Sharing the Cost of Acidic Soil Conditions

An integrated approach to soil conservation and sustainable soil management

Nova Scotia Federation of Agriculture

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Background

Nova Scotia's natural resources provide the province with a competitive advantage. As users and stewards of much of the province's natural resources, the farm community is uniquely positioned to lead the way and build on private, voluntary initiatives to safely use and protect the province's natural resources and assure environmental health.

Conservation practices and stewardship produce the best results when they are clearly understood by the industry and are supported by progressive public policy

Conservation practices and stewardship produce the best results when they are clearly understood by the industry and are achieved through constructive and progressive public policy initiatives. *Sharing the Cost of Acidic Soil Conditions An integrated approach to soil conservation and sustainable soil management* is part of the Nova Scotia Federation of Agriculture's commitment to sustainable agricultural practices and environmental management practices that often extend beyond the farm gate. The Federation's strategy places a priority on working with partners to improve soil, water and air quality and environmental risk management standards through the development of outcome-based public policy using sound science and cost benefit analysis to achieve goals.

Soil Acidity

With respect to soil acidity, Nova Scotia is at a strategic disadvantage for two principal reasons: 1) Nova Scotia has naturally acidic soils, and; 2) acid rain risk in Nova Scotia is among the highest in North America acerbating the further acidification of soils.

Nova Scotia is at a strategic disadvantage because it has naturally acidic soils and a high risk from acid rain

Until the early 1990's the government of Nova Scotia recognized this disadvantage and provided incentives for the use of limestone as a mediation strategy. The Agriculture and Marketing Act deals specifically with the limestone. Section 106 of the Act provides the Governor in Council with a number of powers related to limestone, among them to: "facilitate the economical distribution of limestone by rebates of freight rates, cash bonuses or by such other methods as may be deemed advisable and for such periods as is deemed expedient;". It is just as advisable and can be deemed just as important today as it was when the legislation was enacted; in fact, it may be more important today than ever before.

A cursory examination of the data available on soil acidity along with other antidotal evidence supplied by nutrient management planners indicates that accelerated soil acidity is now emerging as a major issue in agricultural soils. Rates of acidification have increased significantly in recent years, and the application of lime to acid soils is still considerably below that which is required to balance the annual soil acidification rate.

Acidification permanently reduces the productive capacity of agricultural soils, and can adversely affect water resources and biodiversity.

Acidification permanently reduces the productive capacity of agricultural soils, and can adversely affect water resources and biodiversity. Rural communities are most directly affected by soil acidification and its associated problems. Farm businesses can suffer long term economic losses due to reduced productivity, and/or have the additional cost of rehabilitating degraded soils. Loss of farm income has a direct impact on rural economic stability.

It can be argued that public expenditures focused on reducing soil acidity and maintaining optimal soil pH for efficient crop growth is a public or collective good, similar to expenditures on transportation or other public expenditures aimed at developing and/or maintaining competitiveness. Soil acidity is a major issue affecting more than just agriculture; it is as much about maintaining and protecting the integrity of one of the province's most valuable and fragile natural resources – soil. There are a number of compelling environmental arguments that speak strongly in favour of a public investment in maintaining agricultural soils at an optimal soil pH levels.

The addition of lime to agricultural land is an example of a practice that not only has an agronomic role, but also provides benefit to the environment and society at large.

The addition of lime to agricultural land is an example of a practice that not only has an agronomic role, but also provides benefit to the environment and society at large. As indicated, Nova Scotia is at a strategic disadvantage due to the movement of acid rain from the Eastern Seaboard of United States and the lack of natural alkalinity in its water and soil systems. Nova Scotia is one of the most heavily acid rain impacted jurisdictions in North America (Environment Canada, 2005) which exacerbates the lack of natural alkalinity in the parent material from which our soils are formed.

While the origins of soil acidity are multiple, the costs associated with mediating the impacts in agricultural soils fall directly on the landowner. The lime required to offset this acid deposition increases the cost of production for Nova Scotia producers relative to producers in other jurisdictions.

High levels of soil acidity in Nova Scotia's agricultural soils can also have serious impacts on water, air and soil quality leading to serious environmental consequences for other sectors in Nova Scotia's economy and impacting the general public. Following is a discussion of the causes and the potential impacts of high soil acidity in Nova Scotia's agricultural soils.

The Origins of Acidity in Nova Scotia Soils

There are a number of factors to be considered in understanding and assessing the pH status of Nova Scotia soils. These primarily include the naturally acidic condition of Nova Scotia's soils, non-agricultural impacts on acidity and agricultural impacts on acidity.

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Nova Scotia soils are naturally acidic and therefore fields under agricultural production require an intensive lime program to establish and maintain pH at levels sufficient to achieve acceptable crop yield and quality. Nova Scotia is part of the Canadian Shield and the soils of the region have formed from granite, sandstone and basalt parent materials that have little or no inherent capacity to neutralize acid or act as a buffer. This coupled with their formation under forest vegetation, in a sub-humid climate where basic cations are readily leached from the soil profile, has resulted in acidic, low organic matter soils with a low buffering capacity. In their native state these soils are not suitable for the growth of the wide range of agricultural crops that are needed to support our agricultural economy (Environment Canada, 2005).

Nova Scotia is a region that receives high acidic loading from acid rain. Acid rain refers to the acidic contaminants contained in air pollution and its resulting impacts following deposition on soil and water through rain, snow and/or fog. The source of these pollutants results from the burning of fossil fuels releasing sulfur dioxide (SO_2) and nitrogen oxides (NO_X) into the air where it combines with moisture to form sulfuric and nitric acids. Acidity can also be deposited in a dry form as particulates. Winds can carry this pollution thousands of kilometers from the source, before it falls to the earth.

Environment Canada (1998) predicts that Nova Scotia will continue to receive acid rain above critical loads even after the U.S. reduces emission levels.

The acid rain being deposited in Nova Scotia originates primarily in the US Mid-Atlantic states, Southern Ontario and Ohio valley. These gases are carried by prevailing winds to the northeast. Nova Scotia is one of the most heavily impacted areas in North America and has the highest percentage of lost fish habitat due to acid rain (Watt and Hinks, 1999). It receives more than twice the amount of acid rain that it can buffer (Watt. ND). Environment Canada (1998) predicts that Nova Scotia will continue to receive acid rain at levels above critical loads even after the United States reduces emission levels through legislation.

Acid rain causes acidification of water bodies, damages trees and decreases soil pH levels. Surface waters are sensitive to acidification that can decrease or eradicate the fish populations. The Canadian government has estimated that over 14,000 lakes have been affected. The acidification of rivers in southwest Nova Scotia has been associated with significant losses of Atlantic salmon (Lacroix 1987). Streams flowing over soils that have low buffering capacity are also affected.

Soils can also be impacted by acid rain. An experiment conducted in PEI in 1980 demonstrated that poorly limed fields, especially in low rainfall areas, were greatly affected by acid rain and significant declines in pH levels were observed (Raad and Veinot, 1980).

Nova Scotia traditionally relies heavily on ammonium nitrate fertilizers which release acid into the soil when microorganism break them down into nitrates.

Agricultural management, in particular the use of nitrogen fertilizers, can also contribute to the acidification of soil. In comparison to warmer agricultural regions like Ontario and Quebec, relatively modest rates of nitrogen fertilizer are used in Nova Scotia. There are some crops, forages and vegetables for example that require higher levels of nitrogen fertilizer. The use of ammonium-based fertilizers results in soil acidification. Unlike other regions of Canada, Nova Scotia has traditionally relied heavily on nitrogen fertilizer sources such as calcium ammonium nitrate, ammonium nitrate that are at least 50% nitrate-based. Conversion of ammonium nitrogen to nitrate forms by microorganisms releases acid to the soil thereby further decreasing pH levels.

The Benefits of Maintaining Optimal Soil pH

The agronomic benefits of lime application to agricultural soils are well documented and broadly accepted. What is less frequently understood is the benefit to the surrounding environment. The application of lime to agricultural lands can have a positive impact on the soil, air and water quality.

Water Quality

Water is a poorly buffered system, as a result water quality can be significantly impacted by acid rain and the acidity associated with surface runoff or groundwater recharge. The application of lime to agricultural land can have a direct effect on the pH of adjacent streams by reducing acid input and through the transport of bases dissolved in drainage water to adjacent water bodies.

Well over 50 rivers in Nova Scotia are impacted by acid input, and up to one third of the salmon productivity has been lost in Nova Scotia. In 1989, salmon angling license sales dropped by over 70%

due to acid rain effects on stock (Watt and Hinks. 1999). Decreasing pH levels of our water courses not only affects fish life but also all the interdependent ecosystems (fish, plants and other organisms).

Conservation groups are liming headwater lakes, expensive, labor intensive and often dangerous when equipment is used on frozen lakes to spread lime. The Atlantic Salmon Federation and other sponsors are currently funding a pilot project that is a first in Canada. The project uses a machine called a lime doser that feeds lime into the West River near Sheet Harbour at intervals through underground piping. Research has indicated that lake acidification is largely controlled by the chemistry of water draining from surrounding soils. Nova Scotia farmlands are primarily located near river valleys and have the potential to aid in increasing the pH of water draining into the rivers. The liming of agricultural soils decreases acidity loads and increases the loading of bases to these systems, helping to offset the impacts of acid rain.

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Agricultural practices have been identified as major contributor of nitrate and phosphorus levels in surface water. In freshwater lakes and streams, phosphorus is a limiting factor in the growth of aquatic plants. This increased growth, reduces water clarity, increases water treatment problems (odor, taste, increased infiltration costs), reduces oxygen in water, alters fisheries, cause fish kills and increases toxins (blue-green algae) affecting human and animal health. Additions of significant amounts of nitrogen and/or phosphorus from agricultural operations remove these limitations and allow for increased plant and algal growth.

The magnitude of nitrogen and phosphorus loading from agriculture is related to the efficiency of nutrients. Nitrogen loading occurs primarily as dissolved nitrates, phosphorus moves both as dissolved phosphates and as insoluble phosphorus associated with particles carried in eroded materials. Accumulation of nutrients in soil increases nutrient loading to water bodies. This accumulation generally occurs as a result of elevated levels of nutrient addition in an attempt to compensate for sub-optimal plant growth.

Adjusting soil pH to levels that are more suitable for plant nutrient uptake increases the efficiency of nutrient use and allows for optimal plant production at lower rates of fertilizer application and thereby reduces the risk of nutrient

When soil pH levels are less than optimal for plant growth, nutrient uptake becomes increasingly less efficient, increasing the potential for loss to the environment. Most nutrients are more available to the crop at pH's between 6.0-8.0. There can be a 40% reduction in nutrient uptake and efficiency in crops when pH levels are below 5.9. At pH's below 5.0, aluminum, iron and manganese become more available and are toxic to crops. Excess aluminum can restrict root growth and function. Adjusting soil pH to levels that are more suitable for plant nutrient uptake increases the efficiency of nutrient use and allows for optimal plant production at lower rates of fertilizer application and thereby reduces the risk of nutrient impacts on water.

Air Quality

Air quality is influenced by emissions of nitrogen compounds such as ammonia (NH_3) and nitrogen oxides (NO_X). Ammonia in the atmosphere also combines with sulfate and nitrate aerosols to produce the fine particulate matter that produces smog. These small particles (smog) when inhaled can be a significant threat to human health. Nitrogen oxides when combined with volatile organic compounds (VOC) in the presence of sunlight can contribute to the formation of ground level ozone.

Maintaining optimum soil pH levels is an important method to improve nitrogen use efficiency, avoid the accumulation of NO_3- in soil and in reducing N_2O emissions

Under conditions of oxygen stress found in wet or waterlogged soils, soil microbes convert nitrate (NO_3) to nitrous oxide (N_2O) and nitrogen gas (N_2). Nitrous oxide is a significant greenhouse gas (GHG). It is responsible for 60% of Canadian agriculture's GHG emissions. Reduction of N_2O emissions is considered one of the primary opportunities for agriculture to mitigate its greenhouse emissions and contribute to Canada's reduction commitments. NO_3 accumulation is symptomatic of over-fertilization and/or sub-optimal conditions for plant growth. Maintaining optimum soil pH levels is an important method to improve nitrogen use efficiency, avoid the accumulation of NO_3- in soil and in reducing N_2O emissions.

Lime amendments are an essential practice for sustaining the production of agricultural crops in non-calcareous soils such as those found in Nova Scotia. The effective and timely utilization of liming materials and choice of liming material represents another important opportunity to reduce CO_2 emissions resulting from agricultural activities. The use of liming material which either result lower CO_2 emissions associated with production (e.g., limestone vs. lime calcification) or the use of alternate alkaline waste products (e.g., fly ash or paper mill wastes) represent significant opportunities to maintain economic crop production, increase the efficiency of nutrient use and to maintain soil quality while minimizing CO_2 emissions associated with agricultural activities.

Soil Quality

The production of food and fiber is essential to society. Agricultural soils provide the most economically efficient means of producing food and fiber. Agriculture has successfully responded to society's ever-increasing demand for food. Canada's cultivated land has expanded 5 fold over the past half century. As prime agricultural land is increasingly being taken out of production to accommodate urban and other non-renewable uses, agricultural production and expansion is forced to move to marginal land. In many instances these marginal lands require increased inputs to raise the level of productivity to a point where crop productivity, soil quality, wildlife habitat can be sustained and environmental impacts be avoided. This use of marginal lands is increasing in Nova Scotia due to increased urban development in traditional agricultural areas, such as the Halifax -Truro corridor, and the Annapolis Valley.

The production of food and fiber is essential to society. Agricultural soils provide the most economically efficient means of producing food and fiber. Agriculture has successfully responded to society's ever-increasing demand for food.

Through good soil management practices, producers can enhance the production of food and fibre as well as provide significant benefits through improved soil quality, healthy wildlife habitat and other environmental considerations. Nova Scotia soils have many benefits other than providing a medium for crop production.

These include:

- providing habitat for a variety of species;
- acting as a buffering filter for acid rain to protect fish habitats;
- retaining and filtering water;
- sequestering carbon which helps to mitigate the greenhouse effect;
- efficiently cycling nitrogen and phosphorus to reduce environmental risk.

Maintaining soil pH at optimum levels is a key factor in sustaining agricultural productivity as well as preserving and building the buffering capacity of a valuable economic resource.

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The positive benefits of limestone include:

- improving soil physical, chemical and biological properties;
- increasing nutrient availability to the crop;
- improving soil structure which helps water infiltration rates;

- reducing soil crusting;
- increasing beneficial bacteria activity;
- increasing root growth;
- improving nutrient and water uptake thereby reducing soil erosion;
- reducing the risk of ground and surface water contamination;
- increasing the efficiency of fertilizer applications;
- bacteria are more active at higher pH levels.

The pH Status of Agricultural Soils in Nova Scotia

In 1981-82 the Department of Agriculture and Marketing reported average soil pH 5.7. Reports published in the 30 years reported low soil pH, frequently going below 5.0.

The Nova Scotia Soil Test Laboratory Service operated by the Nova Scotia Department of Agriculture (NSDA) monitors and reports on soil pH levels based on soil samples submitted for analysis. The reports provide an opportunity to track the pH status of agricultural soils in Nova Scotia. The 1981-82 Nova Scotia Department of Agriculture and Marketing, Soils and Crops Branch Annual Report provided information on pH levels by county reporting average pH levels of 5.7 (range 4.4 - 6.5). Soil survey reports published in the 1950's, 60's and 70's provide pH levels for the top horizon of the dominant soils utilized for agriculture by county. The levels reported tended to be very low, frequently dropping below 5.0.

The Nova Scotia Department of Agriculture Quality Evaluation Division Laboratory currently has soil test records dating back to 1999 (previous data is in an inaccessible format). A review of available data from 1999 to 2004 indicated the following:

In 1999, 71% of soils tested were below an optimal pH of 6.5. In 2004, 75% were below optimal levels.

In 1999, 6816 soil samples were analyzed at the NSDAF laboratory (Appendix 1 and 2). Of the samples tested, 19% were below pH 5.5 (extremely acidic), 19% were between 5.5-5.9 (acidic), 33% were between 6-6.4 (adequate for most crops but still require lime) and 29% were at optimum levels (6.5 and over) (Appendix 2). **In total, 71% of soils tested were below optimum pH levels.**

In 2004 similar results were obtained, of the 7662 soil samples analyzed, **75% of soils were below optimum levels with 42% being quite acidic.**

Realizing the Potential Productivity of Nova Scotia's Agricultural Soils

Only 40% of producers soil test therefore there is no realistic way to estimate lime requirements. A conservative cost for lime alone would be over $17 million

According to the Nova Scotia Agricultural Statistics, in 1996 there were 432,200 acres (174,980 ha) farmed. Based on the observed pH status of Nova Scotia agricultural soils, producers would need **738,411 tonnes of lime** to bring soil pH up to an optimum level for crop production. <u>This is a conservative number because farms having low pH levels are also less likely to soil test and therefore may be underrepresented in the survey statistics.</u>

It is estimated that only about 40% of producers soil test on a regular basis. Without a soil test, there is no realistic way to estimate lime requirements. At a current cost of approximately $24/tonne of lime (not including transportation costs), this would cost over **$17 million**. In 1999, about 28,000 tonnes of lime was purchased, only 4% of what was required (See Appendix 3). Clearly the potential productivity of agricultural soils in Nova Scotia is not being realized due to sub-optimal soil conditions.

Increasing the soil pH levels on the 75% of the farmland that is below optimum levels will not only increase agricultural productivity but also assist in providing a natural filter to block the impact of soil acidity on Nova Scotia water bodies.

At low pH levels, only 50-75% of available nitrogen will be taken up by the crop. This potentially leaves the remainder tied up on soil particles, available for potential release into the air as a gas or to be leached out to water bodies. Based on an average 125 kg/ha of nitrogen applied (pastures require 100 kg/ha, forages require about 130 kg/ha and vegetables can require up to 220 kg/ha of nitrogen), this could potentially be a loss of over 3 million kg of nitrogen to air and water. Atmospheric nitrogen deposition on estuaries and coastal water bodies can be adversely affected. Liming can significantly reduce this risk.

At low pH levels, only 50-65% of phosphorus will be taken up by the crop. This potentially leaves the remainder tied up on soil particles or available for movement through soil erosion. Based on an average phosphorus applications of 100 kg/ha, there is a potential loss of up to 4 million kg of phosphorus to water.

Until the early 1990's, the government of Nova Scotia recognized the importance of maintaining soil pH and the fundamental disadvantage borne by Nova Scotia producers resulting from acid deposition on agricultural soils by providing incentives for the production and use of limestone.

Until the early 1990's, the government of Nova Scotia recognized the importance of maintaining soil pH and the fundamental disadvantage borne by Nova Scotia producers resulting from acid deposition on agricultural soils by providing incentives for the production and use of limestone. Since that time the province has reversed its position and resisted the implementation of programs and policies. The current lime program put into place to assist agriculture in 2005 and modified in 2006 does not adequately address this problem.

Program and Policy Options

An expanded lime (soil amendment) program would not only result in a more competitive and productive agriculture sector in Nova Scotia, it would also benefit the general public through the provision of environmental benefits.

An expanded soil amendment program will increase the productivity of NS most valuable resource, soils while providing additional benefits to the environment such as climate change, soil and water quality and the fishery industry.

An agricultural soil amendment program represents a cost effective approach to increasing the productivity of Nova Scotia's most valuable resources, its agricultural soils; while providing additional benefits with respect to climate change, the fishery and soil and water quality. Increasing the soil pH levels on the 75% of the farmland that is below optimum levels will not only increase agricultural productivity but also assist in providing a natural filter to block the impact of soil acidity on Nova Scotia water bodies. It will also improve the efficiency of crop nutrient uptake reducing greenhouse emissions and the potential contamination of watercourses.

Aglime is the most common soil amendment that is used to increase soil pH levels in the Maritimes. Aglime is a calcitic or dolomitic limestone that has been crushed to different levels of fineness to allow it to react in the soil to increase the pH level. Each province has its specifications regarding lime quality. In Nova Scotia, an approved Aglime under the current funding program must be ground to a fineness where almost 100% of the material passes through a 10 mesh sieve and 60% through a 100 mesh sieve. Dolomotic limestone must have a minimum neutralizing value of 95% and calcitic limestone must have a minimum of 90%.

There are a number of products that have the ability to neutralize soil pH such as aglime, wood ash, lime mud and sludge. The agriculture industry has been successfully using these products while helping other industries to control their waste material.

Recently, the agricultural industry has become interested in using other cost effective soil amendments that will neutralize soil pH. One such product is wood ash or lime mud, a by-product produced by the Forestry and Power industry. Wood ash is a proven effective liming material in other provinces and states. Other soil amendments have been under review by the Agricultural Community for their abilities to neutralize soil pH.

In order to develop an effective soil amendment policy it is essential to be able to compare the ability of various soil amendments, including aglime, to neutralize soil acidity. There are methods that look at the factors that affect soil neutralization.

Various states and provinces use different names to define a total effectiveness rating so that an actual neutralizing value can be determined for the various soil amendments. For example, A & L Laboratories (Ontario) uses an ECC (Efficiency Calcium Carbonate) rating (A & L Canada Laboratories, 2002) . Nebraska uses ECCE (Effective Calcium Carbonate Equivalent) (Mamo et al. ND). Arkansas uses ECCE or ENM (Effective Neutralizing Material) of products to determine the ELM (Effective Liming material) of the product (Jennings and Gadberry, 2006). Ohio uses the term ENP (Effective Neutralizing Power) (Little and Watson, 2002). Other areas call it a "Lime Score". All use similar formulas to arrive at the "real" neutralizing ability of the soil amendment.

There are methods that can be used to determine the actual neutralizing value of the various soil amendments so that accurate comparisons can be made.

There are two main factors that affect the ability of the soil amendment to increase soil pH:

CCE (Calcium Carbonate Equivalent or Neutralizing Value). The CCE is the value of the acid-neutralizing ability of a carbonate rock in comparison to pure calcium carbonate. The more impurities in the product the lower the total neutralizing value (purity). The CCE does not indicate solubility or availability of the nutrient components. The CCE for an aglime is usually between 90-100%, calcium oxide 180% and wood ash 30-60%. (Jennings and Gadberry, 2006) (A & L Canada Laboratories, 2002) (Mamo et al. ND) (Little and Watson, 2002).

Fineness factor. This influences how quickly the soil pH can be neutralized. The fineness factor is determined by the percentages of product that pass through various size mesh sieves. The higher the percent of fine particles, the more surface area per tonne of product, which in turn will be more effective for a quicker increase in soil pH levels. (Jennings and Gadberry, 2006) (A & L Canada Laboratories, 2002) (Mamo et al. ND) (Little and Watson, 2002).

Research has shown that there is a relationship between the fineness level and crop yield response. This could be termed a third factor, **Reactivity** (Ag Lime Association. ND). For example, some products that have high levels of calcium oxide (ex. burnt or quicklime) will break down to a very fine powder and quickly react with water to neutralize soil. Wood ash contains high levels of calcium oxides and can react similar to quicklime. Oxides are the most efficient of all liming materials but are very expensive. Some labs will conduct a reactivity test to estimate the behavior of the liming material in the soil.

In order to compare the effectiveness of various soil amendments (i.e. lime, wood ash, etc), these factors must be considered. Different limestone sources could have different liming abilities. When both factors are considered, it is called the Effective Calcium Carbonate Equivalent (ECCE). See Appendix 4 for the method to determine ECCE for soil amendment products.

Nova Scotia Soil Amendment Program

An effective soil amendment program that benefits agricultural producers and the general public through the provision of environmental benefits would include various products that neutralize soil pH. The subsidy would be based on the ECCE of the product.

The Nova Scotia Soil Amendment Program should consider the following:

An effective soil amendment program that benefits agricultural producers and the general public through the provision of environmental benefits would include various products that neutralize soil pH. The subsidy would be based on the ECCE of the

A). Expand the definition of the current lime program to include other products that will neutralize soil pH.

B). Trucking Subsidy – the subsidy should be based on current yearly Truckers Association of Nova Scotia transportation rates (tonne mile) and not on location of a particular product. An expanded soil amendment program would enable producers to choose the best product based on their soil requirements and cost effectiveness.

<u>The subsidy rates would be determined by the ECCE of the product</u>. This ensures that the highest subsidy would be applied on products that most efficiently neutralize soil pH.

1) 100% of the subsidy would apply on products with an ECCE between 70-100%. Most aglimes have an ECCE of 75%.

2) 75% of the subsidy would apply on products with an ECCE between 45-70%.

3) 50% of the subsidy would apply on products with an ECCE between 15-45%. Wood ash would fit within this category.

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Appendix 1- Number of Soil Samples in each County by pH levels

Soil Sample Reports from the NSDAF Quality Evaluation Division

				Soil pH levels		
County	**Year**	**Total Samples**	**Below 5.5**	**Btw 5.6-5.9**	**Btw 6.0-6.4**	**6.5 & Over**
Annapolis	1999	723	151	201	245	126
	2004	270	44	66	102	58
Antigonish	1999	186	25	20	85	56
	2004	373	57	63	125	128
Cape Breton	1999	359	36	45	125	153
	2004	185	62	37	43	43
Colchester	1999	1830	333	292	607	598
	2004	1631	380	372	484	395
Cumberland	1999	231	68	41	72	50
	2004	738	98	167	282	191
Digby	1999	68	19	27	9	13
	2004	64	21	13	20	10
Guysborough	1999	19	1	3	11	4
	2004	47	15	18	11	3
Halifax	1999	432	119	80	88	145
	2004	323	91	54	72	106
Hants	1999	484	79	99	169	137
	2004	617	107	139	209	162
Inverness	1999	127	20	17	43	47
	2004	269	67	67	66	69
Kings	1999	1791	353	379	633	426
	2004	2301	403	495	767	636
Lunenburg	1999	145	26	24	38	57
	2004	150	35	30	48	37

Pictou	1999	314	33	41	118	122
	2004	473	123	115	144	91
Queens	1999	16	2	5	4	5
	2004	14	7	3	2	2
Richmond	1999	6	2	0	0	4
	2004	5	0	1	1	3
Shelburne	1999	2	0	2	0	0
	2004	35	9	14	3	9
Victoria	1999	3	0	0	0	3
	2004	1	0	0	0	1
Yarmouth	1999	80	21	10	19	30
	2004	158	38	51	40	29

Appendix 2 - % Soil Samples in each County by pH levels

	% Soil Samples	
County	**Year 1999**	**Year 2004**
Annapolis		
Below pH 5.5	21 %	16%
pH 5.6 - 5.9	28%	24%
pH 6.0 -6.4	34%	38%
pH 6.5 and over	17%	22%
Antigonish		
Below pH 5.5	13%	15%
pH 5.6 - 5.9	11%	17%
pH 6.0 -6.4	46%	34%
pH 6.5 and over	30%	34%
Cape Breton		
Below pH 5.5	10%	34%
pH 5.6 - 5.9	13%	20%
pH 6.0 -6.4	35%	23%
pH 6.5 and over	42%	23%
Colchester		
Below pH 5.5	18%	23%
pH 5.6 - 5.9	16%	23%
pH 6.0 -6.4	33%	30%
pH 6.5 and over	33%	24%
Cumberland		
Below pH 5.5	29%	13%
pH 5.6 - 5.9	18%	23%
pH 6.0 -6.4	31%	38%
pH 6.5 and over	22%	26%
Digby		
Below pH 5.5	28%	33%
pH 5.6 - 5.9	40%	20%
pH 6.0 -6.4	13%	31%
pH 6.5 and over	19%	16%
Guysborough		
Below pH 5.5	5%	32%
pH 5.6 - 5.9	16%	38%
pH 6.0 -6.4	58%	24%
pH 6.5 and over	21%	6%

Halifax		
Below pH 5.5	28%	28%
pH 5.6 - 5.9	19%	17%
pH 6.0 -6.4	20%	22%
pH 6.5 and over	33%	33%
Hants		
Below pH 5.5	16%	17%
pH 5.6 - 5.9	21%	23%
pH 6.0 -6.4	35%	34%
pH 6.5 and over	28%	26%
Inverness		
Below pH 5.5	16%	25%
pH 5.6 - 5.9	13%	25%
pH 6.0 -6.4	34%	25%
pH 6.5 and over	37%	25%
Kings		
Below pH 5.5	20%	18%
pH 5.6 - 5.9	21%	22%
pH 6.0 -6.4	35%	33%
pH 6.5 and over	24%	27%
Lunenburg		
Below pH 5.5	18%	23%
pH 5.6 - 5.9	17%	20%
pH 6.0 -6.4	26%	32%
pH 6.5 and over	39%	25%
Pictou		
Below pH 5.5	11%	26%
pH 5.6 - 5.9	13%	24%
pH 6.0 -6.4	38%	30%
pH 6.5 and over	38%	20%
Queens		
Below pH 5.5	13%	50%
pH 5.6 - 5.9	31%	22%
pH 6.0 -6.4	25%	14%
pH 6.5 and over	31%	14%

Richmond		
Below pH 5.5	33%	0%
pH 5.6 - 5.9	0%	20%
pH 6.0 -6.4	0%	20%
pH 6.5 and over	67%	60%
Shelburne		
Below pH 5.5	0%	26%
pH 5.6 - 5.9	100%	39%
pH 6.0 -6.4	0%	9%
pH 6.5 and over	0%	26%
Victoria		
Below pH 5.5	0%	0%
pH 5.6 - 5.9	0%	0%
pH 6.0 -6.4	0%	0%
pH 6.5 and over	100%	100%
Yarmouth		
Below pH 5.5	26%	25%
pH 5.6 - 5.9	13%	32%
pH 6.0 -6.4	24%	25%
pH 6.5 and over	37%	18%

Appendix 3 – Lime Purchases 1961-2005

Information taken from Agricultural Statistics, Province of Nova Scotia (NSDAF) 1969, 1977, 1991 and 1999. The years 2000-2005 were taken from the Atlantic Fertilizer Institute (2005). These include lime purchases that are non-agricultural.

Limestone	Amount Purchased
Year	**(Tonnes)**
1961	48,283
1962	36,274
1963	53,626
1964	47,042
1965	54,650
1966	56,407
1967	54,429
1968	71,308
1969	72,087
1970	61,686
1971	51,582
1972	40,609
1973	54,943
1974	67,718
1975	86,313
1976	101,375
1977	71,076
1978	101,319
1979	73,682
1980	99,330
1981	94,195
1982	109,748
1983	89,769
1984	97,248
1985	92,732
1986	74,435
1987	96,876
1988	75,990
1989	86,712
1990	75,477
1991	67,631
1992	70,946
1993	58,041
1994	55,128
1995	55,000
1996	22,582
1997	23,786
1998	18,203
1999	27,709
2000	30,367
2001	36,901
2002	39,396
2003	28,615
2004	29,333
2005	24,909

Appendix 4 – Determining Actual Neutralizing Value of Soil Amendments

ECCE or ELM = (Fineness Factor) x (% CCE) x (100)

Fineness Factor:

Particle Size Range (Mesh Size)	**Efficiency Factor**
Coarser than 10	0.0
10-60	0.4
60-100	1.0
Finer than 100	1.0

Multiply the efficiency factor by the % retained by the mesh sieve. Add them together for Fineness Factor. *efficiency factor is similar for different areas.

Example: Lime that has 96% CCE

Mesh Sieve Size	**% Material Passing Sieve**
10	98
60	68
100	60

What is the fineness factor?

Mesh Sieve Size	**% Material Retained**	**Efficiency Factor**	**Effectiveness Rating %**
Coarser than 10	2	0.0	0.0
10-60	30	0.4	12.0
60-100	8	1.0	8.0
Finer than 100	60	1.0	60.0

Fineness Factor = 0.0 + 12.0 + 8.0 + 60.0 **= 80%**

ECCE (ELM) = Fineness Factor x CCE x 100
= 0.80 x 0.96 x 100
= 76.8%

On a tonne basis (1000 kg), the product would have 768 kg of effective liming material.

Each soil amendment can have a calculated ECCE for a true comparison between products.

For example; a lime recommendation from the lab is for 1 tonne/ha. If the lime products used in Nova Scotia have an average ECCE of 80% (800 kg of ELM) and the producer wants to use a wood ash with an ECCE of 40% (400 kg of ELM), they would need to apply 2-3 tonnes/ha for every 1 tonne/ha of lime.