LIME GUIDELINES FOR FIELD CROPS IN NEW YORK

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Department of Crop and Soil Sciences Extension Series E06-2
Cornell University

June 9, 2006

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Acknowledgments:

We thank Carl Albers, Area Field Crops Extension Educator, Cornell Cooperative Extension of Steuben, Chemung, and Schuyler Counties, for his review of an earlier draft of this extension bulletin.

Correct citation:

Ketterings, Q.M., W.S. Reid, and K.J. Czymmek (2006). Lime guidelines for field crops in New York. First Release. Department of Crop and Soil Sciences Extension Series E06-2. Cornell University, Ithaca NY. 35 pages.

Downloadable from: http://nmsp.css.cornell.edu/nutrient_guidelines/

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Nutrient Management Spear Program

Collaboration among the Cornell University Department of Crop and Soil Sciences, PRODAIRY and Cornell Cooperative Extension
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1. INTRODUCTION

Achieving optimum pH is essential for field crop production because soil pH affects many soil properties and processes including nutrient cycling, soil microbial activity and soil structure. The native pH of a soil is determined by the type(s) of rock, or parent material, the soil was developed from. The characteristics of the parent material influence soil mineralogy and the quantity of exchangeable cations that determine soil pH. Most agricultural soils in New York are acidic and have a pH ranging from 4.5-7.0. Some New York soils are "calcareous", meaning they contain free calcium carbonate, or lime deposits in the surface layer. Calcareous soils tend to have a pH in the range of 7.0-8.5 and the pH tends to be quite stable, so pH management is usually not an issue. However, naturally acidic agricultural soils need to be monitored for pH and lime will need to be applied for optimum field crop production.

In this bulletin we give background information on pH and acidity (Section 2), describe soil sampling procedures (Section 3) and analytical tests for pH and acidity (Section 4), outline how a lime recommendation can be derived based on soil properties and crop pH requirements (Section 5), briefly describe what can be done to lower the pH (Section 6), list and describe different liming materials (Section 7), state minimum quality guarantees for lime materials sold in New York (Section 8), and outline considerations for lime application (Section 9).

2. BACKGROUND INFORMATION

2.1 pH Basics

The pH of a soil is a measure of hydrogen ion activity ($[H^+]$) in the soil solution. As the H^+ activity increases, soil pH decreases. As the soil pH decreases, most desirable crop nutrients become less available while others, often undesirable, become more available and can reach toxic levels (see Section 2.3: Soil pH and Crop Production).

Hydrogen activity is mathematically expressed as a negative logarithm: $pH = -\log[H^+]$. Because of the logarithmic scale, one unit decrease in pH implies a 10 time increase in acidity so a soil with a pH of 5.0 is 10 times more acid than a soil with a pH of 6.0 and 100 times more acid than a soil with pH 7.0 (Figure 1).

New York agricultural soils:		4.5 ------------- 7 --------- 8.5		
Total pH scale:	0 ------------------------------ 7 -------------------------------- 14			
	Acid	Neutral		Basic or Alkaline

Figure 1: Total pH scale and common pH range of New York soils.

The pH of a soil can be changed by human activity as well as by natural events. In humid climates such as found in New York, the leaching of calcium (Ca^{2+}), magnesium (Mg^{2+}) and potassium (K^{+}) ions leads to an increase of active hydrogen and aluminum (Al^{3+}) in the soil and results in a decrease in pH. In arid climates where there is little or no water movement through the soil, the cations Ca^{2+}, Mg^{2+}, and K^{+} (and in some regions also sodium, Na^{+}) dominate, and soils tend to be neutral or alkaline. Typically, the addition of inorganic fertilizers and organic nutrient sources (compost and manure) leads to a decrease in pH due to the formation of two strong inorganic acids, nitric (HNO_3) and sulfuric acid (H_2SO_4). This is further explained in Section 2.4 (Effect of Fertilizer Application on Soil pH).

Pure water has a pH of 7.0. Normal rain is acidic (pH between 5.0 and 6.0) because carbon dioxide (CO_2) in the atmosphere combines with water molecules to form carbonic acid. Rain is called acid rain if the pH is less then 5.0. Acid rain (or snow) is primarily a result sulfur oxides (SO_x) and nitrogen oxides (NO_x) in the atmosphere reacting with oxygen in the air to form nitric acid and sulfuric acid.

As Figure 2 shows, the average pH of precipitation in New York tends to be acidic and range from pH 4.4 to 4.6, about as low as any in the US (National Atmospheric Deposition Program (NRSP-3)/National Trends Network, 2006). In the US, about 2/3 of all SO_2 and 1/4 of all NO_x comes from electric power generation that relies on burning fossil fuels like coal.

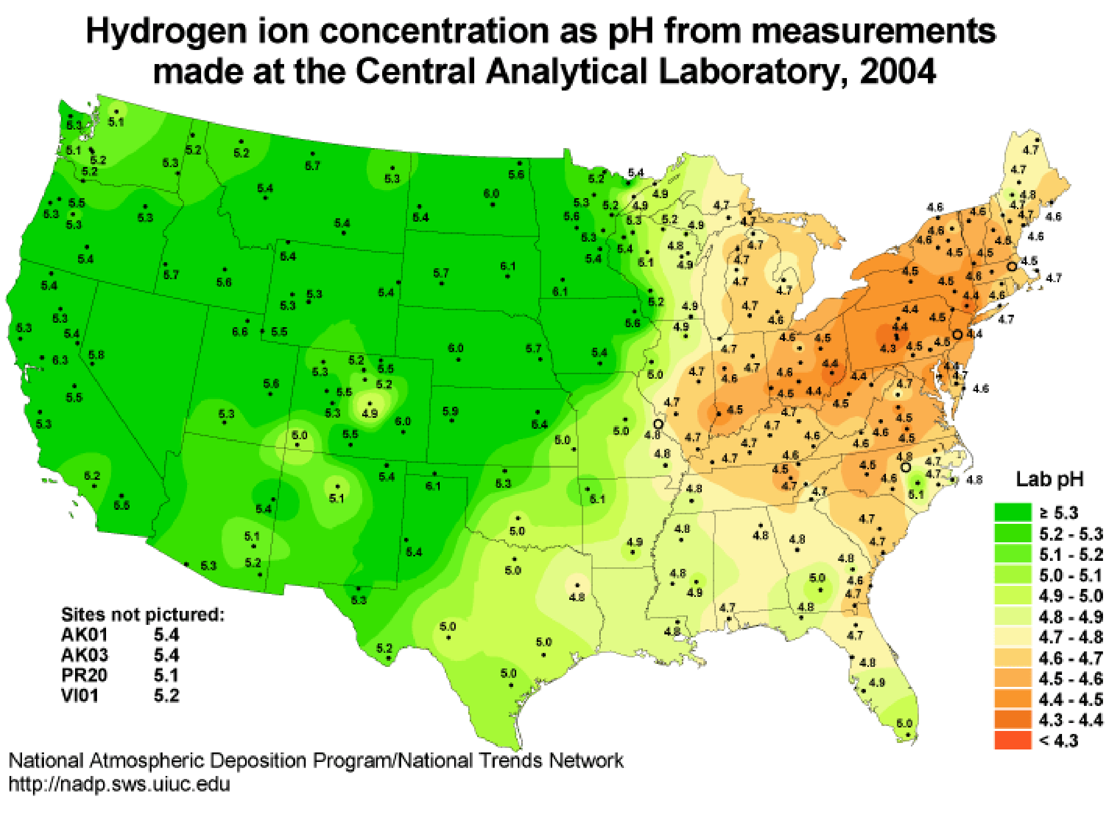

Figure 2: Precipitation pH in the US in 2004 as measured at the Central Analytical Laboratory (National Atmospheric Deposition Program, 2006).

2.2 Soil Acidity

The ability of a soil to resist a change in pH is known as the soil's buffer capacity. A soil with a large buffer capacity will need more lime per unit pH change than a soil with a small buffer capacity. The buffer capacity greatly depends on texture and organic matter content. A clay soil will need more lime to neutralize acidity than a sandy soil. A soil with high organic matter will need more lime than a soil with low organic matter. The buffer capacity of the soil reflects its total acidity which is the sum of three different forms of acidity: (1) active acidity; (2) salt-replaceable acidity; and (3) residual acidity.

Active acidity reflects the H^+ ion activity in the water of the soil (called soil solution) and is measured with a pH in water measurement. To neutralize only the active acidity, very little liming material is needed but such a change is also very short-lived due to the existence of salt-replaceable and residual acidity. Because the active acidity (pH) is only a very small fraction of the total soil acidity, a pH measurement can tell you whether or not lime needs to be added but it does not tell you how much lime is needed to increase the pH to the desired level.

> Box 1:
>
> *A pH measurement can determine if lime is needed. An estimate of the soil's buffering capacity is needed to determine how much lime is needed.*

Salt-replaceable acidity and residual acidity can be described as the soil's capacity to resist change in the soil solution pH. Salt-replaceable acidity is the H^+ and Al^{3+} activity in solution when shaken with a salt solution. This can be described as relatively weakly bound H^+ and Al^{3+}. The soil's buffer capacity increases with amount of salt replaceable H^+ and Al^{3+} as these ions can quickly move into the soil solution. Residual activity is associated with aluminum hydroxyl ions and H^+ and Al^{3+} ions that are strongly bound in non-exchangeable forms by organic matter and clay minerals. Taken together, salt-replaceable and residual acidity represent the buffering capacity (ability to resist a change in pH upon lime addition). A higher buffer capacity means that a soil is more resistant to change in pH and will require more lime to achieve the same change in pH as a less buffered soil. Clayey soils and soils with more organic matter will have greater amounts of salt-replaceable and residual acidity (greater buffer capacity) than sandy and low organic matter soils. The clayey soils will thus need more lime to neutralize than a sandy soil. In Section 4.2 (Buffer Capacity of the Soil) we will explain how such buffer capacity is determined in the laboratory.

2.3 Soil pH and Crop Production

As soils become acidic, especially below pH 5.5, nutrient availability to plants decreases and toxic amounts of Al and other metals may reduce crop production or even make the production of some crops impossible. Liming to optimum pH increases the availability of essential nutrients (Table 1), supplies Ca and Mg, improves soil conditions for

> Box 2:
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> *Liming to optimum pH increases the availability of essential nutrients,, supplies Ca and Mg, improves soil conditions for microorganisms, increases the effectiveness of triazine herbicides, and improves soil structure.*

microorganisms, increases the effectiveness of triazine herbicides, and improves soil structure.

When interactions between nutrients are taken into account, the optimum pH for most crops falls between 5.5 and 7.0. If the soil's pH is adjusted to optimal for phosphorus (P) availability, the availability of other nutrients, if present in sufficient amounts, will be satisfactory as well. However, there are exceptions to this general rule caused by soil texture or crop selection. For example, liming some sandy soils to pH 6.0 or higher may cause micronutrient deficiencies. Although this is not the case for field crops, certain trees and shrubs require large amounts of certain micronutrients and therefore require a lower optimum pH. Examples include rhododendrons and azaleas which require iron (Fe) and manganese (Mn) that is only available in sufficient amounts when soil pH is low (iron availability decreases with increasing pH from 4.0 to 6.0). In other crops, such as potatoes, lower pH is used to control disease.

Table 1: Optimum pH ranges for soil nutrients, microorganisms and reduced Al toxicity. Adapted from Figure 9.18 in "Nature and Properties of Soils" by Brady and Weil, 1996.

	pH range				
	Availability increase with pH increase in this range:	Availability decreases with pH increase in this range:	"Optimum"	Availability decreases with pH increase in this range:	Availability increase with pH increase in this range:
Nitrogen	4.0-5.5	-	5.5-8.5	-	-
Sulfur	4.0-5.5	-	5.5-8.5	-	-
Calcium	4.0-5.8	-	5.8-6.8	-	6.8-8.5
Magnesium	4.0-5.8	-	5.8-6.8	-	6.8-8.5
Phosphorus	4.0-6.0	-	6.0-7.0	7.0-8.5	-
Iron	-	4.0-6.0	6.0-6.6	6.6-8.5	-
Manganese	-	4.0-6.0	6.0-6.6	6.6-8.5	-
Molybdenum	4.0-6.0	-	6.0-8.5	-	-
Copper	4.0-5.3	-	5.3-6.8	6.8-8.5	-
Boron	4.0-5.3	-	5.3-6.8	6.8-8.5	-
Zinc	-	4.0-5.3	5.3-6.8	6.8-8.5	-
Aluminum*	-	4.0-5.8	5.8-8.5	-	-
Fungi			4.0-8.5	-	-
Bacteria	4.5-5.5		5.5-8.5	-	-
Actinomyces	4.5-5.5		5.5-8.5	-	-

* Optimum identifies the pH range in which aluminum toxicity is not an issue.

2.4 Effect of Fertilizer Application on Soil pH

The reaction of ammonium forming fertilizers (e.g. ammonium nitrate, urea, urea ammonium nitrate, anhydrous ammonia, ammonium sulfate) with oxygen (a process called oxidation) results in the formation of nitrate (NO_3^-) and H^+ ions (Figure 3). To counter the acid forming reaction of such fertilizers in soils without free calcium carbonate (calcareous soils), lime will be needed. If pure calcium carbonate is used as the liming material, 3.6 lbs of calcium carbonate will be needed to neutralize the acidity produced per lb of N derived from ammonium from anhydrous ammonia, ammonium nitrate, and urea. Therefore, because of extra H^+ released, per pound of N, ammonium sulfate creates twice as much acidity as other N materials. Thus, ammonium sulfate will need twice as much calcium carbonate to neutralize the acidity it creates (Figure 3). Manure contains urea and organic N. The urea is rapidly mineralized to ammonium and converted to nitrate while the organic N will go through mineralization to ammonium more slowly. Both conversions will acidify the soil. However, the overall acidifying effect of a manure source depends on the type of manure. For example, litter from laying hens typically has a high calcium carbonate content causing it to have a liming effect.

$$\underset{\textbf{(ammonia)}}{2\,NH_3} + \underset{\text{(oxygen)}}{4\,O_2} \rightarrow \underset{\text{(nitrate)}}{\mathbf{2\,NO_3^-}} + \underset{\text{(“acid”)}}{\mathbf{2\,H^+}} + \underset{\text{(water)}}{2\,H_2O}$$

$$\underset{\textbf{(ammonium nitrate)}}{NH_4NO_3} + \underset{\text{(oxygen)}}{2\,O_2} \rightarrow \underset{\text{(nitrate)}}{\mathbf{2\,NO_3^-}} + \underset{\text{(“acid”)}}{\mathbf{2\,H^+}} + \underset{\text{(water)}}{H_2O}$$

$$\underset{\textbf{(urea)}}{(NH_2)_2CO} + \underset{\text{(oxygen)}}{2\,O_2} \rightarrow \underset{\text{(nitrate)}}{\mathbf{2\,NO_3^-}} + \underset{\text{(“acid”)}}{\mathbf{2\,H^+}} + \underset{\text{(water)}}{H_2O}$$

$$\underset{\textbf{(ammonium sulfate)}}{(NH_4)_2SO_4} + \underset{\text{(oxygen)}}{4\,O_2} \rightarrow \underset{\text{(nitrate)}}{\mathbf{2\,NO_3^-}} + \underset{\text{(sulfate)}}{SO_4^{2-}} + \underset{\text{(“acid”)}}{\mathbf{4\,H^+}} + \underset{\text{(water)}}{2\,H_2O}$$

Figure 3: Ammonium fertilizers are acid forming (i.e. they ultimately decrease the soil pH even though urea may initially increase the pH).

3. SAMPLING A FIELD FOR PH

It is recommended to test each field for pH (and fertility) at least once in 3 years or twice per rotation. If the past field management is unknown, more frequent sampling is highly recommended as it will help to establish a reliable assessment of lime and fertilizer needs. Take a minimum of 10-15 subsamples from across a field (identified as an area differing from its neighboring areas in crop growth, soil

> Box 3:
>
> *It is recommended to test each field for pH (and fertility) at least once in 3 years or twice per rotation. More frequent sampling will result in a more reliable assessment of past field management and current lime needs.*

type, drainage, fertility levels, and/or past management). Typically, a sampled unit should not be more than 10-15 acres unless past experience indicates wider uniformity. If considerable within-field variability in pH is expected, grid sampling is recommended as variable rate application of lime can be economically and environmentally advantageous. A description of grid sampling can be found in the 2006 Cornell Guide for Integrated Field Crop Management (http://www.fieldcrops.org – 2.10.6).

Soil samples can be taken at any time during the year when the soil is not frozen or saturated. Due to seasonal variability of nutrient availability (and pH), it is recommended to sample at about the same time in the year. For more information on soil sampling, see Agronomy Fact Sheet 1: Soil Sampling for Field Crops (http://nmsp.css.cornell.edu/publications/factsheets.asp).

For conventional tillage systems, a sample core from 0-8 inches is recommended. Under minimum or no-tillage systems, the surface inch of the soil may become acid more rapidly than the deeper layer so in no-till or minimum tillage systems, the pH values of two soil layers (0-1 and 0-6 inches) should be determined.

4. Measuring Soil pH and Exchangeable Acidity

4.1 Soil pH

Soil testing laboratories routinely measure soil pH in a suspension of soil in water (1:1 or 1:2 soil to water ratio). At Cornell University, the Cornell Nutrient Analysis Laboratory (CNAL) measures pH in a 1:1 (volume) suspension of soil and water. Such a pH measurement is accurate to +/- 0.01 pH unit. Soil pH can vary through the season depending on, among others, the amount of soluble salts in the soil solution. With NY soils, higher soluble salt levels result in lower pH values. In a humid climate, the soil is nearly free of salts in the early spring due to leaching during late fall, winter and early spring, as well as a lack of nitrification in these seasons. At planting, salt levels are generally high due to nitrification and fertilizer and/or manure addition. During the growing season, salt levels will decline due to plant uptake. Following harvest in the months where there is no crop growing but still active mineralization and nitrification, salt levels can be quite high. Thus, in NY, we tend to find the lowest pH values end of May to early June and in fall following corn harvest. The highest levels will generally occur after snowmelt.

> Box 4:
>
> *Soil pH can vary through the season depending, among others, on the amount of soluble salts in the soil solution. High salt levels reduce soil pH. It is recommended to sample at about the same time of the year each time samples are taken.*

CNAL assembles pH test kits that can be used to determine the soil pH in the field (Figure 4). The kit contains two indicator or dye solutions, a plastic spot plate, a color chart and instructions. The indicator dyes come in plastic bottles and remain in good condition for years provided they are not exposed to direct sunlight or high temperatures.

The chlorophenol red indicator is most sensitive in the strongly and moderately acid ranges (pH 5.0-6.0). The bromothymol blue indicator is most sensitive in the slightly acid to neutral range (pH 6.0-7.0). The large "wells" in the spot plate should be filled (one-half to two-thirds full) with dry to moist soil. Soil can be tested any time the ground is dry enough to work. Once one of the wells is filled, the chlorophenol red indicator solution is added slowly – drop by drop – to one of the wells until the soil is just saturated or until some of the solution can be seen between the soil particles. It is important not to excessively flood the soil; this will result in an inaccurate test, especially on sandy soils. After addition of the indicator solution, it should be allowed to react with the soil for one minute (use the stirrers supplied with the kit to gently mix the soil and solution or rotate the spot plate). After the indicator has been allowed to complete its reaction with the soil, the spot plate should be inclined at an angle so that a drop of the reacted indicator will flow from the soil and into the small channel. The stirrers supplied with the kit can be used to touch the reagent and lead it down the channel. To determine the pH, the color of the reacted indicator should be compared with the red sequence on the color chart. If the color of the reacted indicator is a lighter orange than the orange that corresponds with a pH of 5.0, the pH of the soil is lower than 5.0 and a different indicator should be used (low range pH kits contain this indicator). If the color is darker red/purple than indicated for pH 6.2, the pH is greater than 6.2 and procedure should be repeated from the beginning using the bromothymol blue indicator. If the color of the reacted bromothymol blue indicator is darker green than the color that identifies a pH of 7.2, the pH of the soil is greater than 7.2 and no lime application is needed. The Cornell pH test kit allows for pH measurements within 0.2 pH units. If very accurate pH measurements (and/or an estimate of the soil's buffering capacity) are needed, samples should be sent to the laboratory. To order Cornell pH test kits, contact CNAL (Phone: (607) 255-4540; Fax: (607) 255-7656; E-mail: soiltest@cornell.edu). Order forms can be obtained from the CNAL website: www.css.cornell.edu/soiltest/. Most local Cornell Cooperative Extension offices (Appendix A) will do the pH test for you if you bring your samples to the office.

Figure 4: Cornell pH kits allow growers to measure pH within 0.2 pH unit.

4.2 Exchangeable acidity

The Cornell Nutrient Analysis Laboratory (CNAL) estimates soil buffering capacity by measuring exchangeable acidity (reported in meq/100 g soil). A different measure, "Buffer pH", is used by other laboratories for a similar purpose. The exchangeable acidity test determines the total potential acidity present in the soil between its actual pH and that of pH 8.0 (Greweling and Peech, 1965). The measure serves to help estimate the lime requirement to reach the desired pH based on the soil's buffer capacity. Exchangeable acidity is only reported for soils with a pH of 6.1 or lower because measurements become less accurate for soils with higher pH. For soils with pH greater than 6.2 but lower than the pH desired for the rotation, the soil's buffer capacity is based on the anticipated Cation Exchange Capacity (CEC) of the soil (see Section 5: Calculating Lime Requirements).

5. CALCULATING LIME REQUIREMENTS

5.1 Using CNAL Soil Test Data (pH and Exchangeable Acidity)

The Cornell lime recommendations for mineral soil (i.e. all soils except for organic soils) and a specific crop rotation are based on: (1) current and desired pH; (2) exchangeable acidity; (3) base saturation at the current and the desired pH; and (4) tillage depth. A different approach is taken for organic soils (see below). All lime rate guidelines are based on 100% Effective Neutralizing Value (ENV) of the liming material and actual applications of a specific liming material need to be corrected for the ENV of the material (see Section 7: Liming Materials).

The desired pH is based on the desired pH of the crop(s) with the highest desired pH in the 6-year rotation. For example, in a 3 year corn, 3 year alfalfa rotation, the greatest desired pH is 7.0 (for alfalfa production). The desired pH's for NY field crops are listed in Appendix B.

If the current pH is greater than the minimum pH desired for the rotation, the lime requirement is zero. The same requirement holds for soils with pH 7.9 or higher. For soils with a pH of 6.1 or lower, the requirements (Lime Req in tons/acre 100% ENV) are determined by the exchangeable acidity (EA in meq/100 g), base saturation (fraction of the cation exchange capacity occupied by exchangeable bases K^+, Mg^{2+}, Ca^{2+}) at the original and at the desired pH, and the tillage depth (inches):

$$\text{Lime Req.} = EA*0.5*(BS_{desired}-BS_{original})/(1-BS_{orginal})*(\text{tillagedepth}/6) \qquad [1]$$

There is a relationship between the quantity of basic cations, acidic cations and soil pH. This relationship for New York soils is shown in Figure 5. At similar organic matter levels, as the percent base saturation increases, the soil pH increases. This general relationship occurs in most mineral soils with similar soil mineralogy and climate. Notice that at about pH 8 the soil is 100% base saturated (100% of the soil is saturated with bases) and at pH 7 the soil is about 80% saturated. Use figure 5 to determine the base saturation at the desired pH and the original pH of the soil.

Lime requirements are adjusted depending on tillage depth. Because deeper tillage results in mixing of a larger amount of soil with the liming material, for the same desired increase in pH, lime rates must be increased as tillage depth increases. Actual adjustments made by CNAL and Cornell University's nutrient management software (Cornell Cropware) are listed in Table 3.

pH	Base Saturation (fraction)
<4.5	0.00001
4.5	0.021
4.6	0.035
4.7	0.050
4.8	0.073
4.9	0.102
5.0	0.135
5.1	0.171
5.2	0.228
5.3	0.320
5.4	0.420
5.5	0.480
5.6	0.515
5.7	0.540
5.8	0.570
5.9	0.600
6.0	0.620
6.1	0.635
6.2	0.655
6.3	0.675
6.4	0.695
6.5	0.710
6.6	0.730
6.7	0.740
6.8	0.755
6.9	0.770
7.0	0.795
7.1	0.812
7.2	0.830
7.3	0.847
7.4	0.863
7.5	0.880
7.6	0.900
7.7	0.925
7.8	0.950
7.9	0.975
>7.9	1.000

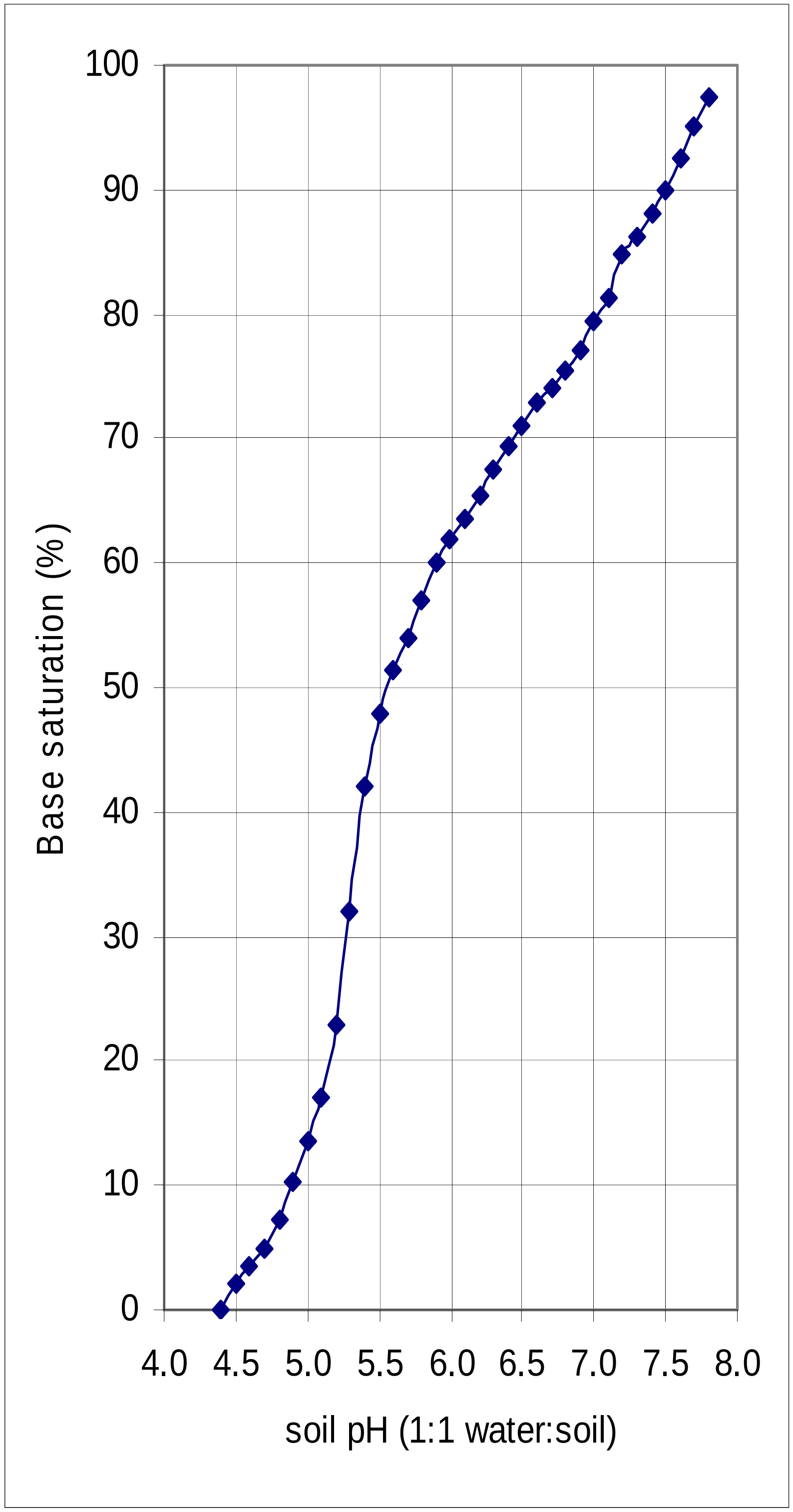

Figure 5: Base saturation as affected by soil pH based on New York soils (From Lathwell and Peech, 1973).

As mentioned in Section 3 (Sampling a Field for pH), in no-tillage or minimum tillage systems, samples of the 0-1 should be taken in addition to a 0-6 inch core. If the pH of the surface 0-1 inches is less than desired, but the pH of the 6-inch core is adequate, a small lime addition (1 to 1 ½ tons of lime per acre) is recommended to raise the pH of the soil surface. If both samples are strongly acidic, do not use no-till methods for the establishment of legumes unless lime has been applied and mixed with the soil for at least 6 to 9 months to permit the lime to react with the soil (see Section 9: Timing Consideration). If the surface pH is adequate, but the pH of the 6-inch core is lower than desired, legumes might be no-till seeded with a slightly lower overall pH or without waiting so long for the applied lime to react as when both zones have a low soil pH. Downward movement of lime to subsurface layers is very slow and only occurs after the surface layer has reached >80% saturation which means the pH of the surface needs to be around 7.0 to let lime to move downward.

Table 3: Lime requirement adjustments for depth in tilled systems.

Options:	Tillage depth for equation	Lime requirement adjustment
1-7 inches	6	*1.00
7-9 inches	8	*1.33
9+ inches	10	*1.67

Based on equation [1], the data represented in Table 3 and Figure 5, and Appendices B and C, the lime requirement for any 6-year crop sequence (6 cropping years; 3 past years and 3 future years) can be calculated. A couple of examples are give here.

Example 1:

Three years of corn followed by three years of alfalfa.
Initial pH 6.0, exchange acidity (EA) 10 me/100 gram soil.
Tillage depth is 8 inches.

In this rotation, alfalfa is the crop with the highest desired pH.
Desired pH = 7.0 (Appendix B).
Base saturation ($BS_{original}$) at pH 6.0 = 0.620 (Figure 5).
Base saturation ($BS_{desired}$) at pH 7.0 = 0.795 (Figure 5).

$$\text{Lime Req.} = EA*0.5*(BS_{desired}-BS_{original})/(1-BS_{orginal})*(tillagedepth/6)$$
$$= 10*0.5*(0.795-0.620)/(1-0.620)*8/6$$
$$= 3.1 \text{ tons/acre}$$

If the exchange acidity would have been 15 instead of 10 me/100 gram:

$$\text{Lime Req.} = 15*0.5*(0.795-0.620)/(1-0.620)*8/6 = 4.6 \text{ tons/acre}$$
$$= 4.6 \text{ tons/acre (so more lime needed with equal pH but higher EA)}$$

Lime requirements for pastures depend on the species in the pasture. Many New York pastures consist of clover-grass mixes which will benefit from lime application if the pH is less than 6.2. For pastures, sample to a depth of 0-6 inches and apply recommended lime rates when the soils are dry to avoid rutting and reduce the risk of compaction. Proper pH adjustment is the key for legume establishment and retention. Once the legume is established it will contribute a substantial amount of N needed for the pasture through N fixation, thus reducing the need for additional N fertilizer. Since lime is applied to the surface and not mixed into the soil, it will require more time to react.

For certain soils it is not economically beneficial to add lime to adjust for a small pH deficit. The Cornell Nutrient Analysis Laboratory and Cornell Cropware ignore a pH deficit of less than or equal to 0.4 for soils with a high Lime Index ("high" lime soils). This includes the following soil types: Amenia, Benson, Camillus, Clarkson, Dover, Farmington, Fryeburg, Grenville, Guffin, Hilton, Hogansburg, Honeoye, Lima, Nellis, Palatine, Staatsburg, Summerville, and Weaver (see also Appendix C). Appendix D shows the lime recommendations to increase the soil pH to 7.0, 6.5, and 6.2 for different combinations of initial soil pH and exchangeable acidity. An example calculation is shown below.

Example 3:

Continuous corn.
Initial pH 6.0, exchange acidity (EA) 6 me/100 gram soil.
Honeoye soil (Lime Index = High) with tillage depth of 8 inches.

Desired pH = 6.2 (Appendix B).
Base saturation ($BS_{original}$) at pH 6.0 = 0.620 (Figure 5).
Base saturation ($BS_{desired}$) at pH 6.2 = 0.655 (Figure 5).

Lime Req. = $EA*0.5*(BS_{desired}-BS_{original})/(1-BS_{orginal})*(tillagedepth/6)$
= 6*0.5*(0.655-0.620)/(1-0.620)*8/6
= 0.4 tons/acre = *no additional lime recommended at this stage*

Example 4:

Three years of corn followed by three years of alfalfa.
Hoosic (SMG=4) with tillage depth of 8 inches. Initial pH 6.5.

Desired pH = 7.0 (Appendix A).
Estimated CEC = 16 $cmol_c$/kg soil (Table 2).
Base saturation at pH 6.5 = 0.710 and at pH 7.0 = 0.795 (Figure 5).

Lime Req. = $CEC*0.5*(BS_{desired}-BS_{original})*(tillagedepth/6)$
= 16*0.5*(0.795-0.710)*8/6
= 0.9 tons/acre

As mentioned above, where the pH of the soil is 6.2 or higher, CNAL does not report exchangeable acidity. For those fields, the lime requirements are based on the soil group's anticipated cation exchange capacity (CEC):

$$\text{Lime Req.} = CEC_{group}*0.5*(BS_{desired}-BS_{original})*(\text{tillagedepth}/6) \qquad [2]$$

The CEC of a soil consists of exchangeable bases (mostly Ca, K, and Mg in New York soils) and exchangeable acidity. Average CEC values that have been assigned to each of the five mineral soil management groups are listed in Table 4. This table reflects the fact that a soil with a high CEC will require a higher lime application per pH unit change. *This approach should not be taken for soils with pH of 6.1 or lower where accurate exchangeable acidity values can be obtained.*

Example 2:

Three years of corn followed by oats, wheat, and clover.
Initial pH 5.6, exchange acidity (EA) 9 me/100 gram soil.
Tillage depth is 8 inches.

In this rotation, wheat is the crop with the highest desired pH.
Desired pH = 6.5 (Appendix B).
Base saturation ($BS_{original}$) at pH 5.6 = 0.515 (Figure 5).
Base saturation ($BS_{desired}$) at pH 6.5 = 0.710 (Figure 5).

$$\begin{aligned}\text{Lime Req.} &= EA*0.5*(BS_{desired}-BS_{original})/(1-BS_{orginal})*(\text{tillagedepth}/6)\\ &= 9*0.5*(0.710-0.515)/(1-0.515)*8/6\\ &= 2.4 \text{ tons/acre}\end{aligned}$$

Table 4: Cation exchange capacity is determined by the soil management group (SMG).

SMG	General Description	CEC $cmol_c$/kg soil
1	Fine-textured soils developed from clayey lake sediments and medium- to fine-textured soils developed from lake sediments.	25
2	Medium- to fine-textured soils developed from calcareous glacial till and medium-textured to moderately fine-textured soils developed from slightly calcareous glacial till mixed with shale and medium-textured soils developed in recent alluvium.	20
3	Moderately course textured soil developed from glacial outwash and recent alluvium and medium-textured acid soil developed on glacial till.	18
4	Course- to medium-textured soils formed from glacial till or glacial outwash.	16
5	Course- to very course-textured soils formed from gravelly or sandy glacial outwash or glacial lake beach ridges or deltas.	12

Soils classified as organic or muck soils (soils classified as Soil Management Group 6 in Appendix C), represent only a very small portion of New York's field crop acres. The deep muck soils can be acidic. Shallower mucks can have marl mixed with or very close to the surface. On muck soils, a pH of 5.2-6.0 (one unit lower than for mineral soils) is usually adequate for economic field crop production. Because muck soils have a very high percentage of organic matter, their cation exchange capacity and pH buffer capacity are very large so addition of lime to levels recommended for field crops is often not economically feasible. If a pH increase is desired, it requires 1000 lbs of 100% ENV material to increase the surface 6 inches of mucks with 0.1 pH unit.

5.2 Using the Cornell pH Test Kit

General lime recommendations can be obtained by using initial soil pH, desired pH, and soil texture. Tables 5, 6, and 7 give the *approximate* amounts of lime required to increase the soil pH to 7.0, 6.5, and 6.2, respectively. Lime rates are based on an 8 inch plow depth for these tables as well. The rates should be increased or decreased by 12% for each inch of tillage depth more or less than 8 inches. Because the guidelines are based on average values for the exchange acidity or CEC (measured values can vary widely within a similar soil type), and the field pH kit is accurate within 0.2 pH unit, guidelines obtained using the pH kit are less accurate than those derived from actual soil test data. Especially when the soil pH is below 6.0, it is recommended that the lime requirement be obtained from a complete soil test that includes exchangeable acidity and laboratory pH measurement (CNAL, Bradfield Hall, Cornell University, Ithaca NY 14853. Phone: (607) 255-4540; Fax: (607) 255-7656; E-mail: soiltest@cornell.edu). Order forms can be obtained from the CNAL website: www.css.cornell.edu/soiltest/.

> Box 5:
>
> *For soils with a pH of 6.1 or less, have the soil analyzed for pH and exchangeable acidity to obtain accurate lime guidelines.*

Table 5: Approximate rate of lime (tons/acre 100% ENV) required to increase the pH of the soil to 7.0 for alfalfa and soybeans.*

Initial soil pH from pH kit	Sands	Loams	Silt Loams and Loams	Clays and Silty Clay Loams
4.5	2.5	6.0	9.5	13.0
4.6-4.7	2.5	6.0	9.0	12.5
4.8-4.9	2.5	5.5	8.5	12.0
5.0-5.1	2.0	5.0	7.5	10.5
5.2-5.3	1.5	4.0	6.5	8.5
5.4-5.5	1.0	3.0	4.0	6.0
5.6-5.7	1.0	2.0	3.0	4.5
5.8-5.9	1.0	1.5	2.5	3.5
6.0-6.1	0.5	1.5	2.0	3.0
6.2-6.3	0.5	1.0	1.5	2.0
6.4-6.5	0.5	1.0	1.0	1.5
6.6-6.7	0.5	0.5	0.5	1.0

Table 6: Approximate rate of lime (tons/acre 100% ENV) required to increase the pH of the soil to 6.5 for birdsfoot trefoil, wheat and barley.*

Initial soil pH from pH kit	Sands	Loams	Silt Loams and Loams	Clays and Silty Clay Loams
4.5	2.5	5.5	8.5	11.5
4.6-4.7	2.0	5.5	8.0	11.0
4.8-4.9	2.0	5.0	7.5	10.5
5.0-5.1	2.0	4.5	6.5	9.5
5.2-5.3	1.5	3.5	5.0	7.5
5.4-5.5	1.0	2.0	3.0	4.5
5.6-5.7	0.5	1.5	2.0	3.0
5.8-5.9	0.5	1.0	1.5	2.0
6.0-6.1	0.5	0.5	1.0	1.5
6.2-6.3	0.5	0.5	0.5	1.0

Table 7: Approximate rate of lime (tons/acre 100% ENV) required to increase the pH of the soil to 6.2 for clovers, corn, oats and grasses.*

Initial soil pH from pH kit	Sands	Loams	Silt Loams and Loams	Clays and Silty Clay Loams
4.5	2.0	5.0	7.5	10.5
4.6-4.7	2.0	5.0	7.5	10.0
4.8-4.9	2.0	4.5	7.0	9.5
5.0-5.1	1.5	4.0	6.0	8.5
5.2-5.3	1.5	3.0	4.5	6.5
5.4-5.5	0.5	1.5	2.5	3.5
5.6-5.7	0.5	1.0	1.5	2.0
5.8-5.9	0.5	0.5	1.0	1.0

* Lime rates are based on an 8 inch plow depth and need to be reduced or decreased by 12% for each inch shallower or deeper than 8 inches. Also decrease the lime rate by one-third if the soil is gravelly.

6. Decreasing Soil pH

For field crops, decreasing the soil pH is not necessary or economical in most cases. However, there are acid loving plants such as blueberries that do not tolerate moderate to high pH values, and crops that require a lower pH to control soil born diseases. Potatoes are an example of the latter. If the pH of a soil needs to be decreased, acid-forming organic or inorganic materials need to be added. Organic materials that are effective are leaf mold, pine needles, tanbark, sawdust, and acid moss peat. Inorganic chemicals include aluminum sulfate, ferrous sulfate (for plants that require large amounts of iron), and elemental sulfur. Sulfur is usually less expensive and more effective than on a per pound basis, but may require up to a year for complete reaction. The amount to be added depends on the soil's buffering capacity and its original pH level. More information on lowering soil pH for production of blueberries can be found in Table 4 of the 2006 Pest Management Guidelines for Berry Crops (Section 2.6, http://www.hort.cornell.edu/extension/commercial/fruit/Berries/pestman/pdfs/2006BerryGuidelines.pdf.

7. Liming Materials

> Box 6:
>
> *Agricultural lime is a product whose Ca and Mg compounds neutralize acidity:*
>
> CaO - Calcium oxide
> *(Lime, Burned lime, Quick lime)*
>
> $Ca(OH)_2$ - Calcium hydroxide
> *(Hydrated lime, slaked lime)*
>
> $CaCO_3$ - Calcium carbonate
> *(Calcitic limestone)*
>
> $CaCO_3$, $MgCO_3$ - Ca and Mg carbonates
> *(Dolomitic limestone)*

New York State law defines agricultural liming material as: "all materials and all calcium and magnesium products in the oxide, hydrate, carbonate or silicate form or combinations thereof and intended for use in the correction of soil acidity, including such forms of material designated as burned lime, hydrated lime, carbonate of lime, agricultural limestone, slag and marl" (§ 142-aa). Common materials are listed in Box 6. These materials react with water and CO_2 in the soil to form Ca^{2+} and/or Mg^{2+} and bicarbonate $(HCO_3)^{2-}$. The Ca^{2+} and Mg^{2+} replace H^+ and Al^{3+} on the exchange complex releasing H^+ and Al^{3+} into the soil solution. The bicarbonate reacts with the H^+ and Al^{3+} to form CO_2 and neutral compounds such as water and $Al(OH)_3$. Thus, the liming process contains two steps: (1) replacement of H^+ and Al^{3+} on the exchange complex; and (2) neutralization of the H^+ and Al^{3+} ions in solution by the bicarbonate. This process is shown in Figure 6.

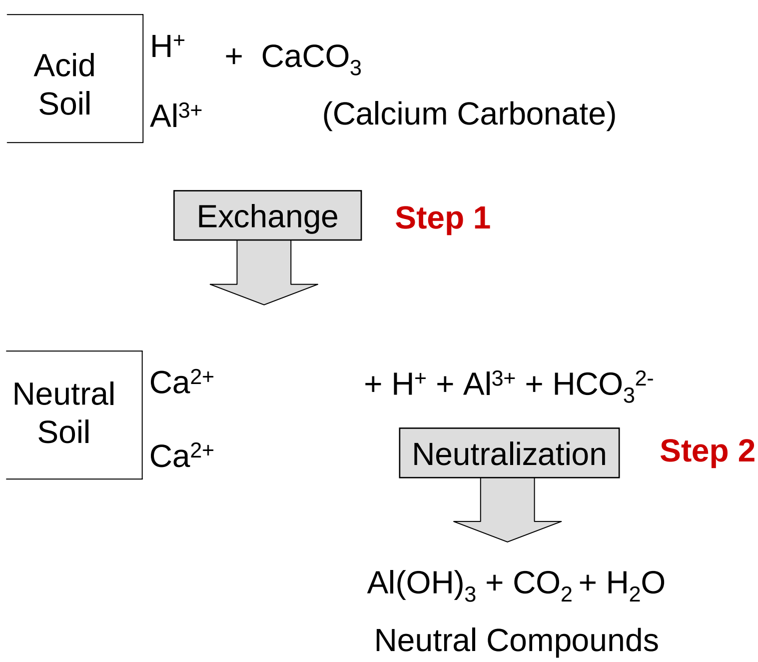

Figure 6: Two-step reaction of agricultural lime (in this case $CaCO_3$) with the soil.

It is a fairly common misconception that gypsum is a liming material. Gypsum is calcium sulfate ($CaSO_4$). The Ca in gypsum can displace the H^+ and Al^{3+} on the soil's exchange complex but the sulfate cannot neutralize the acidity. Thus, gypsum is not a liming material. It is however, an excellent source of calcium and sulfur because it does not alter soil pH.

Box 7:

Gypsum is not a liming material. It is, however, an excellent source of calcium and sulfur.

To compare one liming material with another, quality standards must be used. The total neutralizing value (TNV) of a liming material is usually expressed as the Calcium Carbonate Equivalent (CCE) of the material. To calculate the CCE of a lime source, divide 100 by the molecular mass of the liming material and multiply this ratio by 100. For example, the molecular mass of CaO is 40+16=56 so the CCE of pure CaO is (100/56)*100=179% (Table 8). This means that 1 ton of CaO will neutralize as much as 1.79 tons of pure calcium carbonate. In other words, if one ton of pure calcium carbonate is needed, this requirement can be met with 100/179=0.56 tons of CaO.

Table 8: Common liming materials (assume 100% pure materials).

Chemical name	Common Name	Chemical Formula	Calcium Carbonate Equivalent
Calcium carbonate	calcitic lime stone,	$CaCO_3$	100
Ca,Mg carbonate	dolomitic lime stone	$CaMg(CO_3)_2$	109
Calcium oxide	lime, burned lime, quick lime	CaO	179
Calcium hydroxide	hydrated lime, slaked lime	$Ca(OH)_2$	136

For a given amount of acidity, a corresponding amount of liming material is needed regardless of the fineness of the material. However, the finer the material, the quicker it will react (Figure 7). Particle size distribution is measured by passing the material through a set of sieves. Sieve sizes are expressed as the number of wires per inch so materials that pass through a 100 mesh sieve are much finer than materials that pass through a 60 mesh sieve.

The rate of reaction of a liming material is determined by the particle sizes of the material; 100% of lime particles passing a 100-mesh screen will react within the 1st year while only 60% of the liming materials passing a 20-mesh sieve (but held on 100 mesh sieve) will react within a year. Material that does not pass the 20 mesh sieve is not expected to react within a 1 year following application. Oxides and hydroxides are typically in powder form so 100% of the material is assumed to react within the year of application. These materials react with water so care must be taken to avoid direct contact with skin and eyes. For other lime sources, CCE needs to be adjusted for the fineness of the material.

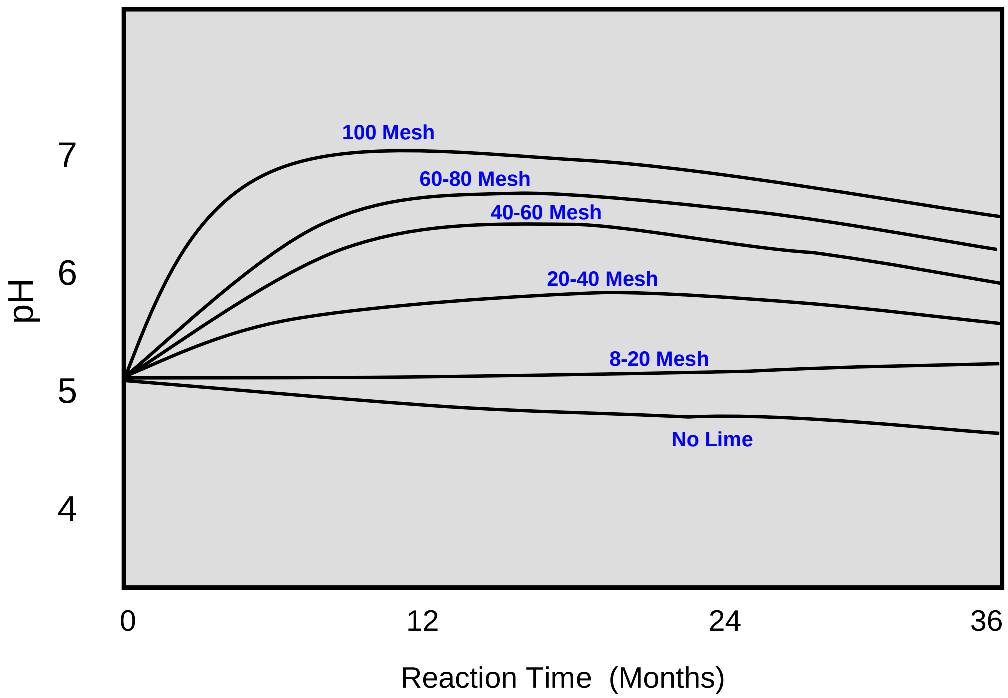

Figure 7: Liming materials react faster or slower depending on fineness of the material.

To determine the fineness factor of a limestone (1) subtract the % passing a 100 mesh sieve from the % passing a 20 mesh sieve and multiply this percentage by 0.60; and (2) add the % passing the 100 mesh sieve to the value obtained in step 1 and divide the sum by 100. For example: the fineness of a material of which 70% passes a 100 mesh sieve and 97% passes a 20 mesh sieve is {(97-70)*0.60 +70}/100=0.86.

Once we know the CCE and the fineness of a liming material, we can calculate its Effective Neutralizing Value (ENV). The ENV is calculated by multiplying a liming material's CCE and its fineness factor. As an example: a liming material with CCE of 90% and a fineness of 0.86 has an ENV of 90*0.86= 77.4.

As mentioned before, recommendations on a soil test report are based on 100% ENV equivalent material. To determine the actual application rate, divide the recommended rate by the ENV and then multiply by 100. Thus, if 2 tons/acre 100% ENV is recommended, this can be satisfied with 2 tons/acre calcitic limestone, 1.1 ton/acre burned lime (2/179*100), or 1.5 tons/acre hydrated lime (2/136*100). To compare liming materials for cost effectiveness, compare the price per ENV and not the cost per lbs of product. Examples are given on page 18.

If a soil is deficient in magnesium, the use of dolomitic limestone is recommended as it is the most economic way to provide magnesium to acidic soils.

Example 5:

Lime source: CCE = 78.8%, 70% passes a 100 mesh sieve, 97% passes 20 mesh. I need 3 tons/acre 100% ENV material. How much of this lime source to use?

Answer:
CCE = 78.8%
Fineness factor = {(97-70)*0.60 +70}/100=0.86
ENV = CCE*fineness factor = 78.8*0.86 = 67.8%
Required: 3 tons/acre 100% ENV
= 3*(100/67.8) = 4.2 tons/acre of this material

Example 6:

Lime source A has an ENV of 70% and costs $30/ton. Source B costs $35 per ton but has an ENV of 85%. I have a 50 acre field that needs 3 tons of 100% ENV per acre. How much material do I need of source A versus source B and what material is most costs effective?

Answer:
Amount needed:
Lime A: 50*3/0.70=214.3 tons (4.3 tons/acre)
Lime B: 50*3/0.85=176.5 tons (3.5 tons/acre)
Total costs:
Lime A: 214.3*$30=$6429 ($128.57/acre)
Lime B: 176.5*$35= $6176 ($123.53/acre)
Lime source B is more cost-effective ($5/acre cheaper than source A).

8. NEW YORK LIME LAW

The New York State Department of Agriculture and Markets (NYSDAM) regulates agricultural liming materials as outlined in Article 9-A: Sale of Agricultural Liming Materials (http://public.leginfo.state.ny.us/menuf.cgi, link to "Laws of New York", AGM Agriculture and Markets, Article 9-A "Sale of Agricultural Liming Materials").

Sections 142-cc and 142-gg in Article 9-A state that for New York, a liming material must be properly labeled with guaranteed analyses and have a CCE of 60% or greater, at least 80% must pass a 20 mesh sieve, and 30% must pass a 100 mesh sieve. This implies that the fineness factor should be greater than or equal to 0.60 and that the ENV should be 36% or greater:

---

§ 142-cc: *"No agricultural liming material shall be sold, offered, or exposed for sale, bartered, given or otherwise supplied in this state unless there shall be affixed to each package in a conspicuous place on the outside thereof a plainly printed, stamped or* *otherwise marked label, tag or statement or in the case of bulk sales or transfers there shall be provided a certified weigh slip plainly printed, stamped or otherwise marked, which shall certify as follows:*

1. *The name, principal office address, and plant location of the manufacturer, producer or distributor.*
2. *The identification of the product as to the type of liming material.*
3. *The brand under which it is sold or supplied.*
4. *A statement expressing the minimum total neutralizing value stated as* ***calcium carbonate equivalence*** *and the minimum* ***fineness****, at time of delivery.*
5. *The net weight of the material.*
6. *The kind and amount of adulterant or foreign material therein, if any, expressed by weight of the material.*
7. *In the case of any material which has been damaged, hydrated, adulterated or otherwise changed subsequent to the original packaging, labeling, or loading thereof and before delivery to the consumer, a plainly marked notice to that effect shall be affixed by the vendor to the package or accompanying statement, such notice to identify the kind and degree of such damage, hydration, adulteration or other change therein.*
8. *A guarantee of the calcium and magnesium content expressed as a percentage by weight of each such element.*
9. *For agricultural liming material sold in bulk, a guarantee of the percentage of its* ***effective neutralizing value****, as determined in accordance with regulations adopted by the commissioner. Such value shall also be expressed separately as the weight of such bulk material necessary to equal one ton of agricultural liming material having and effective neutralizing value of one hundred percent.*

At every site, from which agricultural liming products are delivered in bulk, and at every place where consumer orders for bulk deliveries are placed, there shall be conspicuously posted a copy of the statement required by this section for each brand of material.

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§ 142-bb. Prohibition. 1. *No person shall sell, offer or expose for sale, barter, give or otherwise supply in this state as an agricultural liming material, except as provided in subdivision two of this section, any product which does not have* ***a minimum*** *total neutralizing value of* ***sixty per centum calcium carbonate equivalence*** *and, except hydrated lime and burned lime,* ***a minimum fineness of eighty per centum passing a twenty mesh sieve and thirty per centum passing a hundred mesh sieve*** *nor for which a certificate of registration has not been filed and a license has not been issued pursuant to this article; nor shall he or she permit any claim or guarantee to be indicated upon any label, tab, or package or accompanying statement to the effect that such material possesses a higher specification than such material does in fact contain; nor shall he or she sell, offer or expose for sale, barter, give or otherwise supply any such material adulterated with any substance injurious to the growth of plants (other than weeds) or animals or humans when applied in accordance with directions for use accompanying the product; nor shall he or she sell, offer or expose for sale any agriculture liming material in this state without a label or accompanying statement and weigh slip as required by section one hundred forty-two-cc.*

2. Insofar as it shall be used as an agricultural liming material in this state, no person shall sell, offer or expose for sale, barter, give or otherwise supply in this state as wood ash, any product which does not have a minimum total neutralizing value of thirty per centum calcium carbonate equivalence and otherwise satisfy the requirements set forth in subdivision one of this section.

(Verified June 5, 2006).

9. Timing Considerations

Successful crop production, especially with pH sensitive legumes, requires pH adjustments well in advance of planting. If the soil pH is 6.0 or less and a new legume seeding is planned, the liming materials should be applied at least six months before seeding for the lime to react with the entire plow layer. If there is insufficient time for an adequate reaction, half of the recommended lime should be plowed down and the remainder disked into the soil surface before seeding. If the pH is 5.5 or lower, apply lime and defer seeding until next year (for no-till seeding guidelines see Section 5: Calculating Lime Requirements). Many New York State farmers have had great success with applying soil test based recommended lime rates for alfalfa fields while the field is still in corn. Another approach is to lime during the last year of hay in the rotation, making the lime application directly after second or third cutting when soils are dry and best able to support heavy lime application equipment, thus minimizing the risk of soil compaction. Also, as the sod re-grows, it will help prevent runoff of the lime as a result of heavy rains on fields that prone to runoff. Lime applied to corn stubble requires some type of incorporation (light disking, field cultivator, or chisel plow). A cover crop of oats or winter rye will help provide further protection against soil erosion.

> Box 7:
>
> *Timing of lime application is important! If the soil pH is 6.0 or less and a new legume seeding is planned, the liming materials should be applied at least six months before seeding. If the pH is 5.5 or lower, apply lime a year in advance of the new legume seeding. When the lime requirement is more than 4 tons/acre (100% ENV), use a split application.*

If a rapid increase in pH is desired, calcium oxide (burned lime or quick lime) or hydroxide sources (hydrated lime or slaked lime) can be considered. As explained in Section 7 (Liming Materials), these sources increase the pH of the soil much faster than calcitic or dolomitic limestones. This could be desirable if a quick increase in pH is needed. However the effects are of shorter duration. Additional care must be taken when handling calcium oxide and hydroxide sources as they react quickly with water.

Regardless of crop, when the lime requirement is greater than 4 tons/acre, plow down half of the lime required and work the remainder into the surface. Generally, for economic returns, it is recommended to not apply more than ~6 tons 100% ENV within a 4 to 5 year rotation. If more is required, apply up to 6 tons in the current rotation and retest the soil again in 3 years. If rates are desired on a 1,000 square feet basis, rates in tons/acre need to be divided by 0.02 to equal pounds of lime per 1,000 square feet.

REFERENCES

- Brady, N.C., and R.R. Weil (1996). The nature and properties of soils. Prentice-Hall, Inc. Upper Saddle River NJ.
- Cornell Cooperative Extension (2006). 2006 Cornell guide for integrated field crop management. Accessible via: http://www.fieldcrops.org.
- Greweling, T. and M. Peech (1965). Chemical soil tests. Cornell University Agricultural Experiment Station, Cornell University, Ithaca NY.
- Lathwell, D.J. and M. Peech (1973). Interpretation of chemical soil tests. Bulletin 995. Cornell University Agricultural Experimental Station, New York College of Agriculture and Life Sciences, Cornell University, Ithaca, NY. 40 pages.
- National Atmospheric Deposition Program (NRSP-3). 2006. NADP Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820.

Relevant Cornell Agronomy Fact Sheets include:

Agronomy Fact Sheet # 1: Soil Sampling for Field Crops
Agronomy Fact Sheet # 5: Soil pH for Field Crops
Agronomy Fact Sheet # 6: Lime Recommendations
Agronomy Fact Sheet # 7: Liming Materials

These Fact Sheets are accessible at:

http://nmsp.css.cornell.edu/publications/factsheets.asp

APPENDICES

Appendix A: Cornell Cooperative Extension Offices

County	Telephone	County	Telephone	County	Telephone
Albany	(518) 765-3500	Hamilton	(518) 548-6191	Rockland	(845) 429-7085
Allegany	(716) 699-5701	Herkimer	(315) 866-7920	St. Lawrence	(315) 379-9192
Broome	(607) 772-8954	Jefferson	(315) 788-8450	Saratoga	(518) 885-8995
Cattaraugus	(716) 699-2377	Lewis	(315) 376-5270	Schenectady	(518) 372-1622
Cayuga	(315) 255-1183	Livingston	(585) 658-3250	Schoharie	(518) 234-4303
Chautauqua	(716) 664-9502	Madison	(315) 684-3001	Schuyler	(607) 535-7161
Chemung	(607) 734-4453	Monroe	(716) 461-1000	Seneca	(315) 539-9251
Chenango	(607) 334-5841	Montgomery	(518) 762-3909	Steuben	(607) 664-2300
Clinton	(518) 561-7450	Naussau	(516) 292-7990	Suffolk	(631) 727-7850
Columbia	(518) 828-3346	Niagara	(716) 433-8839	Sullivan	(845) 292-6180
Cortland	(607) 753-5077	Oneida	(315) 736-3394	Tioga	(607) 687-4020
Delaware	(607) 865-6531	Onondaga	(315) 424-9485	Tompkins	(607) 272-2292
Dutchess	(845) 677-8223	Ontario	(585) 394-3977	Ulster	(845) 340-3990
Erie	(716) 652-5400	Orange	(845) 344-1234	Warren	(518) 623-3291
Essex	(518) 962-4810	Orleans	(585) 798-5191	Washington	(518) 746-2560
Franklin	(518) 483-7403	Oswego	(315) 963-7286	Wayne	(315) 331-8415
Fulton	(518) 762-3909	Otsego	(607) 547-2536	Westchester	(914) 285-4620
Genesee	(585) 343-3040	Putnam	(845) 278-6738	Wyoming	(585) 786-2251
Greene	(518) 622-9820	Rensselaer	(518) 272-4210	Yates	(315) 536-5123
NY city	(212) 340-2900				

Appendix B: Desired and Minimum pH for NY Field Crops

Crop Code	Desired pH	Minimum pH	Crop Description
ABE	7.0	6.7	Alfalfa trefoil grass, Establishment
ABT	7.0	6.7	Alfalfa trefoil grass, Topdress
AGE	7.0	6.7	Alfalfa grass, Establishment
AGT	7.0	6.7	Alfalfa grass, Topdress
ALE	7.0	6.7	Alfalfa, Establishment
ALT	7.0	6.7	Alfalfa, Topdress
BCE	6.5	6.4	Birdsfoot trefoil clover, Establishment
BCT	6.5	6.4	Birdsfoot trefoil clover, Topdress
BGE	6.5	6.4	Birdsfoot trefoil grass, Establishment
BGT	6.5	6.4	Birdsfoot trefoil grass, Topdress
BSE	6.5	6.4	Birdsfoot trefoil seed, Establishment
BST	6.5	6.4	Birdsfoot trefoil seed, Topdress
BTE	6.5	6.4	Birdsfoot trefoil, Establishment
BTT	6.5	6.4	Birdsfoot trefoil, Topdress
BSP	6.5	6.4	Spring barley
BSS	6.5	6.4	Spring barley with legumes
BUK	6.2	6.0	Buckwheat
BWI	6.5	6.4	Winter barley
BWS	6.5	6.4	Winter barley with legumes
CGE	6.2	6.0	Clover grass, Establishment
CGT	6.2	6.0	Clover grass, Topdress
CLE	6.2	6.0	Clover, Establishment
CLT	6.2	6.0	Clover, Topdress
CSE	6.2	6.0	Clover seed production, Establishment
CST	6.2	6.0	Clover seed production, Topdress
COG	6.2	6.0	Corn grain
COS	6.2	6.0	Corn silage
CVE	6.2	6.0	Crownvetch, Establishment
CVT	6.2	6.0	Crownvetch, Topdress
GIE	6.2	6.0	Grasses intensively managed, Establishment
GIT	6.2	6.0	Grasses intensively managed, Topdress
GRE	6.2	6.0	Grasses, Establishment
GRT	6.2	6.0	Grasses, Topdress
PGE	6.2	6.0	Pasture, Establishment
PGT	6.2	6.0	Pasture improved grasses, Topdress
PIE	6.2	6.0	Pasture intensively grazed, Establishment
PIT	6.2	6.0	Pasture intensively grazed, Topdress

Appendix Table A (continued):

Desired and Minimum pH for NY Field Crops

Crop Code	Desired pH	Minimum pH	Crop Description
PLE	6.2	6.0	Pasture with legumes, Establishment
PLT	6.2	6.0	Pasture with legumes, Topdress
PNT	6.2	6.0	Pasture native grasses
RYC	6.2	6.0	Rye cover crop
RYS	6.2	6.0	Rye seed production
TRP	6.5	6.0	Triticale peas
MIL	6.2	6.0	Millet
OAS	6.2	6.0	Oats with legume
OAT	6.2	6.0	Oats
SOF	6.2	6.0	Sorghum forage
SOG	6.2	6.0	Sorghum grain
SOY	7.0	6.7	Soybeans
SSH	6.2	6.0	Sorghum sudan hybrid
SUD	6.2	6.0	Sudangrass
WHS	6.2	6.0	Wheat with legume
WHT	6.5	6.5	Wheat
SUN	6.5	6.4	Sunflower

Appendix C: Lime Index and Soil Management Group for NY Soils.

Soil Name	SMG	Lime Index
Acton	4	
Adams	5	
Adirondack	4	
Adjidaumo	1	
Adrian	6	
Agawam	4	
Albia	3	
Albrights	2	
Alden	3	
Allagash	5	
Allard	3	
Allendale	3	
Allis	3	
Alluvial Land	3	
Almond	3	
Alps	3	
Altmar	5	
Alton	5	
Amboy	4	
Amenia	4	H
Angola	2	
Appleton	2	
Arkport	4	
Armagh	2	
Arnot	3	
Ashville	3	
Atherton	3	
Atkins	3	
Atsion	5	
Au Gres	5	
Aurelie	3	
Aurora	2	
Barbour	3	
Barcelona	3	
Barre	1	
Bash	3	

Soil Name	SMG	Lime Index
Basher	3	
Bath	3	
Becket	4	
Becraft	3	
Belgrade	3	
Benson	4	H
Berkshire	5	
Bernardston	4	
Berrien	5	
Berryland	5	
Beseman	6	
Bice	5	
Biddeford	2	
Birdsall	3	
Blasdell	3	
Bombay	4	
Bonaparte	4	
Bono	1	
Boots	6	
Borosaprists	6	
Boynton	3	
Braceville	4	
Brayton	4	
Bridgehampton	3	
Bridport	2	
Briggs	4	
Brinkerton	2	
Broadalbin	4	
Brockport	1	
Brookfield	3	
Buckland	3	
Bucksport	6	
Budd	4	
Burdett	2	
Burnham	3	
Busti	3	

Soil Name	SMG	Lime Index
Buxton	2	
Cambria	2	
Cambridge	3	
Camillus	3	H
Camroden	3	
Canaan	4	
Canaan-rock outcrop	4	
Canadice	2	
Canandaigua	3	
Canaseraga	3	
Canastota	2	
Caneadea	2	
Canfield	3	
Canton	4	
Carbondale	6	
Carlisle	6	
Carrollton	3	
Carver	5	
Carver-Plymouth	5	
Castile	4	
Cathro	6	
Cathro-Greenwood	6	
Cattaraugus	3	
Cavode	2	
Cayuga	2	
Cazenovia	2	
Ceresco	3	
Chadakoin	3	
Chagrin	3	
Champlain	5	
Charles	3	
Charlton	4	
Chatfield	4	
Chaumont	1	
Chautauqua	3	
Cheektowaga	5	
Chenango	3	
Cheshire	4	
Chippeny	6	

Soil Name	SMG	Lime Index
Chippewa	3	
Churchville	2	
Cicero	2	
Clarkson	2	H
Claverack	4	
Clymer	4	
Cohoctah	4	
Collamer	3	
Colonie	5	
Colosse	4	
Colrain	4	
Colton	5	
Colwood	3	
Conesus	2	
Conotton	3	
Constable	5	
Cook	5	
Copake	4	
Cornish	3	
Cosad	4	
Cossayuna	4	
Covert	4	
Coveytown	4	
Covington	1	
Crary	4	
Croghan	5	
Culvers	3	
Dalbo	3	
Dalton	3	
Danley	2	
Dannemora	4	
Darien	2	
Dawson	6	
Deerfield	5	
Deford	4	
Dekalb	4	
Depeyster	3	
Deposit	3	
Derb	3	

Soil Name	SMG	Lime Index
Dixmont	5	
Dorval	6	
Dover	4	H
Duane	4	
Dunkirk	3	
Dutchess	4	
Duxbury	4	
Edwards	6	
Eel	2	
Eelweir	4	
Elka	4	
Ellery	3	
Elmridge	5	
Elmwood	4	
Elnora	5	
Empeyville	4	
Enfield	3	
Ensley	3	
Erie	3	
Ernest	3	
Essex	5	
Fahey	5	
Farmington	3	H
Farnham	4	
Fernlake	4	
Fonda	2	
Fredon	4	
Freetown	6	
Fremont	2	
Frenchtown	3	
Frewsburg	3	
Fryeburg	3	H
Fulton	1	
Gage	3	
Galen	4	
Galestown	5	
Galoo	4	
Galoo-rock outcrop	4	
Galway	4	

Soil Name	SMG	Lime Index
Genesee	2	
Georgia	4	
Getzville	3	
Gilpen	3	
Gilpin	3	
Glebe	4	
Glebe-Saddleback	4	
Glendora	4	
Glenfield	3	
Gloucester	4	
Glover	4	
Gougeville	5	
Granby	5	
Grattan	5	
Greene	3	
Greenwood	6	
Grenville	4	H
Gretor	3	
Groton	4	
Groveton	4	
Guff	1	
Guffin	1	H
Gulf	4	
Hadley	3	
Haights	3	
Haights-Gulf	2	
Hailesboro	3	
Halcott	2	
Halsey	4	
Hamlin	2	
Hamplain	2	
Hannawa	4	
Hartland	4	
Haven	4	
Hawksnest	3	
Hempstead	4	
Henrietta	6	
Herkimer	3	
Hermon	4	

Soil Name	SMG	Lime Index
Hero	4	
Heuvelton	2	
Hilton	2	H
Hinckley	5	
Hinesburg	4	
Hogansburg	4	H
Hogback	5	
Hogback-Ricker	5	
Holderton	3	
Hollis	4	
Holly	2	
Holyoke	3	
Holyoke-rock outcrop	3	
Homer	2	
Honeoye	2	H
Hoosic	4	
Hornell	2	
Hornellsville	3	
Houghtonville	5	
Houghtonville-Rawson	5	
Housatonic	3	
Houseville	2	
Howard	3	
Hudson	2	
Hulberton	2	
Ilion	2	
Insula	4	
Ipswich	6	
Ira	4	
Ischua	3	
Ivory	2	
Jebavy	5	
Joliet	4	
Junius	5	
Kalurah	4	
Kanona	2	
Kars	4	
Kearsarge	3	
Kendaia	2	

Soil Name	SMG	Lime Index
Kibbie	3	
Kingsbury	1	
Kinzua	3	
Knickerbocker	5	
Lackawanna	3	
Lagross	3	
Lagross-Haights	3	
Lairdsville	2	
Lakemont	1	
Lakewood	5	
Lamson	4	
Lanesboro	3	
Langford	3	
Lansing	2	
Leck Kill	3	
Leicester	4	
Leon	5	
Lewbath	3	
Lewbeach	3	
Leyden	2	
Lima	2	H
Limerick	3	
Linden	4	
Linlithgo	3	
Livingston	1	
Lobdell	3	
Lockport	2	
Lordstown	3	
Lovewell	2	
Lowville	4	
Loxley	6	
Lucas	2	
Ludlow	4	
Lupton	6	
Lyman	4	
Lyman-Becket-Berkshire	4	
Lyme	5	
Lyons	2	
Machias	4	

Soil Name	SMG	Lime Index
Macomber	4	
Macomber-Taconic	4	
Madalin	1	
Madawaska	5	
Madrid	4	
Malone	4	
Manahawkin	6	
Mandy	3	
Manheim	2	
Manhoning	2	
Manlius	3	
Mansfield	3	
Maplecrest	2	
Marcy	3	
Mardin	3	
Marilla	3	
Markey	6	
Marlow	4	
Martisco	6	
Massena	4	
Matoon	1	
Matunuck	6	
Medihemists	6	
Medomak	3	
Melrose	4	
Menlo	4	
Mentor	4	
Merrimac	4	
Middlebrook	3	
Middlebrook-Mongaup	3	
Middlebury	3	
Millis	4	
Millsite	4	
Mineola	4	
Miner	1	
Mino	4	
Minoa	4	
Mohawk	2	
Moira	4	

Soil Name	SMG	Lime Index
Monadnock	4	
Monarda	4	
Mongaup	3	
Montauk	4	
Mooers	5	
Morocco	4	
Morris	3	
Mosherville	4	
Muck	6	
Muck-Peat	6	
Mundal	4	
Mundalite	3	
Mundalite-Rawsonvill	3	
Munson	2	
Munuscong	4	
Muskego	6	
Muskellunge	3	
Napoleon	6	
Napoli	3	
Nassau	4	
Naumburg	5	
Nehasne	4	
Nellis	4	H
Neversink	4	
Newfane	4	
Newstead	4	
Newton	5	
Niagara	3	
Nicholville	4	
Ninigret	4	
Norchip	3	
Norwell	5	
Norwich	3	
Nunda	2	
Oakville	5	
Occum	4	
Odessa	2	
Ogdensburg	4	
Olean	2	

Soil Name	SMG	Lime Index
Ondawa	4	
Oneida	4	
Onoville	3	
Ontario	2	
Onteora	3	
Ontusia	3	
Oquaga	3	
Oramel	2	
Organic	6	
Orpark	2	
Orwell	2	
Ossipee	6	
Otego	2	
Otisville	4	
Otsego	3	
Ottawa	5	
Ovid	2	
Palatine	2	H
Palms	6	
Palmyra	3	
Panton	1	
Papakating	2	
Parishville	4	
Parsippany	1	
Patchin	3	
Pawcatuck	6	
Pawling	4	
Paxton	4	
Peacham	3	
Peat	6	
Peat-Muck	6	
Peru	4	
Petoskey	4	
Phelps	3	
Philo	3	
Pillsbury	4	
Pinckney	3	
Pipestone	5	
Pittsfield	4	

Soil Name	SMG	Lime Index
Pittstown	4	
Plainbo	5	
Plainfield	5	
Plessis	3	
Plymouth	4	
Podunk	4	
Poland	2	
Pompton	4	
Pootatuck	4	
Pope	4	
Potsdam	4	
Poygan	1	
Punsit	3	
Pyrities	4	
Quetico	4	
Quetico-Rock Outcrop	4	
Raquette	4	
Rawsonville	5	
Rawsonville-Beseman	5	
Rayne	3	
Raynham	3	
Raypol	3	
Red Hook	4	
Redwater	3	
Remsen	2	
Retsof	2	
Rexford	4	
Rhinebeck	2	
Ricker	4	
Ricker-Lyman	4	
Ridgebury	4	
Rifle	6	
Riga	2	
Rippowam	4	
Riverhead	4	
Rockaway	2	
Romulus	2	
Ross	2	
Roundabout	3	

Soil Name	SMG	Lime Index
Rumney	2	
Runeberg	4	
Ruse	4	
Rushford	3	
Saco	3	
Salamanca	3	
Salmon	4	
Saprists	6	
Saugatuck	5	
Scantic	2	
Scarboro	4	
Schoharie	1	
Schroon	5	
Schuyler	3	
Scio	3	
Scituate	4	
Scriba	4	
Searsport	4	
Shaker	2	
Shoreham	2	
Sisk	4	
Skerry	5	
Sloan	3	
Sodus	4	
Somerset	5	
St Johns	4	
Staatsburg	3	H
Stafford	4	
Steamburg	3	
Stetson	5	
Stissing	4	
Stockbridge	3	
Stockholm	5	
Stowe	4	
Sudbury	4	
Suffield	2	
Summerville	4	H
Sun	4	
Sunapee	4	

Soil Name	SMG	Lime Index
Suncook	5	
Suny	4	
Surplus	4	
Surplus-Sisk	4	
Sutton	4	
Swanton	4	
Swartswood	4	
Swormville	1	
Taconic	3	
Taconic-Macomber	3	
Tawas	6	
Teel	2	
Tioga	3	
Toledo	2	
Tonawanda	2	
Tor	4	
Torull	3	
Towerville	3	
Trestle	3	
Trout River	5	
Troy	3	
Trumbull	1	
Tughill	4	
Tuller	3	
Tunbridge	4	
Tunbridge-Adirondack	4	
Tunkhannock	3	
Turin	2	
Tuscarora	4	
Unadilla	3	
Valois	3	
Varick	2	
Varysburg	2	
Venango	3	
Vergennes	1	
Vly	3	
Volusia	3	
Waddington	4	
Wainola	5	

Soil Name	SMG	Lime Index
Wakeland	3	
Wakeville	3	
Wallace	5	
Wallington	3	
Wallkill	3	
Walpole	4	
Walton	3	
Wampsville	3	
Wappinger	3	
Wareham	5	
Warners	3	
Wassaic	4	
Watchaug	4	
Waumbeck	4	
Wayland	2	
Weaver	3	H
Wegatchie	3	
Wellsboro	3	
Wenonah	4	
Westbury	4	
Westland	2	
Wethersfield	4	
Wharton	2	
Whately	4	
Whippany	2	

Soil Name	SMG	Lime Index
Whitelaw	4	
Whitman	4	
Wilbraham	4	
Willdin	3	
Willette	6	
Williamson	4	
Willowemoc	3	
Wilmington	4	
Wilpoint	1	
Windsor	5	
Winooski	4	
Wolcottsburg	1	
Wonsqueak	6	
Woodbridge	4	
Woodlawn	4	
Woodstock	4	
Woodstock-rock outcrop	4	
Wooster	3	
Woostern	3	
Woostern-Bath-Valois	3	
Worden	4	
Worth	4	
Wurtsboro	4	
Wyalusing	3	
Yalesville	4	
Yorkshire	3	

Lime Index:
This is the original lime or base saturation status of the soil. Soils classified as High (H) were developed from lime stone and usually have some residual lime in the profile.

Soil Management Group (SMG)
The SMG is determined by their clay content, soil rooting depth and soil structure. A clayey or silty clay loam soil with deep rooting belongs to SMG 1 while a sandy soil is in SMG 5. Most of the silt loam soils in the central plains are group 2 soils and the silt loams of the Southern tier tend to be group 3. For more detail, see the latest Cornell Guide for Integrated Field Crop Management (http://www.fieldcrops.org).

Appendix D: Cornell Lime Guidelines Lookup Tables (Based on 100% ENV and 8 inch plow depth)

Tons of 100% ENV limestone per acre to raise pH to 7.0 (alfalfa, soybeans)

	Exchange Acidity (me/100 gram soil)																				
Soil pH	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Tons of 100% ENV limestone per acre																				
4.4	2.6	3.2	3.7	4.2	4.8	5.3	5.8	6.4	6.9	7.4	7.9	8.5	9.0	9.5	10.1	10.6	11.1	11.7	12.2	12.7	13.2
4.5	2.6	3.2	3.7	4.2	4.7	5.3	5.8	6.3	6.9	7.4	7.9	8.4	9.0	9.5	10.0	10.5	11.1	11.6	12.1	12.6	13.2
4.6	2.6	3.2	3.7	4.2	4.7	5.3	5.8	6.3	6.8	7.4	7.9	8.4	8.9	9.5	10.0	10.5	11.0	11.6	12.1	12.6	13.1
4.7	2.6	3.1	3.7	4.2	4.7	5.2	5.8	6.3	6.8	7.3	7.8	8.4	8.9	9.4	9.9	10.5	11.0	11.5	12.0	12.5	13.1
4.8	2.6	3.1	3.6	4.2	4.7	5.2	5.7	6.2	6.8	7.3	7.8	8.3	8.8	9.3	9.9	10.4	10.9	11.4	11.9	12.5	13.0
4.9	2.6	3.1	3.6	4.1	4.6	5.1	5.7	6.2	6.7	7.2	7.7	8.2	8.7	9.3	9.8	10.3	10.8	11.3	11.8	12.3	12.9
5.0	2.5	3.1	3.6	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6	9.2	9.7	10.2	10.7	11.2	11.7	12.2	12.7
5.1	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5
5.2	2.4	2.9	3.4	3.9	4.4	4.9	5.4	5.9	6.4	6.9	7.3	7.8	8.3	8.8	9.3	9.8	10.3	10.8	11.3	11.8	12.2
5.3	2.3	2.8	3.3	3.7	4.2	4.7	5.1	5.6	6.1	6.5	7.0	7.5	7.9	8.4	8.8	9.3	9.8	10.2	10.7	11.2	11.6
5.4	2.2	2.6	3.0	3.4	3.9	4.3	4.7	5.2	5.6	6.0	6.5	6.9	7.3	7.8	8.2	8.6	9.1	9.5	9.9	10.3	10.8
5.5	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.3	5.7	6.1	6.5	6.9	7.3	7.7	8.1	8.5	8.9	9.3	9.7	10.1
5.6	1.9	2.3	2.7	3.1	3.5	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.5	6.9	7.3	7.7	8.1	8.5	8.9	9.2	9.6
5.7	1.8	2.2	2.6	3.0	3.3	3.7	4.1	4.4	4.8	5.2	5.5	5.9	6.3	6.7	7.0	7.4	7.8	8.1	8.5	8.9	9.2
5.8	1.7	2.1	2.4	2.8	3.1	3.5	3.8	4.2	4.5	4.9	5.2	5.6	5.9	6.3	6.6	7.0	7.3	7.7	8.0	8.4	8.7
5.9	1.6	2.0	2.3	2.6	2.9	3.3	3.6	3.9	4.2	4.6	4.9	5.2	5.5	5.9	6.2	6.5	6.8	7.2	7.5	7.8	8.1
6.0	1.5	1.8	2.1	2.5	2.8	3.1	3.4	3.7	4.0	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4	6.8	7.1	7.4	7.7
6.1	1.5	1.8	2.0	2.3	2.6	2.9	3.2	3.5	3.8	4.1	4.4	4.7	5.0	5.3	5.6	5.8	6.1	6.4	6.7	7.0	7.3

Lime guidelines in this table are based on 100% Effective Neutralizing Value (ENV) and a plow depth of 8 inches. Correct the rate for the actual ENV of the lime source and plow depth.

Tons of 100% ENV limestone per acre to raise pH to 6.5 (birdsfoot trefoil, wheat and barley)

	Exchange Acidity (me/100 gram soil)																				
Soil pH	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Tons of 100% ENV limestone per acre																				
4.4	2.4	2.8	3.3	3.8	4.3	4.7	5.2	5.7	6.2	6.6	7.1	7.6	8.0	8.5	9.0	9.5	9.9	10.4	10.9	11.4	11.8
4.5	2.3	2.8	3.3	3.8	4.2	4.7	5.2	5.6	6.1	6.6	7.0	7.5	8.0	8.4	8.9	9.4	9.9	10.3	10.8	11.3	11.7
4.6	2.3	2.8	3.3	3.7	4.2	4.7	5.1	5.6	6.1	6.5	7.0	7.5	7.9	8.4	8.9	9.3	9.8	10.3	10.7	11.2	11.7
4.7	2.3	2.8	3.2	3.7	4.2	4.6	5.1	5.6	6.0	6.5	6.9	7.4	7.9	8.3	8.8	9.3	9.7	10.2	10.7	11.1	11.6
4.8	2.3	2.7	3.2	3.7	4.1	4.6	5.0	5.5	6.0	6.4	6.9	7.3	7.8	8.2	8.7	9.2	9.6	10.1	10.5	11.0	11.5
4.9	2.3	2.7	3.2	3.6	4.1	4.5	5.0	5.4	5.9	6.3	6.8	7.2	7.7	8.1	8.6	9.0	9.5	9.9	10.4	10.8	11.3
5.0	2.2	2.7	3.1	3.5	4.0	4.4	4.9	5.3	5.8	6.2	6.6	7.1	7.5	8.0	8.4	8.9	9.3	9.7	10.2	10.6	11.1
5.1	2.2	2.6	3.0	3.5	3.9	4.3	4.8	5.2	5.6	6.1	6.5	6.9	7.4	7.8	8.2	8.7	9.1	9.5	10.0	10.4	10.8
5.2	2.1	2.5	2.9	3.3	3.7	4.2	4.6	5.0	5.4	5.8	6.2	6.7	7.1	7.5	7.9	8.3	8.7	9.2	9.6	10.0	10.4
5.3	1.9	2.3	2.7	3.1	3.4	3.8	4.2	4.6	5.0	5.4	5.7	6.1	6.5	6.9	7.3	7.6	8.0	8.4	8.8	9.2	9.6
5.4	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3
5.5	1.5	1.8	2.1	2.4	2.7	2.9	3.2	3.5	3.8	4.1	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.5	6.8	7.1	7.4
5.6	1.3	1.6	1.9	2.1	2.4	2.7	2.9	3.2	3.5	3.8	4.0	4.3	4.6	4.8	5.1	5.4	5.6	5.9	6.2	6.4	6.7
5.7	1.2	1.5	1.7	2.0	2.2	2.5	2.7	3.0	3.2	3.4	3.7	3.9	4.2	4.4	4.7	4.9	5.2	5.4	5.7	5.9	6.2
5.8	1.1	1.3	1.5	1.7	2.0	2.2	2.4	2.6	2.8	3.0	3.3	3.5	3.7	3.9	4.1	4.3	4.6	4.8	5.0	5.2	5.4
5.9	0.9	1.1	1.3	1.5	1.7	1.8	2.0	2.2	2.4	2.6	2.8	2.9	3.1	3.3	3.5	3.7	3.9	4.0	4.2	4.4	4.6
6.0	0.8	0.9	1.1	1.3	1.4	1.6	1.7	1.9	2.1	2.2	2.4	2.5	2.7	2.8	3.0	3.2	3.3	3.5	3.6	3.8	3.9
6.1	0.7	0.8	1.0	1.1	1.2	1.4	1.5	1.6	1.8	1.9	2.1	2.2	2.3	2.5	2.6	2.7	2.9	3.0	3.2	3.3	3.4

Lime guidelines in this table are based on 100% Effective Neutralizing Value (ENV) and a plow depth of 8 inches. Correct the rate for the actual ENV of the lime source and plow depth.

Tons of 100% ENV limestone per acre to raise pH to 6.2 (clovers, corn, oats and grasses)

	Exchange Acidity (me/100 gram soil)																				
Soil pH	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Tons of 100% ENV limestone per acre																				
4.4	2.2	2.6	3.1	3.5	3.9	4.4	4.8	5.2	5.7	6.1	6.5	7.0	7.4	7.9	8.3	8.7	9.2	9.6	10.0	10.5	10.9
4.5	2.2	2.6	3.0	3.5	3.9	4.3	4.7	5.2	5.6	6.0	6.5	6.9	7.3	7.8	8.2	8.6	9.1	9.5	9.9	10.4	10.8
4.6	2.1	2.6	3.0	3.4	3.9	4.3	4.7	5.1	5.6	6.0	6.4	6.9	7.3	7.7	8.1	8.6	9.0	9.4	9.9	10.3	10.7
4.7	2.1	2.5	3.0	3.4	3.8	4.2	4.7	5.1	5.5	5.9	6.4	6.8	7.2	7.6	8.1	8.5	8.9	9.3	9.8	10.2	10.6
4.8	2.1	2.5	2.9	3.3	3.8	4.2	4.6	5.0	5.4	5.9	6.3	6.7	7.1	7.5	8.0	8.4	8.8	9.2	9.6	10.0	10.5
4.9	2.1	2.5	2.9	3.3	3.7	4.1	4.5	4.9	5.3	5.7	6.2	6.6	7.0	7.4	7.8	8.2	8.6	9.0	9.4	9.9	10.3
5.0	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0	8.4	8.8	9.2	9.6	10.0
5.1	1.9	2.3	2.7	3.1	3.5	3.9	4.3	4.7	5.1	5.4	5.8	6.2	6.6	7.0	7.4	7.8	8.2	8.6	9.0	9.3	9.7
5.2	1.8	2.2	2.6	2.9	3.3	3.7	4.1	4.4	4.8	5.2	5.5	5.9	6.3	6.6	7.0	7.4	7.7	8.1	8.5	8.8	9.2
5.3	1.6	2.0	2.3	2.6	3.0	3.3	3.6	3.9	4.3	4.6	4.9	5.3	5.6	5.9	6.2	6.6	6.9	7.2	7.6	7.9	8.2
5.4	1.4	1.6	1.9	2.2	2.4	2.7	3.0	3.2	3.5	3.8	4.1	4.3	4.6	4.9	5.1	5.4	5.7	5.9	6.2	6.5	6.8
5.5	1.1	1.3	1.6	1.8	2.0	2.2	2.5	2.7	2.9	3.1	3.4	3.6	3.8	4.0	4.3	4.5	4.7	4.9	5.2	5.4	5.6
5.6	1.0	1.2	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.5	3.7	3.8	4.0	4.2	4.4	4.6	4.8
5.7	0.8	1.0	1.2	1.3	1.5	1.7	1.8	2.0	2.2	2.3	2.5	2.7	2.8	3.0	3.2	3.3	3.5	3.7	3.8	4.0	4.2
5.8	0.7	0.8	0.9	1.1	1.2	1.3	1.4	1.6	1.7	1.8	2.0	2.1	2.2	2.4	2.5	2.6	2.8	2.9	3.0	3.2	3.3
5.9	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.3
6.0	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5
6.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9

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