export some of your manure so that you are in compliance with state regulations.

Farm Nutrient Balance (Based on Crop Removal Rates)									
Yield X Acres X lbs of nutrients removed per unit of yield = Total Nutrient Need									
Crop Removal Rates can be found on Table 19 in "Nutrient Recommendations For Field Crops in Vermont".									
(See Appendix for Table 19 data)									
Producer: Joe Farmer			Farm Name: Green Valley Farm				2009		
Crop	Yield per Acre	Acres	Nitrogen		P <sub>2</sub> O <sub>5</sub>		K <sub>2</sub> O		
			lbs/unit	Total Need	lbs/unit	Total Need	lbs/unit	Total Need	
corn grain	120	150	0.75	13,500	0.4	7,200	0.3	5,400	
corn silage	20	10	9.0	1,800	5.0	1,000	11.0	2,200	
soybeans	40	60	3.2	7,680	1.0	2,400	1.4	3,360	
alfalfa	5	40	50.0	10,000	15.0	3,000	50.0	10,000	
grasses	4	140	40.0	22,400	15.0	8,400	50.0	28,000	
small grains	80	40	1.1	3,520	0.9	2,880	1.5	4,800	
<b>Total Crop(s) Need:</b>				58,900		24,880		53,760	
<b>Manure Supplies:</b>				Use Manure NutValue Worksheet*		10,775		10,856	27,140
<b>Balance:</b>				Estimated Nutrients Needed <i>(Negative # indicates excess)</i>		48,125		14,024	26,620
*Use the figures from the sheet "Estimate of Manure Nutrients Available for Crop Production" in the Manure Production section.									
<b>Does this Balance indicate that you have the land base needed for appropriate application of the volume of waste that your farm produces?</b>									
yes									
Remember to fill out this box. A one word answer is sufficient. If all of your balances are positive, then your answer should be "yes."									

## Typical crop nutrient removal.

(Table 19 from *Nutrient Recommendations for Field Crops in Vermont*)

Crop (units)	Per unit of yield			Typical yield/A	Removal for given yield		
	N	P <sub>2</sub> O	K <sub>2</sub> O		N	P <sub>2</sub> O	K <sub>2</sub> O
Corn (bu)	.75	0.4	0.3	120 (bu)	90	50	35
Corn silage (T) <sup>4</sup>	9	5	11	20 (T)	180	100	220
Grain Sorghum (bu)	0.5	0.6	0.8	120 (bu)	60	70	95
Forage Sorghum (T) <sup>4</sup>	9	3	10	15 (T)	135	45	150
Sorghum/sudangrass <sup>4</sup>	8	7	7	15 (T)	120	105	105
Alfalfa (T) <sup>2,5</sup>	50 <sup>1</sup>	15	50	5 (T)	250	75	250
Red clover (T) <sup>2,5</sup>	40 <sup>1</sup>	15	40	3.5 (T)	140	55	140
Trefoil (T) <sup>2,5</sup>	50 <sup>1</sup>	15	40	3.5 (T)	175	55	140
Cool-season grass (T) <sup>2,5</sup>	40	15	50	4 (T)	150	60	200
Bluegrass (T) <sup>2,5</sup>	30	10	30	2.5 (T)	75	25	75
Wheat/rye (bu) <sup>3</sup>	1.5	1	1.8	60 (bu)	90	60	110
Oats (bu) <sup>3</sup>	1.1	0.9	1.5	80 (bu)	90	70	120
Barley (bu) <sup>3</sup>	1.4	0.6	1.5	75 (bu)	105	45	110
Soybeans (bu)	3.2	1	1.4	40 (bu)	130	40	56
Small grain silage (T) <sup>4</sup>	17	7.0	26	40 (bu)	100	40	160

Note: Adapted from Beegle, 2003.

<sup>1</sup> Legumes fix all their required nitrogen. However, they also are able to use nitrogen as indicated.

<sup>2</sup> For legume-grass mixtures, use the predominant species in the mixture.

<sup>3</sup> Includes straw.

<sup>4</sup> 65% moisture.

<sup>5</sup> 10% moisture.

## LESSON III-2

### Potential Environmental Risks on Your Farm

One of the goals of nutrient management planning is to produce high yield and quality crops while protecting the environment. In order to minimize the farm's environmental impact you must understand the factors that influence the risk of water pollution. Once these factors are identified, appropriate control and management measures can be implemented to minimize environmental pollution.

In previous lessons, we have learned how various nutrients can be lost from our farms. For example, nitrogen can be lost through volatilization, denitrification, leaching, and runoff. Phosphorus can be lost through runoff and erosion. It is important to know how the soil properties, landscape, and management practices on the farm will influence the loss of these nutrients. Some of these properties cannot be modified, such as soil type and slope. A clay soil will be denser and more poorly drained than a sandy soil, leading to an increased chance for runoff. However, there are a number of cropping practices that can be implemented or modified to lower the potential impact.

Most farmers know their soil and land better than anyone else. You know which crops grow best where, what fields require the most tillage, which fields require the most rock picking, and which fields are close to ground or surface water. The goal of analyzing risk is to combine your knowledge with scientific principles to reduce the risk of pollution. This is primarily accomplished by the use of risk models. We have already learned about several of these risk models in the other sessions. The first risk assessment model is RUSLE2. This program incorporates your management practices as well as soil types and slopes into a computer model and determines the potential amount of soil loss from your fields. The more soil loss potential, the riskier the field is in terms of water quality.

Another model is the phosphorus or P-index. This program is used to determine the potential for phosphorus erosion and runoff from your fields into surface water. It incorporates your management, soil type, slope, and proximity to water into its calculation. A high P-index indicates a threat to water quality.

Lastly, there is the *nitrogen leaching index*. This model determines the potential for soil-applied nitrogen (in the form of fertilizer or manure) to be leached into the groundwater. The benefit of these models is that you can change your management practices to reduce your potential risk to water quality. For example, crop rotations with perennial crops and manure incorporation practices can greatly reduce nutrient loss.

In addition to the risk models, there are other potential environmental risks on farms that should be noted and managed. For example, determine where waterways and wells are located on the farm. A waterway might be a brook, stream, river, or sometimes a farm ditch. It is important to identify these areas and provide appropriate vegetated buffers between agricultural crops and the water. The State of Vermont requirement for medium and large farms is 25 feet from the top of the bank of a water course to the edge of the agricultural field.

This area must be vegetated with grass and/or other perennial plants where no manure is spread. For small farms the requirement is 10 feet from the top of the bank. If you are involved with federal nutrient management programs, a 25-foot buffer is required regardless of farm size. Identification of public and private wells is important so that proper manure spreading setbacks can be determined. While identifying risks is often tedious, it is important to remember that we need to be responsible stewards of the land. These risk assessments benefit not only our farms but our local communities.



*Vegetated buffer strips between fields and waterways help to minimize the risk of nutrient loss to surface water.*





## LESSON III-3

### N- or P-Based Management and Manure Spreading Restrictions

The P index is an indicator of the potential for runoff loss of phosphorus from your fields. The P-index will give you a rating for each field: low, medium, high, or very high. From the results of the P-index and your soil test P results, your field is designated as requiring either *N- or P-based management*. You can find the status of each field by looking at the column “Need N- or P-based management” on the environmental risk worksheet. Whether a field is under N-based or P-based management will affect your approach to meeting crop nutrient needs. In a perfect world, we would be able to create a blend of fertilizer that met the exact needs of each field. Since we are using manure to satisfy crop needs and we can’t easily change the nutrient composition of the manure, we will likely be over-applying or under-applying some nutrients. When using manure as a nutrient source, generally there is a tradeoff between N and P. If you apply enough manure to meet the crop’s N needs, there will usually be a buildup of P over time.

The P-index and your soil tests provide us with a way to figure out which type of management is appropriate in each individual field. Let’s define each type of management:

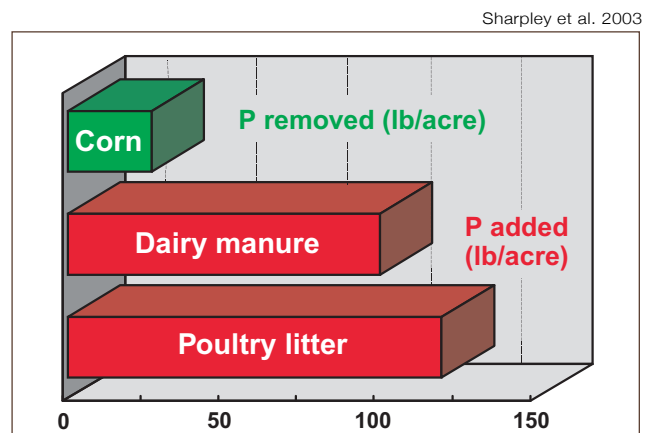
**N-Based Management.** You are managing the crop based on its nitrogen needs. Manure can be applied at rates needed to meet crop removal rates or soil test N recommendations. However, with this

method you must monitor soil test P levels. (N-based management will generally result in a buildup of soil P over time, so be sure to continue monitoring soil test P level.)

**P-Based Management.** You are managing the crop based on its phosphorus needs. You may apply only enough manure to meet P crop removal rates or soil test recommendations for P.

#### Manure Spreading Restrictions

On the risk assessment worksheet you will also find a *manure spreading restriction code*. This code is set up using a stoplight system with red, yellow, and green (see page 71).

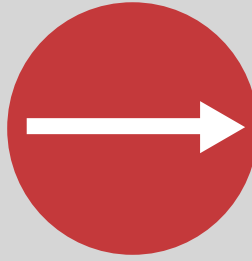


*Applying manure to meet crop N needs (about 200 lbs. available N/acre) adds much more P than corn removes.*

## Manure Spreading Restrictions

### RED

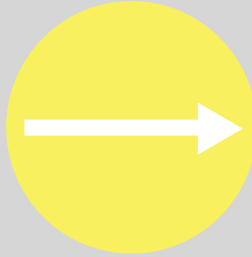
Fields with a **very high** P-index



No P may be added through manure applications. You have to manage these fields carefully in ways that will prevent P runoff and will draw down soil P levels over time.

### YELLOW

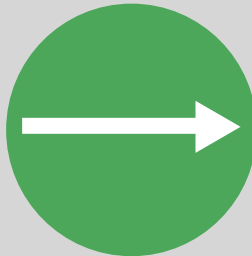
Fields with a **high** P-index or soil test levels greater than 20 ppm. Even if the P-index is medium, you must manage for P if your soil test exceeds 20 ppm.



Manure and fertilizer applications are based on P recommendations. P-based management means that manure application may not exceed rates of P removal by crops.

### GREEN

Fields with a **low to medium** P-index



You can apply manure based on N recommendations. Be careful! If you add 10 lbs. of N per 1000 gallons of manure, you will apply 15,000 gallons of manure to get 150 lbs. of N. This also means you are applying 120 lbs. of P. Your P level will rise over time and soil test results will show levels at high or very high. You must manage this before it happens.

### EXAMPLE OF MANURE CALCULATION FOR “YELLOW” MANURE SPREADING RESTRICTION

With a yellow manure spreading restriction, manure application may not exceed rates of P removal by crops. Look at crop removal rates for corn silage:

Let's say your typical yield is 20 tons/acre (see table on page 66).

*How many lbs. of  $P_2O_5$  are removed per acre?*

**Answer:**

20 tons x 5 lbs.  $P_2O_5$  removed per ton = 100 lbs.

*So how much  $P_2O_5$  can you apply in your manure?*

**Answer:** 100 lbs.

*How much manure do you put down to get 100 lbs. of phosphorus? Refer to the table on page 40.*

On average there are 8 lbs. of  $P_2O_5$  per 1000 gallons of manure. You are allowed to put on 100 lbs. of  $P_2O_5$  ( $8 \times 12 = 96$ ).

12 x 1000 gallons =  
12,000 gallons of manure per acre

Remember that it is best management to not apply more nutrients than the crop needs. Following the soil test recommendation will minimize nutrient over-application. If you just base your measurements on crop removal then you won't utilize all of the nutrients already in your soil. This is a waste of money. In addition, you'll never bring your phosphorus levels down.

## EXERCISE III-3

### Checklist

**H**ere is a list of items that you should have completed before you go on to the next session. Those items found in the computer workbook are listed in blue.

#### SESSION I

- Farm information worksheet
- Maps (proximity, conservation plan, nitrate leaching, topographic, environmental concerns, soils)
- Soil fact sheets
- Soil test results organized
- Soil test interpretation and planning strategy
- Soil test schedule
- RUSLE2 (with your crop rotation indicated)
- Field inventory
- Manure application schedule

#### SESSION II

- Animal waste system overview sheet
- Calculation of amount of manure produced
- Manure test for each storage
- Manure analysis worksheet
- Manure storage nitrogen calculations (one for each manure storage)
- Manure nutrient values
- P-index

#### SESSION III

- Farm nutrient balance
- Risk assessment worksheet