(Table 9). However, assessment of the potential for P runoff loss from an agricultural field requires evaluation of a number of factors, of which soil test P is only one. The Phosphorus Index was developed as a tool to combine various soil and management factors into an index that can serve as a management tool as part of the nutrient management planning process. The revised P Index for Vermont uses several parameters, including erosion, soil hydrologic group, P soil test, rate and method of P application, and buffer characteristics, to estimate the potential for runoff of phosphorus from a given field. The results of the P Index calculation for each field are expressed as an index (0 to 100+) and are assigned a low, medium, high, or very high rating. Recommended management practices for each category can then be used as a guide to prioritize fields and to determine those on which P application should be limited or additional conservation practices implemented. The 2004 version of the Vermont P Index can be downloaded from the Web at: *http://pss.uvm.edu/vtcrops/?Page=nutrientmanure.html#Phosphorus*

Potassium

Plant-available soil K is primarily in the exchangeable form; that is, it is adsorbed to organic matter and clay surfaces but can be readily exchanged with ions in soil solution and taken up by plants. It is exchangeable K that is measured by the Modified Morgan's extractant (NH_4 acetate, pH 4.8). The rate of potash recommended is based on soil test K level and on crop need, as determined by crop type and yield level (Table 11). Recommended K rates for low-testing soils are quite high, especially for corn silage and perennial forages in which the whole plant is harvested. Even for soils in the optimum range, a substantial amount of potash is recommended because soils can be more quickly depleted of K than of P.

Potassium rates for corn silage and hay forages are adjusted based on yield level and on whether corn is harvested for silage or grain because these factors affect plant uptake and removal of K. Less potash is recommended for grass forage than for legumes because the fibrous rooting system of grasses is more efficient at scavenging for K than is the tap root system of legumes. In the case of a legume-grass mix, an adequate K supply is important to maintain the competitiveness of the legumes relative to the grasses. Less potash is recommended for establishment of a perennial forage than for topdressing to minimize any possible fertilizer injury to seedlings. Lower establishment-year yields mean lower K uptake, as well.

A portion of the K recommended for corn (10 to 20 lb K_2O / acre) should be banded with the planter, especially on low- and medium-testing soils. (For more information, see UVM Extension Br 1392, *Starter Fertilizer for Corn in Vermont*.)

If manure will be applied, recommended K rates should be reduced based on manure rate and nutrient content (from manure analysis or typical values, Table 14).

Secondary and Micronutrients

Magnesium Recommendation - All Crops

Magnesium can be deficient on some Vermont soils. Because the available form of both Mg and K is a cation (positively charged ion), there is competition between the two for plant uptake. As a result, Mg deficiency is more likely to occur on high K-testing soils. Therefore, we have different recommendations for two situations—those with K test lower and higher than 200 ppm. For the higher K-testing soils, Mg critical level and recommended rate are adjusted for the K test level.

Situation 1: K soil test is 200 ppm or less.

Mg soil test of 50 ppm is considered adequate.
Mg recommendation, lb/acre = 100 - (2 x Mg soil test)

Situation 2: K soil test is greater than 200 ppm.

Mg recommendation, lb/acre = (0.6 x K test) - (2 x Mg soil test).

Zinc for Corn

Zinc (Zn) deficiency is not a consistent problem in Vermont, but it has caused serious production problems, primarily in corn, in some fields in some years. The Zn soil test provides a guide for Zn fertilizer need, but is best combined with field observations (Table 12). Zinc deficiency is more likely on fields with no recent manure application or on soils with very high soil test P (or excessive P application), low organic matter, or relatively high pH (approaching 7 or higher). Weather conditions are also a factor—with problems more likely under cool spring conditions. Zinc deficiency symptoms generally appear in young corn (6-12 inches tall) as interveinal chlorosis (light color between veins) or wide bands on either side of the midrib of younger

Table 11. Recommended potassium rates for field crops.

	K soil test						
	Low		Medium		Optimum	High	Excessive
K, ppm:	<25	26-50	51-75	76-100	101-130	131-160	>160
	K_2O to apply (lb / acre)						
Corn for silage[1]							
15 or 20 ton / acre	200	160	120	80	60	0[2]	0
25+ ton / acre	240	200	160	120	80	30	0
Corn for grain							
90 or 120 bu / acre	140	100	60	40	30	0[2]	0
150+ bu / acre	180	140	100	60	30	30	0
Alfalfa (>60%)[3]							
Topdress							
2-4 ton / acre	280	240	200	160	100	40	0
5 ton / acre	320	280	240	200	140	60	0
6+ ton / acre	360	320	280	240	180	80	0
Establishment	240	200	160	120	80	40	0
Clover, trefoil, grass, alfalfa (20-60%)[3]							
Topdress							
2-4 ton / acre	220	180	140	100	60	0	0
5+ ton / acre	260	220	180	140	100	0	0
Establishment	180	140	100	80	60	0	0
Small grains, soybeans, buckwheat, dry beans / peas, millet	120	100	80	60	40	0	0
Conservation planting	80	60	40	0	0	0	0

[1] Corn silage yields are wet tons / acre (30-35% DM).
[2] 10-20 lb K_2O / acre recommended as row-applied starter under conditions of early planting, limited drainage, or conservation tillage.
[3] Yields are dry hay equivalent (12-15% moisture). One ton dry hay is equivalent to 2.5 tons haylage (65% moisture).

(upper) leaves. The chlorotic bands do not extend to the tip of the leaf (as they do in Mg-deficient plants). Plants are often stunted in growth. Zinc deficiency usually occurs in spotty, irregularly shaped areas in the field.

Where Zn test is low or deficiency symptoms have been observed in the past, a broadcast application of Zn incorporated with tillage has been more effective than starter Zn and is generally sufficient for five or more years. Zinc sulfate (36% zinc) is the most common fertilizer material and should be applied at a rate to supply 8 to 10 lb / acre of actual Zn (25 lb / acre of $ZnSO_4$). Under less immediate deficiency situations, a low rate (about 2 lb / acre) can be applied annually with starter fertilizer.

Boron on Perennial Legume Forages

Boron (B) deficiency has historically been a problem in Vermont on alfalfa and, to a lesser extent, red clover and birdsfoot trefoil. In fact, some of the early research that showed that serious alfalfa production problems were caused by B deficiency was done by Professor Midgley at the University of Vermont in the 1930's and '40's. Unfortunately a soil test is not reliable for diagnosing the need for B, so B is routinely recommended for topdressing and seeding down alfalfa, trefoil, and red clover—except where B was applied the previous year (Table 13). Care should be taken to avoid excessive rates, especially on legume-grass combinations, because of the potential for B toxicity.

Table 12. Zinc recommendations for corn.

Zn test	Zn level	Deficiency symptoms?	Zn recommendation
ppm			
<0.5	Low	yes / no	8-10 lb / acre, broadcast and incorporated[1]
0.5-0.9	Medium	yes	8-10 lb / acre, broadcast and incorporated[1]
0.5-0.9	Medium	no	8-10 lb / acre, broadcast and incorporated[1]
			or 2 lb / acre in starter annually for 2-3 yrs; then retest
1.0+	Optimum / High	no	None

[1] Adequate for five or more years.

Table 13. Boron recommendations for perennial forages.

Species	Seeding year[1]	Topdress
	lb / acre	
Alfalfa (20-100% stand)	2	1-2
Red clover (20-100% stand)	2	1-2
Trefoil (20-100% stand)	2	1
Grass	0	0

[1] If B applied within past year, none is needed at seeding.

Nutrient Credits from Manure

Nutrient Content

Manure is a very important source of nutrients for crop production in Vermont, supplying more nutrients than purchased fertilizer on most dairy farms in the state. Proper application of manure can result in substantial reductions in fertilizer costs. As with fertilizer, however, careful management is necessary to minimize any adverse effects on water quality. For both economic and environmental objectives, it is important to know the content of nutrients in the manure so that the quantity applied matches crop need. Because the nutrient content of manure is highly variable, sampling and lab analysis are strongly recommended. If the customer provides actual manure analysis, it will be used to calculate available nutrients in manure. Otherwise, estimates will be based on "typical" values shown in Table 14. (Note: If dry matter—DM—content of manure varies greatly from the values in Table 14, nutrient content estimates should be adjusted accordingly.) In either case, recommended fertilizer rates are adjusted for the availability of nutrients from manure applications that have been applied or are planned. Because the nutrients in manure are not fully equivalent to those in fertilizer, the total nutrient content, especially of N, is reduced to account for losses and inefficiency of plant uptake relative to fertilizer. In terms of availability, N in manure consists of two fractions—the ammonium portion, which is potentially equivalent to fertilizer N but is also susceptible to large losses, and the more stable organic fraction, which releases N in an available form over a longer time period (Figure 1).