Pasture Reclamation Process

1. Mow or close graze

This action allows the disc to penetrate deeper so it can break pasture grass and weeds into small pieces. Mowing is ideally done before weeds go to seed for better weed suppression.

2. Disc

Set the disc to the most aggressive angle to cut through sod and rhizomes. This exposes them to UV rays and kills them.

Wait 2 weeks before moving to step 3.

3. Plow

Deep soil penetration from plowing exposes deep roots and rhizomes to UV rays and turns sod upside-down to start the decomposition process.

Wait 2 weeks before step 4.

4. Apply amendments and Disc

This step will bury any seeds that germinated in the past two weeks, thus reducing weed pressure and weed populations that can adversely affect new forage stand development. This step also begins the process of smoothing the pastures which were left very rough from plowing and turns dead organic matter into the soil.

5. Harrow

Helps to smooth pasture before seeding, creating a firm seed bed.

6. Seed

Triticale, or some other winter cover crop

7. **Light** Harrowing

To cover seeds with a **shallow** amount of soil.

8. Wait

*Seeds will germinate and establish before winter.

NEXT SPRING

1. Mow

Optimum time is when 50% of crop is in bloom.

2. Disc

As soon as possible after mowing, turn organic matter into the soil by discing. This plant material is rich in nitrogen and other plant-nutrients. (This is green manure)!

Wait 2-4 weeks after you disc to allow sufficient time for organic matter to decompose.

3. Harrow

Helps to smooth pasture before seeding, creating a firm seed bed.

4. Plant another cover crop or main forage crop depending on soil quality.

5. **Lightly** Harrow to cover seed with a shallow amount of soil.

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COOPERATIVE EXTENSION

Forage

Improving Pastures and Hayfields

Some pastures and hayfields that need improvement aren't well suited to conventional renovation. A pasture may be too steep or too rocky for conventional tillage operations or a hayfield so "bony" that tilling it would turn up many rocks that you'd have to remove before harrowing and reseeding.

By adjusting soil pH and fertility, managing weeds, and if necessary, reintroducing desirable forage species, you can often make such areas productive again without plowing and reseeding.

Your goals for your pastures and hayfields dictate what measures you will take. Before making any improvements, consider how you intend to use the land. A pasture that must meet all the forage needs for animals requires different treatment than one used primarily as an exercise yard, for example. You'll also need to evaluate the field to determine its current condition and decide how much improvement it needs. Some fields may require complete renovation and reseeding, while others may require something less involved. Finally, consider what resources—equipment, money, and time—you have available to devote to the project.

Soil pH and fertility

To remain productive, a forage stand needs a soil environment where forage plants can thrive. Most plant nutrients become available in optimal amounts in soils with a pH range of 6.0-7.0. Most grasses and clovers do well in soils with a pH between 6.0 and 6.5, while other legumes such as birdsfoot trefoil or alfalfa require a soil pH of 6.5 to 7.0.

To support plant growth, plant nutrients must be present in adequate amounts. Any nutrient deficiencies will compromise the success of the stand. In particular, new seedlings require sufficient levels of available phosphorus and potassium to get established.

A soil test is the best way to determine the fertility of your pastures or hayfields. Follow recommendations closely and make any necessary corrections well in advance of any reseeding. If you need to raise soil pH, remember that lime moves down through the soil profile slowly, and it may take as long as a year before you see any response. Broadcast manure or fertilizer in spring or summer to apply nutrients without disturbing the existing sod.

Soil test forms are available from the UNH Cooperative Extension office in your county, or from the UNH Cooperative Extension website at *http://www.ceinfo.unh.edu/Agriculture/Documents/SoilTest.htm*

Weed management

Weeds are often low in nutritive value, and may crowd out more desirable forage plants. Some weed species are poisonous to livestock. Therefore, any plan to renovate forage stands needs to include weed management.

Many weed species cannot withstand repeated cutting throughout the growing season, so you can control these with more intensive grazing or more frequent mowing. Improving soil fertility will promote vigorous growth of desirable forage species, enabling them to compete successfully against weeds. Some weed species, such as Canada thistle and bedstraw, are more persistent and may require herbicide treatments to eliminate them from pastures or hayfields.

Introducing desirable species

Correcting deficiencies in soil fertility and eliminating weeds is often enough to bring a neglected stand back into production. However, sometimes you need to reseed in order to establish desirable species. There are several reseeding techniques available:

Frost seeding involves spreading seed over an existing sod in late winter or early spring. As the ground heaves and contracts with repeated freezing and thawing, seed on the surface gradually works its way into the soil where it can germinate. While this can be an effective, low-cost method for increasing the proportion of certain species, it is usually successful only 60 percent to 70 percent of the time and is not an effective method for completely renovating fields. For best results:

- Remove plant residue from the field with close grazing or by mowing in the fall before seeding.
- Sow seed in late March or early April. Avoid spreading seed on top of snow cover (a few patches are okay), since rapid melting can cause the seed to wash away.
- Certain species work better with frost seeding than others. Red and white clover germinate rapidly, tolerate shading from other plants, and have small seeds that can penetrate into the soil. Many grasses have bulky seeds that remain on the soil surface. The weak seedlings of birdsfoot trefoil and reed canarygrass are unable to compete in an existing sod. Sow clovers at 2 lb./ acre, grasses at 4 lb./acre.

Overseeding involves using a seed drill or cultipack seeder to sow seed during the growing season in an attempt to improve the composition of a pasture or hayfield. Simply broadcasting seed over the field usually gives poor results. Use a seeder to deposit the seed below the soil surface. Like frost seeding, overseeding will yield minor improvements but is not appropriate for complete field renovation. For best results, remove residues with close grazing or mowing prior to seeding, and sow either in early spring or in late summer to minimize competition from established plants.

No-till seeding involves suppressing or killing the existing sod, then using a no-till seed drill to plant seed directly into the killed sod without tilling the soil with plows or harrows. This method is the best way to completely renovate a stand when field conditions do not allow for conventional tillage. However the equipment required may make no-till impractical for small-scale or part-time operations. No-till drills are too expensive for only occasional use, and while some equipment dealers may have one available for rent they are hard to come by. Should you choose to use this method, the following considerations will help you succeed:

- Because you can't use tillage to incorporate lime or fertilizer, address any pH adjustments or nutrient deficiencies the season before planting.
- The best times for planting are late April to early May and mid-August to early September. Spring seedings are best if field conditions allow you to bring equipment on the field, but late summer seedings are better if the field is too wet to work in spring.

- For spring seedings, apply herbicides the previous fall; for late summer seedings, apply herbicides in midsummer, at least three weeks before seeding.
- Certain species are better suited for no-till seedings than others. Red and white clover, and timothy germinate rapidly, but reed canarygrass and birdsfoot trefoil have weak seedlings that may not compete with weeds effectively.
- When seeding legumes, inoculate seed with the appropriate strain of *Rhizobia* bacteria for proper nodulation.

UNH Cooperative Extension Fact sheets for additional information

Poisonous Plants in a Pasture Setting
Herbicide Recommendations for Specific Weed Problems

Written by Carl Majewski, UNH Extension Educator, Agricultural Resources

UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

Forage

Pasture Production with Selected Forage Species

Many species of grasses and legumes serve as forages. However, not all forage species are suited to New Hampshire's climate and growing season, nor are all species adapted to grazing by animals. To be productive in a pasture system, a plant needs to be able to withstand frequent defoliation, provide regrowth quickly throughout the growing season, and provide sufficient yields of high-quality forage.

Most of the suitable pasture species in New Hampshire can be grouped into cool-season perennials, warm season grasses, and cool season annuals. None of the species listed is any better than the others. Rather, species differ in their ability to perform under certain conditions and management practices. When choosing a forage species for new seedings, consider the conditions of your property and the intended use for the forage stand.

Cool season perennials

These species form the backbone of most pastures in the state. As their name implies, they are most productive during the cool, moist weather conditions we have in spring and early fall. Cool season perennials include both grasses and legumes.

Kentucky bluegrass is a sod-forming grass, and its low growth habit enables it to withstand heavy grazing pressure. This makes it ideal for continuous grazing or areas with heavy traffic. However, Kentucky bluegrass goes dormant under dry conditions and makes management during mid-summer a challenge. Also, it yields less dry matter per acre compared to other grass species.

Orchardgrass is a highly productive bunched grass on sites where it is well adapted. It does best on well-drained soils, and it is tolerant of droughty conditions. Winterkill is occasionally an issue in far northern locations or areas prone to winter ice sheeting. With its upright growth habit, orchardgrass performs best when grazed down to a height of 3-4 inches. It grows rapidly after grazing, allowing you rotate animals back into a paddock in 10-14 days during spring. In fact, its growth is so rapid that keeping up with grass growth can be challenging; most producers harvest surplus grass for supplementing summer pastures or winter feed.

Reed canarygrass is another highly productive grass. It is adapted to a wide range of soil conditions, tolerant of poorly-drained and droughty soils alike. Though it is weak in the seedling stage, it is a vigorous, sod-forming grass once established. Reed canarygrass generally matures one or two weeks after orchardgrass. Older varieties have high concentrations of an alkaloid that make the grass unpalatable; use improved low-alkaloid varieties.

Timothy is a bunched grass that is often included in pasture seed mixes. While it is easy to establish and performs well on moderately well-drained soil, it is not an ideal species for pastures. Droughty soils or dry conditions in mid-summer cause it to go dormant for prolonged periods of time. In addition, timothy does not tolerate heavy grazing pressure. To help it persist, allow a rest period of three or four weeks between rotations.

Perennial ryegrass and tall fescue are other grasses sometimes used in pastures. Perennial ryegrass offers better forage quality than any other grass species, but many varieties are not winterhardy enough to persist for more than two or three growing seasons. While it is not recommended, some producers have had limited success seeding perennial ryegrass varieties with high winterhardiness ratings. Tall fescue is a hardy, productive grass sometimes used in pastures. Forage quality is low compared to other grasses, but it retains its quality after going dormant for the winter. Some producers will save fall growth and use it for early winter grazing—a practice called 'stockpiling'. However, tall fescue is infected with an *endophyte*, a fungus that has a symbiotic relationship with the grass. While the endophyte helps the grass survive, it also can cause some health problems in livestock. Use low-endophyte or 'friendly' endophyte varieties for new seedings.

White/Ladino clover is an ideal legume for pastures. It can withstand frequent defoliation and close grazing to a height of 1-2 inches. When sown with a tall grass like orchardgrass, however, graze the sward to a height of 2-3 inches to prevent either the grass or clover from crowding out the other. Common, or Dutch white clover is a particularly low-growing variety that yields relatively little forage. Ladino clover is an improved variety that offers higher dry matter yields.

Birdsfoot trefoil is a legume that offers many advantages. It performs well under a range of soil conditions and provides very high quality forage. Unlike most other forage legumes, birdsfoot trefoil doesn't cause animals to bloat, even with the lush growth that occurs in spring. However, it is slow-growing and weak as a seedling and therefore difficult to establish in pastures. Once established, it persists well in pastures. Prostrate 'Empire' varieties will tolerate grazing pressure better than more upright 'European' types.

Warm season grasses

While the species mentioned above perform best in cool, moist conditions, they do not produce well in the hot, dry weather of July and August. In an effort to provide forage during this 'summer slump', some producers rely on grasses that prefer warm weather.

Sudangrass/sorghum hybrids are annual species that can provide high yields of quality forage, especially the brown midrib (BMR) varieties. Planting in early or mid-June will provide feed by mid July. Young sudan/ sorghum hybrid plants contain high concentrations of prussic acid, a compound highly toxic to livestock. To avoid any problems, let the stand grow to a height of at least 36 inches before allowing animals to graze, and do not allow animals to graze after a frost. Strip grazing the stand will minimize wasted feed from animals trampling stalks.

Millet, including Japanese, German, Hungarian, and common millets, is another annual grass. It yields less than sudan/sorghum hybrids, but it is sometimes used to provide emergency forage during droughty conditions. Plant in late June or early July for best results, and graze when the stand is between six and 12 inches tall.

Switchgrass and big bluestem are perennial grasses native to the prairies of the Midwest, but some growers use them in the Northeast. Switchgrass tolerates moderately well-drained or poorly drained soils, while big bluestem tolerates droughty conditions. Because they grow slowly, these grasses may take two years to become established. For best winter survival, plant in late May or June.

Cool season annuals

These species tolerate the cooler conditions of late fall, early winter, and early spring, and they can extend the grazing season by an additional month or two.

Small grains such as winter rye, winter triticale, spring barley, and oats provide forage during late fall or early spring. Plant in mid-August for grazing by mid-October. Winter rye, wheat, and triticale stay dormant over the winter and provide additional grazing in early spring before perennial grasses start growing. Although cold winter temperatures kill barley and oats, these grasses will still provide grazing in fall.

Brassicas include turnips, kale, swedes, rape, and tyfon (a hybrid of turnip and cabbage). While all brassicas have edible leaves, turnips and swedes provide feed from their roots as well. They do not survive cold winter conditions, but they thrive under cool fall conditions. Plant from late May to early July for best results. To avoid health problems, introduce livestock to brassicas gradually, and limit their consumption to about 75% of their total dry matter intake. Strip grazing will allow animals to graze while preventing them from trampling and wasting feed.

With proper management, pastures based solely on cool season grasses and legumes can produce satisfactory yields. While warm season grasses and cool season annuals have the potential to improve pasture production during those periods when growth from cool season perennials is slow, growing them may not always be cost-effective. Pastures with stony soils or steep slopes make annual tillage and reseeding impractical. When deciding whether or not to use these species in your pastures, consider your soil conditions and the cost of establishment.

The following table gives recommended seeding rates for pasture forage species.

Species		Seeding rate per acre*	
		Alone	In mixes
Cool season perennials	Kentucky bluegrass	12-15 lb.	8 lb.
	Orchardgrass	10-12 lb.	5 lb.
	Tall fescue	12-15 lb.	8 lb.
	Perennial ryegrass	10-12 lb.	6 lb.
	White/Ladino clover	-	1-2 lb.
	Birdsfoot trefoil	-	6 lb.
Warm season grasses	Sudangrass/sorghum hybrids	65 lb.	-
	Millet (all types)	15-20 lb.	-
	Switchgrass	8-10 lb. PLS	-
	Big bluestem	10-12 lb. PLS**	-
Cool season annuals	Small grains	2 bu.	-
	Brassicas	3-5 lb.	-

*Rates are listed for seedlings planted with seed drills or cultipack seeders. If broadcasting, increase rates by 20%
**PLS - pure live seed. PLS = (% germination x % pure seed) x 100%

Written by Carl Majewski, UNH Extension Educator, Agricultural Resources

UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

Forage

Establishing Forage Seedings

The most important considerations in establishing new forage stands are soil fertility, field preparation, seeding method, and weed management.

Your goals for the forage stand dictate what measures you will take. Before making any improvements, consider how you intend to use the land, and decide what management practices are most appropriate. Also, consider the soil and topography of your property, what species you want to grow, and what resources—equipment, money, and time—you have available to devote to the project.

Soil fertility

To be productive, a forage stand needs an environment where it can thrive. Plant nutrients become optimally available at a soil pH between 6.0 and 7.0. Grasses and clovers do well at a pH between 6.0-6.5, while other legumes such as birdsfoot trefoil or alfalfa require a soil pH of 6.5-7.0. Plant nutrients need to be present in adequate amounts in order to support plant growth, and any deficiencies will compromise the success of the stand. In particular, new seedlings require sufficient levels of available phosphorus and potassium to get established.

A soil test is the best way to determine the fertility status of your pastures or hayfields. Follow the testing laboratory's recommendations closely and make any necessary lime or fertilizer applications well in advance of any reseeding. New seedings made in areas cleared from forests demand particular attention, since pH and fertility in these soils are usually quite low. Apply lime at least six months before you plan to seed. Wherever it's practical, use a disc harrow to incorporate lime thoroughly into the plow layer, rather than leaving it on the soil surface. Be sure to note on the soil test sheet if you plan to apply manure to the field, so the recommendations will reflect nutrient contributions from any animal manures you apply.

Soil test forms and instructions on how to take soil samples are available from your county UNH Cooperative Extension office, or from the UNH Cooperative Extension website at *http://www.ceinfo.unh.edu/Agriculture/Documents/SoilTest.htm*

Field preparation

Forage seedlings need a firm seedbed with a granular structure that allows good contact between seeds and the soil. In addition, the soil surface should be free of large stones or clumps of sod, and smooth enough to allow field operations. If you are reseeding an existing forage stand, consider using a burndown (nonselective) herbicide to kill the sod and make tillage operations easier. Use a combination of plowing and discing for tillage; discing alone results in a pulverized, compacted seedbed. Rolling the field with a cultipacker after the final discing will provide a firm seedbed.

Seeding

The best times for establishing forages are late April to early May or the last two weeks of August. April to May seedings take advantage of the moisture available in late spring, providing the location has

well-drained soil that will accommodate field equipment at that time of year. Late summer seedings are better for wet sites, since the soil is usually dry enough to work in August.

There are several different methods of seeding fields:

- A seed drill cuts a thin furrow in the soil, deposits the seed, then covers it and firms the soil with press wheels. Drills are the most reliable, but they are expensive and not always available for rent.
- Cultipack seeders drop the seed from a hopper onto the soil, then toothed rollers press the seed below the surface. While these can occasionally bury some seeds too deep, they provide satisfactory results. Cultipack seeders are often available from equipment dealers.
- If you are only seeding a small area, or if you cannot obtain any of the seeding equipment mentioned above, you may broadcast the seed. Small areas can be broadcast by hand, while larger areas may be broadcast using a fertilizer spreader. It's possible to get decent results with this method, but there's also the risk of spreading seed unevenly. Should you use this method, increase the seeding rate by 20%, and roll the field with a cultipacker afterwards to improve seed/soil contact.

Weed management

Weeds compete with growing forage seedlings, and heavy infestations can cause the seeding to fail. A weed management plan will help ensure success.

If the area you plan to seed features such hard-to-control perennial weed species as bedstraw or horsenettle, you may need to kill them with a burndown herbicide in the season prior to seeding. While selective herbicides may control or suppress weeds in the seeding year, their use may not always be practical. Herbicides are not appropriate for mixed grass and legume seedings, as they will injure either the grass or the legume, depending on the product.

A number of non-chemical practices can minimize weed pressures in the seeding year. Tillage, particularly moldboard plowing, buries weed seeds deep in the soil where they will not germinate. The "stale seedbed" technique involves waiting 10-14 days before the final discing to control the initial flush of germinating weeds. Because weed flushes usually appear in spring, some producers delay planting until late summer when weed pressures are lower. Clipping newly-seeded stands once the seeding is 8-10 inches tall is an effective means of controlling annual weed species.

For further information, see these UNH Cooperative Extension factsheets:

Haymaking
Hay and Haylage Production with Selected Forage Species
Pasture Production with Selected Forage Species
Forage Seeding Mixtures for New Hampshire
Herbicide Recommendations for Specific Weed Problems in Forages

Written by Carl Majewski, UNH Extension Educator, Agricultural Resources

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Conventional Seedings of Hay and Pastureland

by James R. Mitchell, Extension Specialist, Agronomy

Attempts to reseed a field with little or no tillage of the soil are usually only moderately successful. In general as the amount of tillage increases, prior to seeding, the greater the chance of a successful seeding using conventional seeding techniques. However, in some instances when timing has been right, frost seedings in late fall or early spring or no-tillage seedings made with special no-till seeders can be very successful. The success rate of a conventional seeding is greater because there is a reduction of troublesome pests including weeds, an opportunity to mix nutrients with the soil and the development of a desirable seed bed.

Matching Crops With Soils

Soils with good internal drainage that also have good surface drainage have the greatest potential for hay yields when seeded to an alfalfa-grass mixture. Other soils with varying depth, textures, fertility levels and degrees of drainage should be seeded to forage crops that are best adapted to the intended use and the existing soil conditions.

Forage species such as bromegrass, orchardgrass, reed canarygrass, and red clover can only tolerate short periods of drought without significant yield losses. Alfalfa because of its deep tap root can tolerate a longer period of drought. While reed canarygrass, red top and alsike clover can tolerate somewhat poorly drained soils, other forages such as timothy, ladino clover and birdsfoot trefoil are less adapted to these soil conditions. However, all grasses and legumes, including red top and alsike clover will produce best on soils not subjected to periods of standing water.

Lime, Woodash or Biosolids

Lime should be applied well in advance of seeding and in sufficient amounts to achieve a pH level of 6.0-6.5 soon after the date of seeding. On most New Hampshire soils it takes at least a year to receive the full benefit from an application of lime. If soil tests indicate that lime is needed in excess of three tons per acre, plow down the excess and mix three tons thoroughly into the surface by repeated discing. All applications of less than three tons of lime should be disced into the surface soil rather than plowed down. Woodash applications may be substituted for lime to raise the soil pH and supply calcium. Woodash provides a relatively soluble calcium source and soil pH levels can be altered more quickly when woodash is used as a lime equivalent. Biosolids will also supply a source of calcium and magnesium as well as raise the pH of the soil.

Plant Nutrient Needs

Manure, biosolids, green manure crops and fertilizer supply some or all of the nutrient needs of a new forage seeding. While fertilizer can supply all of the first year needs of the seeding, it does not maintain the soil moisture conditions provided by biosolids, manure or a green manure crop. The best way to assure that soil pH and soil nutrient demands are met is a submit a soil sample for analysis several months in advance of a seeding.

Phosphorus (P) is the nutrient which is most critical to a successful crop establishment. Many New Hampshire fields have medium or high levels of phosphorus reflecting past fertilizer practices. Soils with high levels may not require any additional phosphorus at time of seeding. Unlike nitrogen and potassium, phosphorus does not move down through the soil therefore, phosphorus is usually applied prior to seeding and mixed into the soil to supply the needs of the crop for the first 4 or 5 years of the stand.

Potassium (K) levels in fields are often low even though manure and/or high grade K fertilizers have been used regularly in the past. This nutrient is taken up in large quantities by crops, 45-60 pounds per ton of grass or legume hay Potassium is not as necessary as phosphorus at time of seeding because it is soluble and needs to be supplied each year to replace that which is removed by the crop. Manure or woodash can supply large amounts of K for a seeding.

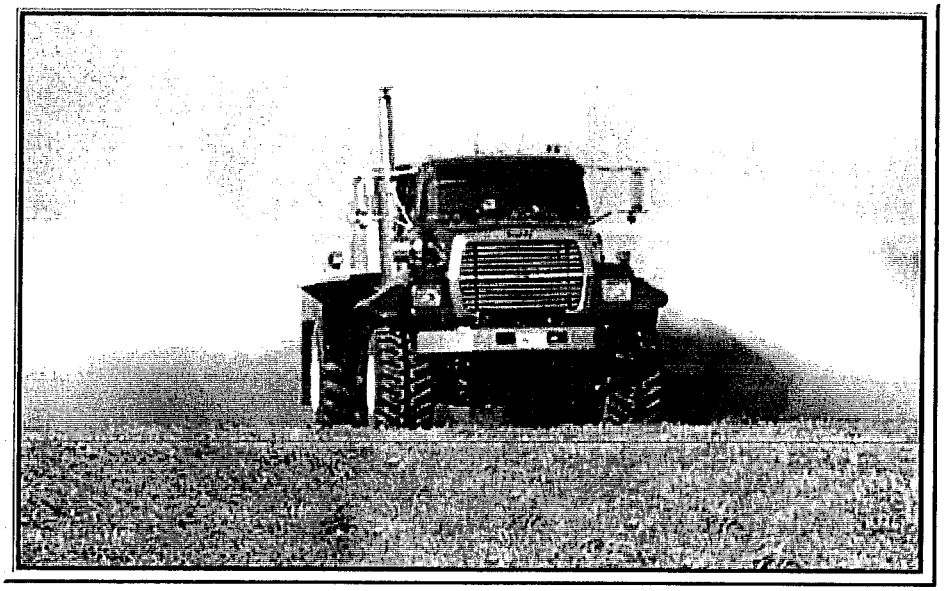
June 1998

Pasture Fertility

Internet Inservice Training

CLEMSON EXTENSION

Review of Lime Quality Considerations



I. What is the Most Common Agricultural Liming Material?

- The most common material used for liming agricultural soils is finely ground limestone, a material composed of varying concentrations of calcium and magnesium carbonates. Limestone has all the desired characteristics of an agricultural liming material.

Why are There so Many Confusing Terms Used When Referring to Aglime?

- **"Lime," "calcitic limestone," "calcite," "dolomite," "dolomitic limestone," "aragonite," "hi-cal"** all are names of aglime materials. As with any widely used material, there is considerable room for confusion. Natural materials can differ considerably in composition from one mine to the next. Technically correct definitions are frequently cumbersome, so everyday-use definitions develop which may be fine in local situations but which can cause confusion when used elsewhere. Legal definitions, as found in state aglime laws, are frequently different from one state to the next.

- **How About Some Definitions of Aglime Terms?** Although brief definitions are also subject to the limitations stated above, here's an attempt at clarifying some common aglime terms used.

- **Lime.** A material which, upon reaction with the soil, increases pH (decreases soil acidity) and does not add harmful elements to the soil. Usually, lime consists of finely ground carbonates of calcium and magnesium, although the term also includes oxides and hydroxides of calcium. The term "lime" is often incorrectly used to imply calcitic limestone exclusively.

- **Calcitic Limestone.** A term widely used by agronomists when referring to agricultural limestone with high calcium content. It contains mainly calcium carbonate but may also contain small amounts of magnesium carbonate. The term is not as restrictive in definition as calcite. It is often used to distinguish materials of low magnesium carbonate content from those of high content, the latter being referred to as dolomitic limestone.

- **Calcite.** A mineral which occurs in nature. Pure calcite is 100% calcium carbonate ($CaCO_3$) which is crystallized in hexagonal form. Calcite is a common constituent in calcitic limestone, dolomite, marble, chalk, marl, seashells, and similar substances. Because the mineral calcite is pure $CaCO_3$, it is the standard by which the acid-neutralizing capability of all other liming materials is measured.

- **Dolomite.** A mineral composed of calcium and magnesium carbonates. Pure dolomite contains 40 to 45% $MgCO_3$ and 54 to 58% $CaCO_3$.

- **Dolomitic Limestone.** A material containing $MgCO_3$ in lesser concentrations than found in dolomite. In the aglime trade, a concentration of 15 to 20% $MgCO_3$ is common for material termed dolomitic limestone.

- **"Hi-Cal" Lime.** A term widely used to identify an agricultural limestone having a high concentration of calcium. It is usually used to distinguish the material from dolomite or dolomitic limestone. Calcite

and calcitic limestones would be considered "hi-cal" aglimes.

II. What Factors Influence Aglime Quality?

The two principal factors influencing aglime quality are:

1. **Its acid-neutralizing capacity**.
2. **The fineness to which it is ground**.

1. Acid-Neutralizing Capacity

• The acid-neutralizing capacity is usually measured as the calcium carbonate equivalent (CCE). The CCE is defined as the acid-neutralizing capacity of a liming material expressed as percent by weight of pure $CaCO_3$. Thus, pure calcite has a CCE of 100%. The fineness to which aglime is ground determines in large part the rate at which it will react in soil. As particle size decreases, aglime dissolves more rapidly and changes pH over a shorter period of time. This translates into increased yields on soils where limestone applications are needed. Particle size is such an important aspect of aglime quality that particle size specifications are part of most aglime laws. It might be noted here that limestone crushed for road-building is far too coarse to be effective in lowering agricultural soil pH, even if applied at several times the recommended aglime rate per acre.

• What are Typical Calcium Carbonate Equivalents (CCE) of Some Liming Materials?

The following table presents typical CCE values of some common liming materials and the tons of each material needed to produce the same neutralizing power as one ton of pure $CaCO_3$.

Typical Calcium Carbonate Equivalent (CCE) of Selected Liming Materials

Liming Material	Typical CCE (%)	Tons Required to be Equivalent to 1.0 Ton of $CaCO_3$
Calcite (pure)	100	1.0
Calcitic limestone	75 to 100	1.3 to 1.0
Dolomitic limestone	75 to 108	1.3 to 0.9
Hydrated lime ($Ca(OH)_2$)	120 to 136	0.8 to 0.7
Wood ash	30 to 70	3.3 to 1.4

- **How is CCE Determined?**

To determine CCE, a carefully weighed sample of the lime material is reacted with an acid under laboratory conditions prescribed by a standardized procedure. Based on the amount and strength of the acid consumed in the reaction the CCE can be calculated. For example, if a 1 gram sample of limestone was reacted with 50 ml of 0.5 N HCl and titrated with 0.25 N NaOH. The titration required 30 ml of 0.25 N NaOH. The calculations would be:

$$\%CaCO_3 \text{ Equivalent} = 2.5 \times (\text{ml HCl} - \text{ml NaOH}/2)$$
$$= 2.5 \times (50 - 30/2)$$
$$= 87.5$$

- **Is It Possible to Have a CCE Greater than 100?**

Yes. When a material contains appreciable amounts of magnesium carbonate, calcium hydroxide, calcium oxide, or magnesium oxide, it will have greater neutralizing power than the same weight of calcium carbonate. This will result in a CCE greater than that of pure $CaCO_3$, which is 100.

2. How is Particle Size of Aglime Measured and Expressed?

The usual testing procedure is to pass a sample through a series of standard sieves and express the results as percentage passing through, or remaining on the variously sized sieves. Sieves are typically made of wire cloth and are designated by the number of openings per linear inch (mesh) in the cloth. For example, a 60-mesh sieve has 60 openings per linear inch (i.e., 3,600 per square inch). A particle passing through a standard 60-mesh sieve would have a diameter of less than 0.0098 inch (less than 0.25 mm). Such material would have the consistency of flour. An aglime will ordinarily be composed of particles of many different sizes, ranging from very fine, dust-like particles to coarse, sand-like ones.

III. Factors Affecting the Reactivity of Lime

1. Purity is expressed as %

2. Fineness is based on mesh size

Mesh size	Reactivity
Coarser than 20 mesh	very little effect after 18 months

30-60	took 6-18 months to neutralize the acidity that was neutralized in 1 month by 80 mesh
100	reacts very rapidly

3. Neutralizing Value of Different Liming Materials

	Material	$CaCO_3$ equivalent
Calcite	$CaCO_3$	100
Dolomite	$CaCO_3 \bullet MgCO_3$	109
Hydrated	$Ca(OH)_2$	136
Burned	CaO	179

$$\frac{\text{M.W.* of material}}{\text{M.W. of } CaCO_3} = \frac{\text{100 g of material}}{\text{X (equivalent to } CaCO_3)}$$

**M.W. = Molecular Weight*

Example using $Ca(OH)_2$

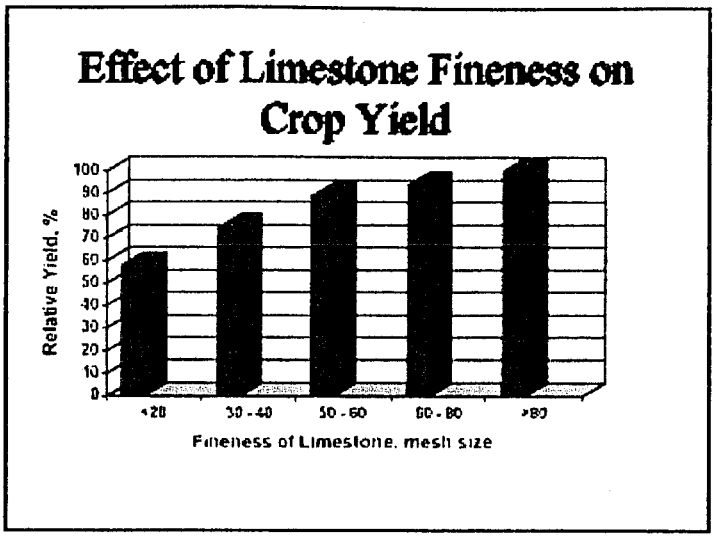
$$\text{M.W.} = \frac{74}{100} = \frac{100}{X}$$

$$74X = 10{,}000$$

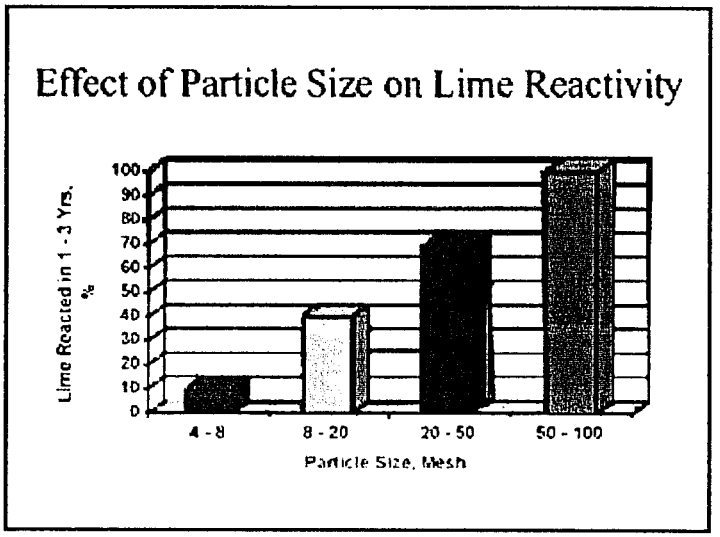
$$X = 136$$

4. Degree of Mixing and Reaction Time

• Lime is very insoluble, therefore, it needs to be mixed throughout the root zone. If the recommended amount of limestone is properly mixed with the soil, planting may follow without delay because enough fine particles are present in limestone to raise soil pH immediately above toxic Al and Mn levels and to correct a Ca deficiency. In the past it was recommended that limestone be applied 2 to 3 months prior to planting. Because of improved tillage equipment for incorporating limestone and improved limestone quality this recommendation is no longer necessary. When limestone is properly incorporated into the soil, liming may be done anytime between the harvesting of one crop and the planting of the next.



Click on graph to enlarge



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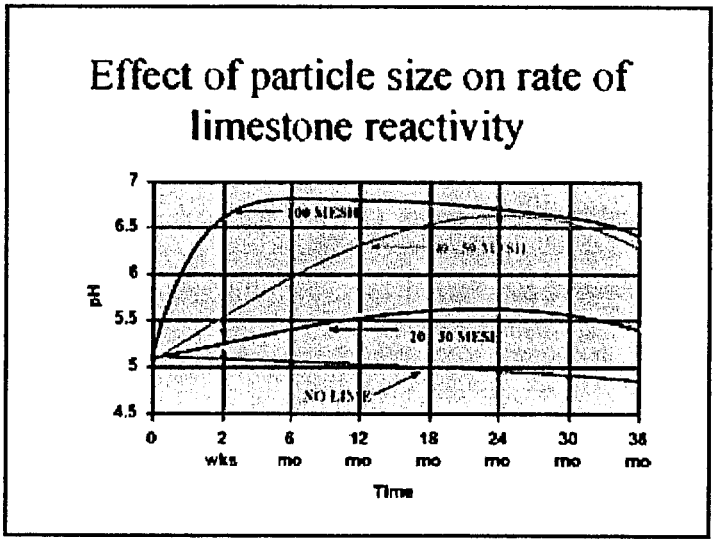

Click on graph to enlarge

IV. Effectiveness of Surface Liming For No-Till Fields and Pastures

- In 1985 a study was initiated at Penn State to look at the effects of surface application of lime on a very acid, long-term no-till soil. Since 1977 this field had been in no-till corn production with no limestone applied. The initial pH of "plow layer" was 5.1 and the surface 2 inch pH was 4.5. The limestone recommendation, based on the SMP buffer pH and a target pH of 6.5, was 6000 lb calcium carbonate equivalent (CCE) per acre. The study included four limestone rates (0, 3000, 6000, 9000 lb CCE/A) and liming programs ranging from applying lime every year to once every five years. Each year the soil was sampled in the spring in 2 inch increments to a depth of 6 inches. No-till corn was grown from 1985 to 1991, no-till soybeans were grown in 1992 and 1993, oats was grown in 1994 and wheat in 1995 and corn in 1996, 1997 and 1998.

- Soil pH results from soil samples taken in the spring of each year from 1985 through 1994 for selected liming programs are given in Figures 1 and 2. The soil pH results for the 6000 lb/A, every third year liming program are shown in Figure 1. This treatment was chosen for illustration because this would be the recommended limestone rate based on a plow depth soil sample and this frequency of liming is fairly common in many areas. The pH results in Figure 2 are from the every year, 3000 lb/A liming program. The every year program is of interest because there has been speculation that more frequent smaller applications of limestone may be necessary in no-till. Several observations can be made based on these results. First, it is clear that the recommended limestone application changed the soil pH in the surface 2 inches within the first year after application. Soil pH measurements taken within the first year indicated that most of the pH change in the surface layer occurred within the first two months after spring liming. This rapid increase at the surface was expected since this was a high quality finely ground limestone with 90% passing a 100 mesh sieve. Although the 0 to 2 inch layer was not subdivided for routine pH determination, spot checks of pH in this layer indicated that most of the pH change was in the surface 1/2 inch. However, there was little change in the soil pH below the surface 2 inches until about the fourth year of the study following subsequent limestone applications. Even after 9 years the soil pH in the 2 to 6 inch layers has not yet reached the target pH of 6.5 that was achieved rather quickly in the surface layer. There is little apparent difference between the standard, every third year liming program, and the more frequent every year liming program.

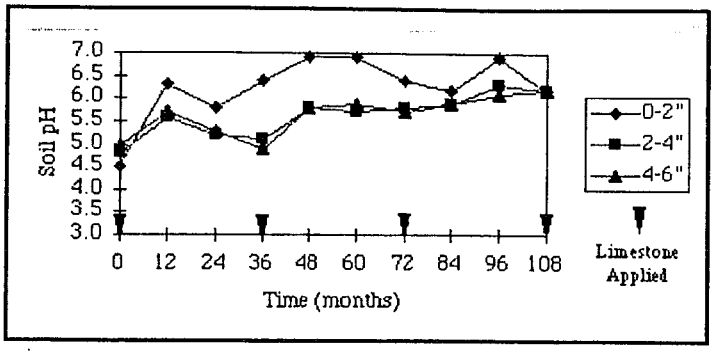

Figure 1. Soil pH vs time for a no-till soil limed at 6000 lb/A every third year

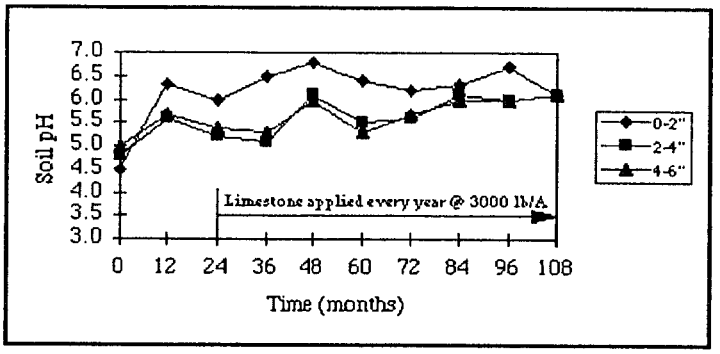

Figure 2. Soil pH vs time for a no-till soil limed at 6000 lb/A initially and then every year since 1987 at 3000 lb/A.

- These pH effects from the liming treatments resulted in slight but generally insignificant increases in corn yield. The greatest yield response was in the wheat crop in 1995. Some negative responses were observed in the years when soybeans were the plots. However, it was speculated that this was due to compaction from the liming operation especially in the more frequent liming programs. A triazine weed control treatment was included in the early years of this study. This work showed that the initial liming which only affected the pH at the soil surface did improve the efficacy of the triazine herbicides. Similar to the effect observed with the triazine activity, there were significant effects on plant tissue concentrations immediately after liming even though the pH effect from the lime was limited to the soil surface. These plant nutrient effects were a significant increase in calcium and a decrease in manganese. From this work it was concluded that surface application of limestone will rapidly change the soil pH at the surface of the soil. It was also observed that even this shallow pH improvement could affect herbicide activity and nutrient availability. A second major conclusion is that a very long time is required to have much effect on the soil pH below the surface 2 inches in no-till crop production. Finally, there seems to be little justification for more frequent liming in no-till systems.

- Thus, the current recommendation is that where possible on a very

acid soil, limestone should be incorporated to adjust the soil pH to the desired level in the entire plow layer before no-till crop production in initiated. Other work has shown that if the soil pH is in the desired range to begin with, it can be maintained by surface applications of limestone in no-till systems. Thus, if a regular liming program is followed and soil pH is not allowed to drop to very low levels further incorporation of limestone should not be necessary. Where incorporation is not possible there are beneficial effects of surface application of limestone to acid no-till soils even though the immediate effect will only be near the soil surface. Also, with surface liming the standard every three year or so liming program based on a regular soil testing program should be adequate.

Prepared by:
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Department of Agronomy
Penn State University

V. Individual State Lime Laws

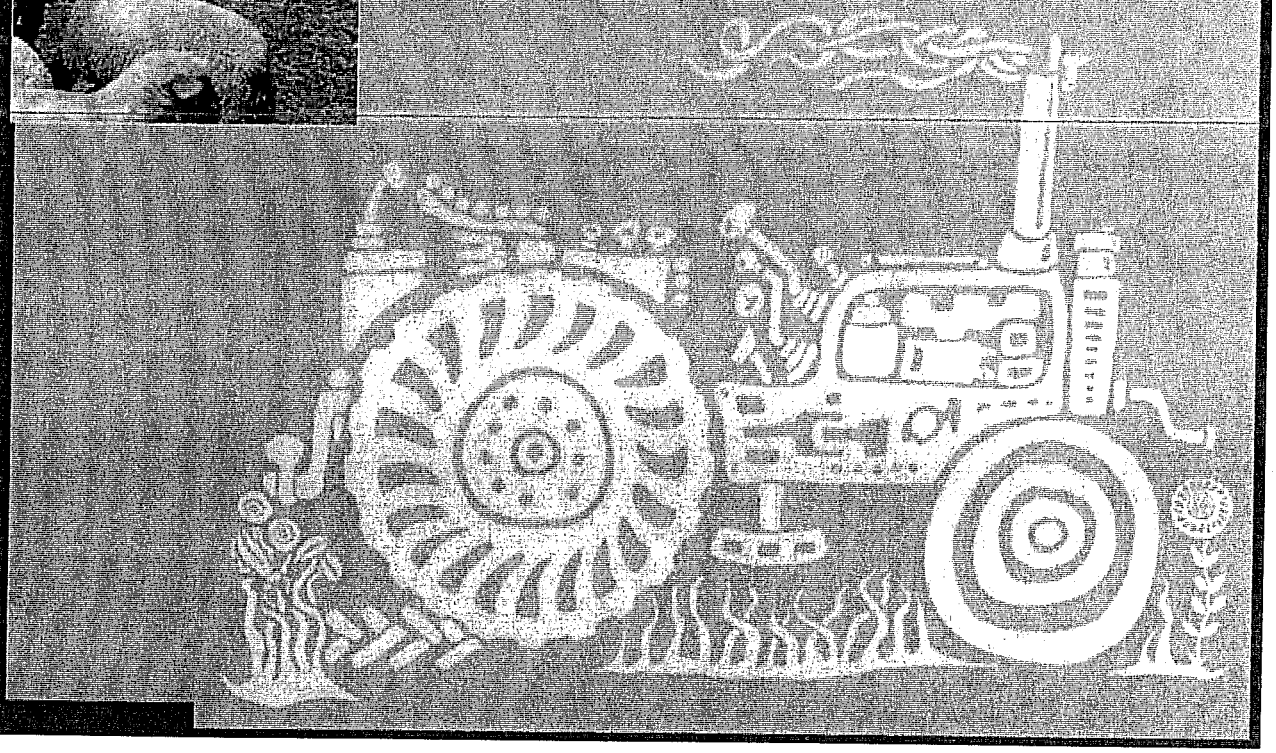
NOTE: Each state has its own lime laws. Although the intent of the following text is to discuss the properties of common lime materials, some of the definitions are dependent on Florida state laws. Lime laws for some states can be found at the following links:

- **South Carolina Lime Laws**
  - **South Carolina Rules, Regulations and Standards**
  - **For a comprehensive list of SC Fertilizer & Lime Law Links.**
- **Georgia Lime Code**
- **Alabama Lime Laws**

 **Return to Pasture Fertility Home Page** 

Land For Good

A Landowner's Guide to Leasing Land for Farming



FARM LEASE AGREEMENT

This Agreement, executed in duplicate, made and entered into as of this _____ day of _____, month _____, year by and between _____, hereinafter called the Lessor, and _____ and _____, herein after called the Lessees.

WITNESSETH:

Lessor and Lessees, for and in consideration of the covenants and agreements hereinafter contained, do hereby enter into the following lease agreement:

1. Lessor shall lease to Lessees commencing on _____ month, _____ day, _____ year, a _____ acre tract of farm land owned by Lessor, located in Section ____, Township ____, Range ____ located in _____ County, _____ State.

2. Lessees shall pay to the Lessor the sum of _____ per year for each year specified in this agreement. The first payment is due _____ month, ____ day, _____ year, and each subsequent payment is to be paid on or before the _____ day of _____ month of each successive year.

3. This lease shall be for a term of ___ years commencing on _____ month, ____ day, _____ year, and terminating on _____ month, _____ day, _____ year.

4. It is understood, and agreed, by Lessor and Lessees that Lessor, or his legal representative reserves the right to dispose of the property herein described, by sale or otherwise at any time during the specified term of this lease. In the event of such sale or disposition, Lessees shall have the right to retain possession of said premises until all crops planted by them during the calendar year in which such event occurs are harvested. In consideration of such demise, Lessees covenant and agree to provide all necessary tools, equipment, fuel, fertilizer, chemicals, herbicides, and labor necessary to operate and maintain the farm in a husband-like manner. Lessees further agree to maintain liability insurance which will name Lessor as an insured under the policy.

5. Lessees further covenant and agree:

    a. To use the premises for agricultural purposes only.

    b. To till all of the tillable land in a husband-like manner and to maintain and repair or replace existing irrigation wells and any related components contributing to the production of irrigation water.

    c. To harvest and remove all crops in due season.

    d. To keep all ditches cleaned of weeds and debris.

e. To mow roadsides and fence rows.

f. To destroy all noxious weeds and grasses and nuisances in compliance with State Law and to be responsible for the purchasing and spreading of up to _____ tons per acre of agricultural limestone, on the _____ of the property, _____ time(s), during the term of this lease. Lessees will pay _____ the cost and Lessor will pay _____ the cost of purchasing and spreading such product.

In the event of sale or other disposition of the property prior to the stated expiration of this agreement, Lessor or his legal representative will refund to Lessees, a pro-rated portion of their actual cost of purchasing and spreading such limestone based on the _____ year term of this lease agreement.

g. To commit no waste or damage on said premises and to permit none to be done.

h. To retain possession of the premises during the term hereof, and not to assign or sublet any portion without Lessor's written consent.

i. That Lessor or his legal representative shall have the right to enter the demised premises at any time to view the same or show the same to prospective purchasers or tenants, or to make repairs or improvements and to permit or deny trespass and/or hunting privileges at the discretion of Lessor.

j. After notice of termination is given by either party, the Lessor or his representative shall have the right to enter the demised premises and plow land on which no harvested crop is growing.

k. That Lessees shall take possession of the leased premises and perform the services to be rendered hereunder as independent contractors subject to the usual hazards of operating a farm, and will assume all risk of accidents in pursuance of their farming operations or in performing repairs and maintenance to buildings, grain storage bins, irrigation units, wells and improvements.

l. To surrender said premises at the expiration of the term of this lease or upon cancellation thereof as herein provided, without further demand or notice, in such condition as shall be in compliance with the provisions hereof.

m. That Lessor shall have the landlord's lien provided by law as security for the rental herein specified, and if the Lessees shall fail to cultivate said premises as herein agreed, or shall fail to keep any of the other covenants in the lease contained, the Lessor or his representative may have the work done and shall be reimbursed therefore from the Lessee's share of the crops, or may at his election, terminate this lease.

6. The Lessor expressly covenants:

    a. That Lessees observing and performing the several covenants and stipulations herein contained shall peacefully hold and enjoy said premises during said term without interruption by Lessor, or any person rightfully claiming under him, except as herein provided.

7. Lessor and Lessees mutually agree that lease will expire _____ month, _____ day, _____ year, but will be renewed automatically for one year unless either party shall give _____ days written notice to the other not to renew this lease.

8. Failure to pay the rental of this farm at the time specified, will result in this contract being null and void.

9. This entire agreement shall be binding upon the parties, their heirs, executors, administrators and assigns.

LESSOR:

_____

LESSEES:

_____

_____

_____

Notary Public

My commission expires:_____