substances, and changes in microbial activity (NAPAP 1987). Acid soils can result from the addition of nitrogen fertilizers to farmland, the growing of leguminous crops, and acidic deposition.

Large quantities of several types of lime are used to neutralize soil acidity. A total of 14 million metric tons of lime were used in the U.S. in 1982 to treat 4.7 million hectares of cropland (NAPAP 1987). This corresponds to an average rate of 1.33 Tons/Acre. Lime is also widely used on residential lawns and gardens and accounts for an additional use of the material.

Lime is also used in fish farming and may be either added directly to the water or to the pond bottom before the pond is filled. Dupree and Huner (1984) recommend that agricultural limestone be applied to the water rather than quicklime or slaked lime because the latter materials may result in toxic conditions. They also state that liming is pointless in ponds with rapid exchange rates, because the chemicals are quickly carried away. Liming the bottom soil of a pond constructed in an acid soil area greatly improves the productivity of the pond and the quality of the water. Bardach et al. (1972) list many species of fish which benefit from the use of lime in many aquaculture situations.

In farm ponds it is similarly recommended that lime be added to increase the fish productivity. The lime makes more of the phosphorus in the system available for plant growth which then results in greater fish production. Soil samples from farm ponds are analyzed to determine how much lime is needed to neutralize the soil acidity.

2. Overview of liming materials

Lime exists naturally in a number of compounds but the most common is $CaCO_3$. Dolomitic limestone $CaCO_3.MgCO_3$ is also abundant but being less soluble, it is not as effective a neutralizing agent. Derivatives of limestone are available and due to their high solubility are commonly used. Neutralization products are usually applied directly to the lake surface using some type of agricultural spreading device, administered from either a boat or aircraft.

<u>Quicklime - CaO.</u> When limestone is heated, $CaO + CO_2$ are produced. Quicklime is not considered desirable in fish management liming because it is highly caustic and therefore difficult to handle, store, and use safely and effectively.

<u>Basic Flyash.</u> This material is a noncombustible byproduct of coal burning. Surface absorbed lime gives flyash its ability to increase pH. Howell (1978) noted that the pH altering ability of a given flyash is correlated to the ratio of oxalate extractable iron to the calcium released at pH 3. The composition of this material varies depending on the composition of the coal burned. Western coals are likely to be basic while eastern coals are acidic. All may contain heavy metals in varying amounts which could have detrimental effects on aquatic biota not to mention adverse indirect effects on man. For this reason, flyash is not considered to be a viable neutralization product.

Soda Ash - Na_2CO_3. Soda ash has been used to neutralize acidic waters on an experimental basis in Sweden (Lindmark 1982) and in New York (Kretser and Colquhoun 1984). It is presently about three times more expensive than agricultural limestone, but may result in a longer lasting neutralization of the water quality. The impacts and effectiveness of these soda ash treatments are still being evaluated and its widespread use is not recommended.

Hydrated Lime - $Ca(OH)_2$. Hydrated lime is formed by adding CaO and H_2O in a ratio of approximately 1:2. This hydrated product has been used for neutralizing lakes. It dissolves readily and has approximately 5 times the neutralizing capacity as a similar weight of agricultural limestone. It is also capable of reducing heavy metals, by chelation and subsequent precipitation from the water column (Scheider and Dillon 1976). Due to high solubility $Ca(OH)_2$ must be used with caution since the pH of the treatment water can rise too rapidly resulting in pH shock to aquatic organisms (Scheider et al. 1975). Although high solubility ($\approx$ 97%) has some advantages, the beneficial effects are often short term. The rapid decline in pH following neutralization with $Ca(OH)_2$ is illustrated in Lohi Lake near Sudbury, Ontario. This lake had a pre-treatment pH of 4.5, in 1973 it was treated with 20-25 lb/acre foot of hydrated lime which raised the pH to 7.0. However, by the summer of 1975 the pH had fallen to 5.5 (Scheider et al. 1975).

The NYSDEC treated over 45 waters with this material since 1959, although many had to be retreated every 1-3 years in order to maintain viable fish populations (Blake 1981). The concentration of $Ca(OH)_2$ used by NYSDEC was 12.5 lb/acre foot for clear water and 25 lb/acre foot for brown water. Most of the waters treated were seepage ponds and therefore had a slow flushing rate. Plosila (1982) monitored the water chemistry of a number of these ponds and reported a range in the magnitude and duration of the effect of treatment.

Agricultural Limestone - $CaCO_3$. Wide availability and low cost make this product especially attractive for surface water neutralization projects. Since $CaCO_3$ is less soluble than $Ca(OH)_2$, greater amounts must be used. A secondary benefit of agricultural limestone is that while it neutralizes acid it also imparts bicarbonate to the water which, directly or indirectly, augments the buffering capacity of the lake. The lower solubility of $CaCO_3$ results in a longer lasting buffering effect relative to $Ca(OH)_2$ (Grahn and Hultberg 1975).

Schofield et al. (1981) and Blake (1981) both suggested an application rate of approximately 1 ton/surface acre. Dickson (1979) used approximately 1 ton $CaCO_3$/surface acre in a Swedish lake of 1976 acres and had adequate pH levels for 8 years following treatment. Bengtsson et al. (1980) suggested lime application rates of about 89-179 lb/acre foot. (One ton/surface acre = 200 lb/acre foot if the average depth is 10 feet.)

Although some lake treatments using agricultural limestone may result in favorable pH conditions for extended periods of time, lakes with high flushing rates generally display beneficial effects for only one or two years (Dickson 1979).

3. New York State Liming Program (1959-Present)

a. The Early Program (1959-1963)

Between 1959 and 1963 a program was undertaken to evaluate the factors limiting productivity of trout fisheries in bog ponds and to determine whether neutralization would improve trout production (Plosila 1982). This research conducted by Plosila (1982) has been summarized in a paper by Kretser and Colquhoun (1984) and much of the following is taken directly from their summary.

A total of 19 Adirondack ponds were treated with hydrated lime in the early research program. Most of these waters received multiple treatments over the five years of the program. The study waters were small, 0.2 to 9.0 ha, ponds in southern Franklin County in the northern Adirondacks. Three of the ponds were clear water acid ponds, and 16 were dark water bog ponds. Pre-treatment pH levels ranged from 3.6 to 4.8. Lime treatment rates were determined by titration of water samples with a test solution of hydrated lime to a pH of 6.8 with extrapolation to the calculated volume of the pond. Ponds were treated by applying $Ca(OH)_2$ (hydrated lime) directly to the ponds from a moving boat. Treated ponds were then stocked with fall fingerling brook trout and rainbow trout from domestic stocks.

Kretser and Colquhoun (1984) present several figures illustrating the effect of the hydrated lime treatments on the water chemistry of several study ponds. The treatments in general produced short-term increases in pH and alkalinity, but upon termination of these treatments the pH and alkalinity decreased and often reached pre-treatment levels within one or two years. Because of the high organic acidity in the bog waters, the effects of adding hydrated lime were greater in the clear water ponds than in the bog ponds.

To determine the effect of the 1959-1963 lime treatments on survival of fish stocked in treated ponds, Plosila (1982) conducted intensive test netting of these ponds in the spring following post-treatment fall stocking. Kretser and Colquhoun (1984) presented the fish survival data as a function of overwinter dissolved oxygen (DO) and pH for brook trout and rainbow trout. These DO and pH measurements however were measured infrequently. Few brook trout (<10%) were found to survive in bog and kettle ponds with DO levels <2 mg/l. However, at higher DO levels and at all pH levels (3.1 to 6.5) survival correlated with neither pH nor DO. (It should be noted that these mid-winter surface pH values may be lower than pH values in deeper water.) Rainbow trout survival on the other hand, was found to be limited by both low DO and low pH levels in bog ponds. This was early field data documenting the greater sensitivity of rainbow trout to low pH than brook trout.

Plosila (1982) concluded that the use of lime should be limited to well oxygenated ponds in which extreme acidity is the predominant limiting factor to trout survival. Hasler et al. (1951) had originally recommended liming as a means of increasing bog pond transparency and ultimately *dissolved oxygen by enlargement of the trophogenic zone* (upper layers of the lake where photosynthesis occurs). DO and pH were not found to be correlated in Plosila's (1982) study however, and there was no evidence that either water clarity or dissolved oxygen of stained bog ponds was affected by lime treatment.

b. Operational and Experimental Lake Neutralization Program (1964-1983)

During the study conducted by Plosila (1982), NYSDEC Fisheries Management Units began a program of operational liming. Kretser and Colquhoun (1984) presented a summary of the 1964 to 1983 time period, and much of what follows is taken directly from their summary. Through 1982, 125 treatments on 56 individual ponded waters (405 ha) had been completed. Ninety-six projects involved the use of hydrated lime; 28 utilized agricultural limestone; and one experimental project utilized an application of soda ash. Some waters received multiple base applications. For example, Little Black Pond, located in the popular Fish Creek state campground, underwent a total of seven treatments. Most treatments since 1976 employed agricultural limestone, in part to reduce the risk of pH shock to resident aquatic organisms exposed to the fast dissolving hydrated lime (Scheider et al. 1975). In addition, neutralization with agricultural limestone, with its slower dissolution rate, was expected to last longer. Agricultural limestone applications at the treatment rate of 2250 kg/ha were expected to maintain favorable water quality for survival of stocked brook trout for a minimum of three years.

In seepage ponds lacking outlet streams and in drainage lakes with very low flushing rates, results were generally good, with measureable improvements in water quality and fish survival (Blake 1981). Treatments generally were unsuccessful in both chemically marginal ponds and waters with high flushing rates. Winter kills of stocked trout often occurred in chemically marginal ponds due to heavy snow cover and subsequent oxygen depletion. On the other hand, many of the successful projects involved small ponds that were completely barren of fish life prior to treatment, but after treatment produced excellent fishing (Blake 1981).

In addition to utilizing limestone and hydrated lime, NYSDEC also investigated the use of soda ash (Na_2CO_3) to neutralize acidic waters. Previous experimentation in Sweden on Lake Lilla Galtsjon indicated that soda ash may be even more efficient and longer lasting than conventional limestone (Lindmark 1982). In 1982 NYSDEC and the Allied Chemical Corporation jointly initiated an eight year cooperative study on Bone Pond to evaluate this material. Many years of research will be required to determine if soda ash is a cost effective, superior neutralizing agent. Since soda ash currently costs about three times as much as agricultural limestone, treatment benefits must last significantly longer to insure cost competitiveness. In Bone Pond (3.7 ha), 4550 kg of soda ash raised pH from a pre-treatment level of 4.7 to the mid-7's, and pH levels are still satisfactory. Twice as much agricultural limestone would have been required to produce similar results.

From 1964 to 1983, the NYSDEC utilized a number of different application methods for treating lakes and ponds with agricultural limestone and hydrated lime. In readily accessible waters, both hydrated lime and agricultural limestone were applied via boat or barge. Bags of the material were usually slit open and manually dumped into the path of the outboard wake for maximum dispersion. These treatments usually occurred in the fall prior to fall stocking. Waters not located in restricted land use areas were sometimes limed using snowmobiles during winter. In these applications the limestone was spread manually over the entire ice surface.

Remote acidic waters were treated by the NYSDEC using a helicopter to transport the lime to the lake. Helicopter methods tried and discarded included: transporting bagged lime inside the helicopter, transporting bagged lime in a sling under the helicopter and transporting a hydrated lime slurry in a fire-fighting water bucket under the helicopter. The method utilized currently to treat remote waters involves a state helicopter equipped to carry a 910 Kg capacity commercial lime bucket. Two such buckets are employed, and while one is loaded with lime, the other is transported to the target water. As the helicopter moves over the pond at an altitude of approximately 200m, a trap door is opened electrically and the load is dumped.

During this time period the recommended dosage rate for hydrated lime ($Ca(OH)_2$) was 9.3 g/m^3 in bog ponds and 3.7 g/m^3 in clear water ponds (Plosila 1982). Hydrated lime, although effective, had some disadvantages, including its rapid dissolution rate and its very fine texture, making handling somewhat difficult. Consequently, agricultural limestone ($CaCO_3$) replaced hydrated lime as the primary neutralizing product utilized in New York State. Although it dissolves slower, its handling characteristics and longer lasting qualities are desirable. The recommended dosage rate for agricultural limestone was 2245 Kg/ha using a recommended particle size between 0.25 mm and 0.75 mm.

Gloss et al. (1988) evaluated the NYSDEC liming program data up until approximately 1982. They were not able to critically analyze the effectiveness of the program, however, because much of the needed water quality monitoring data were lacking. They therefore utilized fish stocking information for these waters in an attempt to evaluate the success of the projects. They found that reliming of lakes was often done after the lake had already been allowed to reacidify, therefore stressing the remaining fish. Gloss et al. (1988) conclude that it is very important for the NYSDEC to (1) carefully monitor the water quality of all lakes in the liming program; and (2) relime the lakes before they are allowed to reacidify. If a lake in the program is not monitored carefully and does reacidify prior to the next neutralization, then the fish would be exposed to large pH changes which could be stressful or toxic.

c. Lake Neutralization Activities in Recent Years (1983-1988)

Since 1983 the DEC liming program has remained relatively small due to a number of factors. From 1983 through 1987 a total of 16 waters were limed as part of the DEC program. All of these projects utilized agricultural limestone as a neutralizing agent, and all except one involved spreading the aglime on the ice during the winter. The exception was the 1985 liming of Horn Lake, which was conducted using the state helicopter and two lime buckets. Nick's Pond, which was studied by Clarkson College during 1979-1980 as a potential liming candidate (Becker 1981; Theiss 1981; Autenreith 1981), was treated by the DEC with agricultural limestone in 1983.

Kretser and Colquhoun (1984) reported that the NYSDEC plan for the 1983-1988 period was to treat 33 ponded waters with re-treatment of 13 of these, for a total of 46 planned treatments. Several reasons were responsible for the NYSDEC not following this proposed plan. A smaller than planned program was necessary because of (1) concerns from the public about possible adverse impacts due to liming; (2) knowledge that a revised liming policy was being developed; and (3) a concern that a larger program would compromise efforts to achieve air pollution controls. In addition adequate funds and personnel to carry out a larger program were lacking.

NYSDEC lake neutralization projects are planned and carried out by regional fisheries personnel. The two regions which have conducted these projects are Region 5 (Ray Brook) and Region 6 (Watertown). During the 1983-87 period Region 5 fisheries staff were involved in only 5 lake neutralization projects. Four of these were funded and carried out by the Franklin County Federation of Fish and Game Clubs with guidance from DEC fisheries staff. In Region 6 also the local sportsmen and fish and game clubs play an integral part in liming projects. By scheduling liming projects for winter months the local sportsmen can utilize their snowmobiles to spread the agricultural limestone over the surface of the ice. Region 6 fisheries staff coordinated 10 winter liming projects over the 1983-87 period plus the helicopter liming of Horn Lake during the fall of 1985.

All neutralization treatments now involve follow-up water chemistry monitoring in order to evaluate the project success and determine when retreatment is necessary. Ponds which are a part of the NYSDEC liming program are monitored on a yearly basis during the summer months to evaluate changes in water chemistry.

4. Waters Limed by the Dept. of Environmental Conservation

A total of 67 different waters have been treated during the 30 years of the DEC liming program. The schedule of treatment is listed in chronological order in Table 2. Since many waters have been treated more than once, Table 3 presents a schedule of new treatments and reapplications each of those years. When considering both new treatments and reapplications, there have been a total of 142 individual treatments in the program.

Table 2. Chronology of ponded waters neutralized by the NYSDEC between 1959 and 1988.

	YEAR OF TREATMENT																													
POND NAME	1959	1960	61	62	63	64	65	66	67	68	69	1970	71	72	73	74	75	76	77	78	79	1980	81	82	83	84	85	86	87	88
SW. AMPHITHEATER POND (02-132)	**	**																												
BLACK POND (02-130)	**	**															**	**				**								
EAST COPPERAS POND (02-138)	**	**	**	**																										
LITTLE BLACK POND (02-130A)	**	**	**	**													**	**				**								
LITTLE E. COPPERAS POND (02-137)	**				**																									
LITTLE ECHO POND (02-126)	**			**																										
LITTLE EGG POND (02-127A)	**	**																**												
NE. AMPHITHEATER POND (02-131)	**	**	**	**																										
NW. AMPHITHEATER POND (02-135)	**	**	**																											
NORTH WHEY POND (02-141)	**																													
SUNDAY POND (02-188)	**	**	**	**								**						**												
TURNOFF POND (02-154)	**	**	**																											
WEST POLLIWOG POND (02-122)	**	**	**	**																										
DOUGLAS POND (03-148)	**	**	**																											
PAYNE LAKE (04-620)	**			**													**							**						
CLEVELAND LAKE (04-619)		**																						**						
CHARLEY POND (02-191A)			**																											
EVIES POND (04-608)			**	**												**	**											**		
LITTLE NORTH WHEY POND (02-141A)				**																										
WOOD POND (02-185)				**																										
LITTLE CLEAR POND (03-172)				**																										
TOM KETTLE LAKE (07-809)				**	**											**	**									**				
LITTLE AMPERSAND POND (02-109)					**				**																					
CLEAR POND (04-230)					**		**				**													**						
T LAKE (07-862)					**	**																								
DUCK POND (03-40)									**																					
DUCK (ECHO) POND (02-136)											**						**	**								**				
BONE POND (02-193)												**												**						
LINDSEY POND (02-200)												**																		
OWL (AVERILL'S) POND (02-99)												**																		
KITFOX POND (03-142)												**																		
BREAD POND (03-268)														**																
HUMDINGER POND (03-269)														**																

Table 2. (cont.)

POND NAME	1959	1960	61	62	63	64	65	66	67	68	69	1970	71	72	73	74	75	76	77	78	79	1980	81	82	83	84	85	86	87	88*
MIKES POND (03-268A)	----	----	--	--	--	--	--	--	--	--	--	----	--	**	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--
DEER POND (03-372)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	**	--	--	--	**	--	--	**	--	--	--	--	--	--	--	--
TOWNLINE POND (03-371)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	**	--	**	--	--	--	--	**	--	--	--	--	--	--	--	--
WOLF POND (03-65)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	**	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--
LONG POND (03-370B)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	**	--	--	--	--	--	----	--	--	--	--	**	--	--	--
ROUND POND (04-907)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	**	--	--	--	--	--	----	--	--	--	--	--	--	--	**
PINE POND (03-368)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	**	--	--	**	--	--	--	--	--	--	--	--
CLEAR LAKE (04-525)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	**	--	--	----	--	--	--	--	--	--	--	--
FALLS POND (04-885)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	--	**	--	----	--	--	--	--	--	--	--	--
HORN LAKE (04-854)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	--	**	--	----	--	**	--	--	**	--	--	--
LONG LAKE (04-610)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	--	--	--	----	--	--	--	--	--	--	--	--
PITCHER POND (04-662A)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	--	--	--	----	--	--	--	**	--	--	--	--
DUELL POND (02-195)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	**	--	--	--	----	--	--	--	--	--	--	--	--
COOLER POND (03-205)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	**	--	--	--	**	--	--	--	--	--	--	--	--
BUCK POND (04-578)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	**	**	--	--	----	--	--	--	--	--	--	--	--
FLORENCE POND (04-664A)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	**	--	--	--	----	--	--	--	--	--	--	--	--
BOOTTREE POND (03-374)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	**	--	--	**	--	--	--	--	--	--	--	--
NINE CORNER LAKE (07-719)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	**	--	**	----	**	--	--	--	--	--	--	--
ICEHOUSE POND (04-876)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	**	--	----	--	--	--	--	--	--	--	--
TAMARACK POND (06-171)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	**	--	----	--	--	--	--	--	--	--	--
BREWER LAKE (04-967)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	**	----	--	--	--	--	--	--	--	**
LIVINGSTON POND (05-705)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	**	----	--	--	--	--	--	--	--	--
GREEN LAKE (07-727)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	**	--	--	--	--	--	--	--
AVALANCHE LAKE (05-707)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	**	--	--	--	--	--	--
HOLMES POND (05-169)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	**	--	--	--	--	--
NICKS POND (04-292)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	**	--	--	--	--	--
DILLON POND (04-308)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	--	**	--	--	--	--
LITTLE OTTER POND (04-664)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	--	**	--	--	--	--
SUNRISE POND (02-117)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	--	**	--	--	--	--
QUIVER POND (04-795)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	--	--
LONG POND (03-170)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	--	--
ROUND POND (03-370A)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	--	--
FEDERATION POND (02-148)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	**	--	--	--
LONG LAKE (04-162)	----	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	**	--

Table 3. Summary of the NYSDEC Base Neutralization Program between 1959 and 1988, showing number of new treatments and reapplications each year, number of hectares treated each year and cumulative hectares for the Program.

	No. of Waters Treated			No. of Hectares Treated	
YEAR	Reapplication	New	Total	Each Year	Cumulative
1959	-	15	15	35.9	35.9
1960	11	1	12	30.7	66.6
61	8	2	10	18.7	85.3
62	8	4	12	32.7	118.0
63	2	3	5	37.2	155.2
64	1	0	1	20.6	175.8
65	1	0	1	6.1	181.9
66	0	0	0	0	181.9
67	1	1	2	37.7	219.6
68	0	0	0	0	219.6
69	1	1	2	12.8	232.4
1970	4	1	5	19.6	252.0
71	0	0	0	0	252.0
72	0	3	3	2.7	254.7
73	0	3	3	45.3	300.0
74	2	1	3	27.1	327.1
75	7	6	13	137.1	464.2
76	5	4	9	32.5	496.7
77	4	2	6	118.6	615.3
78	2	2	4	39.7	655.0
79	1	2	3	55.0	710.0
1980	7	0	7	51.0	761.0
81	1	1	2	65.2	826.2
82	5	1	6	42.7	868.9
83	0	2	2	13.0	881.9
84	3	3	6	43.0	924.9
85	2	3	5	56.0	980.9
86	1	1	2	4.3	985.2
87	0	1	1	13.0	998.2
88	2	0	2	13.4	1011.6

5. Private Liming Activities in New York State

In addition to the NYSDEC lake neutralization activities, there have been numerous projects conducted by private groups on both public and private waters in the Adirondacks. Table 4 and the following discussion are presented in order to indicate the extent of private liming activities in New York State and to relate useful information which has resulted from these projects.

Several projects have been conducted on state waters without the consultation, notification, or recommendation of NYSDEC staff. Middle Sargent Pond (Hamilton County), for example, was limed by private individuals with the intention of improving the fishery. Since the NYSDEC is responsible for fisheries management in state waters, it is imperative that regional fisheries personnel be involved in such projects.

Many research liming projects have been conducted in acidic Adirondack waters, some with limited success. Constable Creek, a tributary to Big Moose Lake (Herkimer County), was treated by constructing a barrier of 55 gallon drums filled with limestone gravel. The drums had holes in both ends so the stream water would pass through the gravel. However, the limestone quickly became unreactive, probably because of a build-up of silt and bacterial slime resulting in a very short-lived treatment. In Big Moose Lake itself, the North Bay was treated one year with agricultural limestone with the intention of creating a refuge area in the lake for fish species sensitive to acidic conditions. The results of this treatment also were short-lived with no observed impact on the fishery.

Schofield et al. (1981) presented additional information evaluating the effectiveness of partial lake liming. Their data from four other Adirondack lakes (2nd Bisby, 4th Bisby, Rock, and Gull) were again inconclusive. Brook trout which were stocked in small limed areas of these acidic lakes did not appear to preferentially utilize these areas of the lakes. Uncertainties included the possible presence of other refuge areas of favorable water quality in other areas of these lakes.

Researchers from Cornell University have been involved in lake neutralization for many years and have demonstrated in many waters the beneficial effects of treatment with agricultural limestone. Flick et al. (1982) discussed lake neutralizations conducted on Mud Pond and Kitten Pond in the Adirondacks. Agricultural limestone was spread on the ice of these two small bog ponds, and pH values increased from pretreatment values under 5 to pH values near or above 6, where they remained for at least 7 years. Flick et al. (1982) also reported on two other ponds (Lower Sylvan Pond and Hyde Pond) which were treated with agricultural limestone. The bottom sediments of these two ponds were then mixed with the lime to depths of 15-20 cm using a specially developed hydraulic jet "plow". Both of these ponds had pretreatment pH levels of about 5 and maintained levels of about 7 for 10 years post treatment. This would be expected in ponds like Hyde Pond which had a flushing rate of only 0.4 times per year. Lower Sylvan Pond however, had a higher flushing rate of 2.8, and although it exhibited abrupt temporary pH drops during spring runoff, the bottom sediment treatment

Table 4. Partial list of waters neutralized by private or university groups in New York State.

WATER	OWNERSHIP	TECHNICAL SUPPORT	YEAR TREATED	REFERENCE
Middle Sargent Pond	State	-	?	-
Constable Creek	Big Moose Property Owners	Syracuse Univ.	approx. 1980	-
North Bay, Big Moose	State	Syracuse Univ.	approx. 1980	-
2nd Bisby Lake	Adirondack League Club	Cornell Univ.	1979	1
4th Bisby Lake	Adirondack League Club	Cornell Univ.	1975,76,78, 79,80	1 2
Rock Lake	Private	Cornell Univ.	1978,79	1
Gull Lake	Private	Cornell Univ.	1974,75,79,80	1
Mud Pond	Adirondack League Club	Cornell Univ.	1974	3
Kitten Pond	Rockefeller Estate	Cornell Univ.	1974	3
Lower Sylvan Pond	Adirondack League Club	Cornell Univ.	1971	3
Hyde Pond	Ross Park	Cornell Univ.	1971	3
Chambers Lake	Adirondack League Club	Cornell Univ.	1976	2
Deer Lake	Adirondack League Club	Cornell Univ.	1975,76,78,79 80,81,82,83	2
Jones Pond	Adirondack League Club	Cornell Univ.	1975,78,79,80	2
Mountain Pond	Adirondack League Club	Cornell Univ.	1973,74,75,76 77,78,79,80 81,82,83	2
Wolf Pond	Private	Cornell Univ.	1984,86,87	4
Mountain Pond	State	Cornell Univ.	1983	5
Big Chief Pond	Private	Cornell Univ.	1983	5
Little Rock Pond	Private	Cornell Univ.	1983	5
Highrock Pond	State	Cornell Univ.	1983	5
Trout Pond	State	Cornell Univ.	1983	5
Barto Lake	Private	Cornell Univ.	1984	5
Jones Lake	Private	Cornell Univ.	1984	5
Indigo Lake	Private	Cornell Univ.	1984	5
Pocket Pond	State	Cornell Univ.	1984	5
Silver Dollar Pond	State	Cornell Univ.	1984	5
Cranberry Pond	Private	LAMP	1985	6
Woods Lake	Private/State	LAMP/Living Lakes	1985,86	6