THIRTY-YEAR TRENDS OF WISCONSIN AGLIME USE

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Land use patterns in Wisconsin have changed considerably over the past thirty years as have the management practices used in various agricultural enterprises. Forage based dairy production continues to be the dominant agricultural industry in the state with alfalfa still the predominant forage grown for feeding dairy animals. The total acreage of alfalfa has changed very little over the past thirty years, however, a large percentage of the concentration of the dairy industry in the state is found on the naturally acid soils of the state. This has resulted in the need for significant inputs of lime on fields where alfalfa is to be grown.

In Wisconsin, the natural pH of soils varies widely, largely depending on the parent material from which the soils were formed. The pH of a soil is important because it affects many chemical and physical reactions in the soil. Some of these include the availability of most of the essential elements, the activity of soil microorganisms, the ability of the soil to hold positively charged nutrients (cations), the solubility of non-essential elements such as heavy metals, and the performance of some herbicides. For all soils, natural and man's processes result in the soil pH dropping with time. For some soils, this change can occur quite rapidly, and is measurable, but for soils derived from limestone bedrock or other alkaline materials the change is very slow and may take decades or centuries.

The rate at which a soil will change in pH depends on several factors. One of the key factors is the soil texture. In general, soils that are higher in clay and organic matter content (heavier textured) will resist change more than sandy (lighter textured) soils. These heavy soils have a much higher buffering capacity, which will tend to allow the soil to resist changes in pH. In general, the average soil pH of soils tested in Wisconsin since 1963 has shown somewhat of an increase over time (Figure 1).

One significant way in which soils become acidic is through the use of fertilizers containing ammonium nitrogen (Table 1). Ammonium accounts for half of the nitrogen in ammonium nitrate, three-quarters of the nitrogen in UAN solutions, and all of the nitrogen in ammonium sulfate, diammonium phosphate, monoammonium phosphate, anhydrous ammonia, and urea. During the past thirty years, total N sales have approximately doubled from about 120,000 tons/year to nearly 240,000 tons/year (Table 2). Clearly, this has resulted in a significant increase in the amount of lime needed to neutralize the acidity resulting from N applications.

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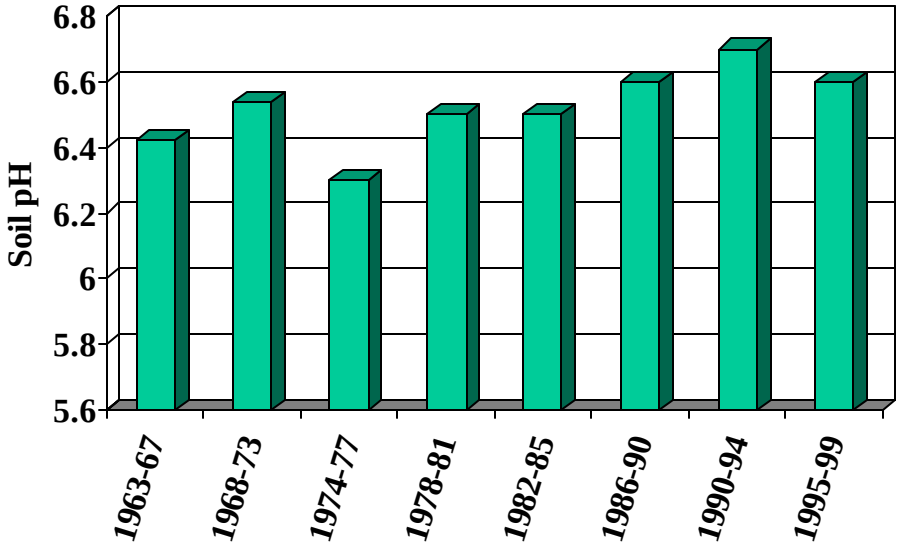
Figure 1. Wisconsin soil pH trends, 1964-99.



Other factors leading to soil acidification include acid rain and the formation of natural acids in the soil from the release of carbonic acid from microbial and plant respiration and the formation of organic acids secreted by plant roots. These contributions to soil acidity are relatively minor when compared to acidity inputs from N fertilizer and manure.

Table 1. Aglime required to neutralize acidity from some acid-forming nitrogen fertilizers.

Nitrogen Source	Pounds of Aglime Needed per Pound of Nitrogen*
Ammonium sulfate	7.5
Diammonium phosphate	7.5
Anhydrous ammonia	5
Urea	5
Solutions (28%-41%N)	4
Ammonium nitrate	4

*Approximation

Table 2 shows some of the long-term trends in dairy cow numbers, cropping patterns, use of N fertilizer and lime over the past thirty years in Wisconsin. Dairy cow numbers have declined from approximately 1,825,000 to around 1,350,000 during that time period. This has resulted in a reduced contribution of acidity from dairy manure. Assuming that manure production/animal has not changed during that time period, this reduction would be about 25%. Despite the fact that alfalfa acreage has not changed much during this thirty year period, there have been significant changes in the acreage of a number of other crops. The amount of corn grown for grain has increased approximately 30% from just over 2 million to nearly 3 million acres. Corn silage acreage is slightly lower than thirty years ago, but indications are that acreage devoted to corn silage production will be

increasing once again largely due to the increase in size of many modern dairy operations. The amount of acreage devoted to soybean production has increased approximately ten-fold during the past thirty years from about 130,000 acres to approximately 1,300,000 acres. Much of this increase can be attributed to the need for economical sources of protein for the state's dairy industry.

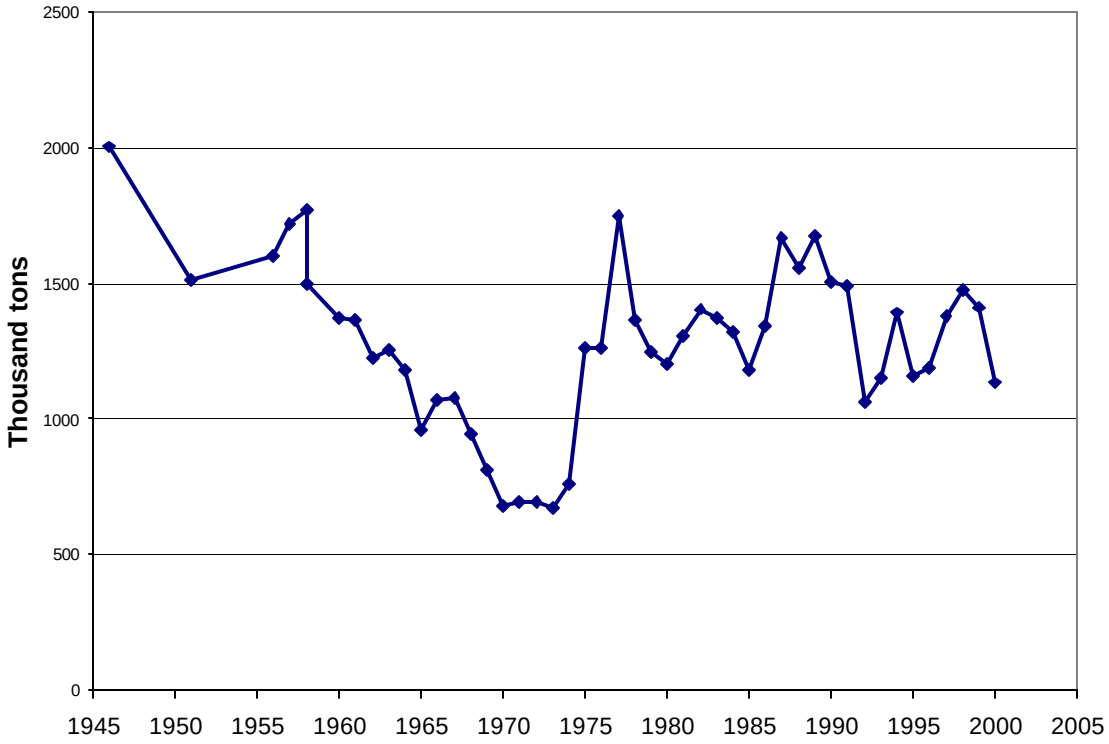
Table 2. Long-term trends in dairy cow numbers, crop production acreage and sales of aglime and nitrogen in WI

Year	Number of cows	Alfalfa	Corn Grain	Corn Silage	Soybeans	N Fertilizer Sales	Aglime Sales
	thousands						
		acres harvested				tons	
1971	1822	3017	2304	852	128	122	691
1972	1832	2950	2143	835	145	128	692
1973	1810	2970	2090	1050	241	116	672
1974	1801	3000	2270	1090	217	140	757
1975	1812	3020	2390	1000	191	133	1262
1976	1807	3010	2180	1320	152	171	1259
1977	1802	3100	2800	980	192	207	1747
1978	1811	3100	2750	920	215	222	1366
1979	1813	3100	3080	900	295	215	1246
1980	1815	3050	3350	775	330	227	1203
1981	1825	2850	3500	874	375	260	1306
1982	1829	3050	3350	880	440	247	1109
1983	1845	3200	2300	830	395	174	1374
1984	1828	3150	3250	830	450	228	1322
1985	1876	3100	3350	900	300	282	1182
1986	1862	3150	3100	760	320	258	1340
1987	1795	2800	2800	730	320	251	1664
1988	1763	3100	1950	1450	390	224	1557
1989	1739	3800	2800	764	410	229	1673
1990	1753	3600	3000	670	430	235	1504
1991	1714	3600	3200	570	550	243	1491
1992	1645	3050	2950	860	690	254	1064
1993	1543	3000	2350	950	590	203	1152
1994	1494	3300	3100	635	830	255	1391
1995	1490	3200	3050	580	800	225	1161
1996	1449	2950	3000	865	870	232	1187
1997	1393	2900	3050	770	1000	238	1380
1998	1369	2900	2950	730	1100	237	1475
1999	1365	3000	2850	730	1300	237[1]	1412
2000	1344	2600	2750	720	1450	237[1]	1132

[1] Estimate based upon average of data from 1994-1998.

The annual sale of aglime has been quite consistent since about 1975, which followed several years of significantly lower sales in the early 1970's (Figure 2). The lower than expected tonnage sales in the early 1970's was at least partially related to the elimination of some cost sharing programs that were in existence before then to encourage the establishment of alfalfa on natively acid soils.

Figure 2. Lime tonnage sales per year



In general, the aglime sold and applied in Wisconsin is neutralizing the acidity resulting from N fertilization and manure applications (Table 3). In addition to neutralizing acidity, the annual lime sales are nearly equivalent in the amount of basic cations they are supplying to what is being removed through cropping practices (Table 4).

Table 3. Aglime required to neutralize the acidity produced from N appplications and to replace basic cations from crop removal. Wisconsin 1971-2000.

Year	N Fertilizer	N from Manure[1]	Total N	Aglime required to neutralize N[2]	Aglime required to replace basic cations removed[3]	Aglime sold
	---------- thousand tons ----------					
1971	122	48	170	679	856	691
1972	128	48	176	704	813	692
1973	116	48	164	654	819	672
1974	140	47	187	749	820	757
1975	133	48	181	722	805	1262
1976	171	47	218	874	646	1259
1977	207	47	254	1017	974	1747
1978	222	48	270	1078	915	1366
1979	215	48	263	1050	976	1246
1980	227	48	275	1099	1010	1203
1981	260	48	308	1232	919	1306
1982	247	48	295	1180	1078	1109
1983	174	48	222	890	1026	1374
1984	228	48	276	1104	1076	1322
1985	282	49	331	1325	954	1182
1986	258	49	307	1228	914	1340
1987	251	47	298	1192	772	1664
1988	224	46	270	1081	450	1557
1989	229	46	275	1099	1110	1673
1990	235	46	281	1124	1246	1504
1991	243	45	288	1152	1214	1491
1992	254	43	297	1189	792	1064
1993	203	41	244	974	787	1152
1994	255	39	294	1177	1185	1391
1995	225	39	264	1056	1188	1161
1996	232	38	270	1080	1018	1187
1997	238	37	275	1098	1027	1380
1998	237	36	273	1092	1082	1475
1999	237[4]	36	273	1092	1313	1412
2000	237[4]	35	273	1091	1089	1132

[1] Assuming 21 tons manure/cow/year with 2.5 lbs NH4-N/ton producing soil acidity.

[2] Assuming 4 pounds of aglime needed to neutralize the acidity produced by one pound of N.

[3] Corn grain, corn silage, alfalfa and soybean acres used in the calculation.

[4] Estimate based upon average of data from 1994-1998.

Table 4. Amount of aglime needed to replace the basic cations in several crops.

Crop	Yield	Aglime required to replace basic cations removed
Corn grain	150 bu/a	25 lb/a
Corn silage	8 ton/a	250 lb/a
Soybean	45 bu/a	125 lb/a
Alfalfa	4 ton/a	685 lb/a

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Another aspect of aglime sales which can be monitored is the neutralizing index (NI) or quality of the material being sold. Since 1993, the Wisconsin Department of Agriculture, Trade and Consumer Protection has been recording the total amount of aglime sales in the various NI categories (Figure 3). In every year the dominant grade sold is 60-69, with 50-59 being the second most common in all years. The next most common grade is the 80-89 material. This is the material that is typically shipped significant distances either by truck or rail from the source quarries, mostly located in eastern Wisconsin, to the areas of the state which have acid soils and no local lime sources, such as north central Wisconsin. The 80-89 material is popular for this market as it is more effective per ton in neutralizing acidity than the lower NI materials and it costs no more to ship a ton of 80-89 material than a ton of lower quality material. For example, four tons of 60-69 liming material has the equivalent neutralizing power as approximately 3 tons of 80-89 grade liming material (Table 5).

Figure 3. Utilization of various lime grades in Wisconsin by year, 1993-2000.

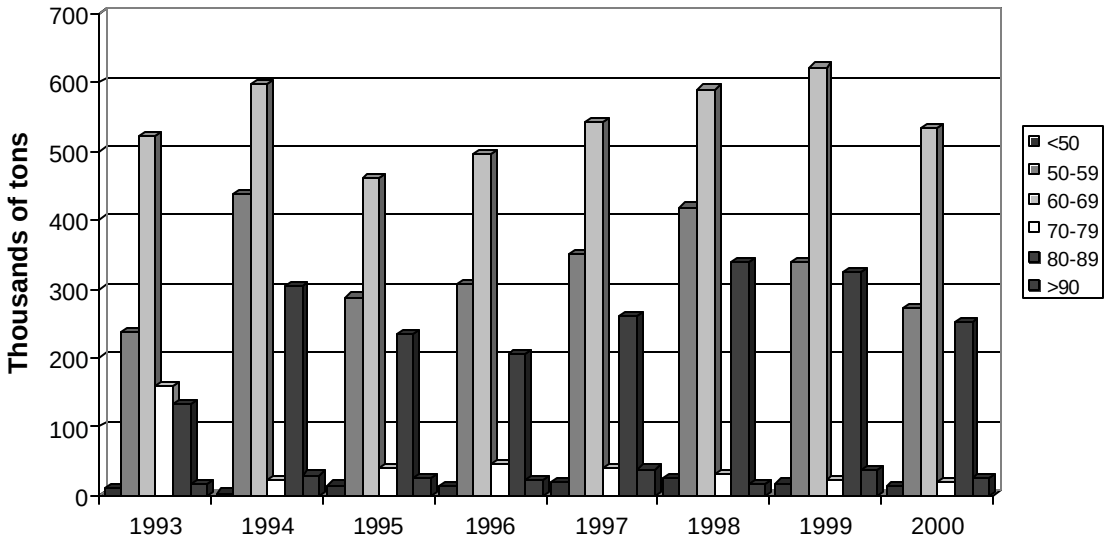

Table 5. Aglime conversion table for different neutralizing index zones.

	Zones of lime quality according to neutralizing index values						
Lime recommendation (60-69 NI)[1]	40-49	50-59	60-69	70-79	80-89	90-99	100+
ton/a	ton/a lime to apply						
1.0	1.4	1.2	1.0	0.9	0.8	0.7	0.6
2.0	2.9	2.4	2.0	1.7	1.5	1.4	1.2
3.0	4.3	3.5	3.0	2.6	2.3	2.1	1.9
4.0	5.8	4.7	4.0	3.5	3.1	2.7	2.5
5.0	7.2	5.9	5.0	4.3	3.8	3.4	3.1
6.0	8.7	7.1	6.0	5.2	4.6	4.1	3.7
7.0	10.1	8.3	7.0	6.1	5.4	4.8	4.3
8.0	11.6	9.5	8.0	6.9	6.1	5.5	5.0
9.0	13.0	10.6	9.0	7.8	6.9	6.2	5.6
10.0	14.4	11.8	10.0	8.7	7.6	6.8	6.2

[1] Soil test recommendations are made for lime having a NI of 60-69.

Summary

There are a number of trends which can be observed when looking at the data from the past thirty years. There has been very little change in the acreage of alfalfa grown in the state over the past thirty years and a relatively stable amount of lime sold annually since 1975. The annual sales of N fertilizer have nearly doubled during this thirty year period. Dairy cow numbers have declined steadily, and corn and soybean acreage has increased. In general, the amount of lime that is land applied each year in Wisconsin is approximately equivalent in neutralizing power to the amount of acidity in the fertilizer N and manure applied each year to the state's fields. Local lime quarries producing 50-59 and 60-69 NI grade aglime are still the dominant materials in terms of tonnage sold annually. The use of the higher NI material such as 80-89 is the common practice where significant shipping distances are involved.

References

Aglime Fact Book. 1986. National Stone Association. Washington D.C.

Peters, J. B. and K. A. Kelling. 1999. Changes in pH with Time, Crop and Soil. Proceedings of the 1999 Wisconsin Fertilizer, Aglime and Pest Management Conference. 38:290-295.

Schulte, E.E. and L.M. Walsh. 1993. Management of Wisconsin Soils, 4th Edition. University of Wisconsin – Extension Publication A3588.

Wisconsin Agricultural Statistics. 1971-2001. Wisconsin Agricultural Statistics Service; Wisconsin Department of Agriculture, Trade and Consumer Protection; United States Department of Agriculture. Madison, Wisconsin.