productivity (Eriksson et al. 1982; 1983; Henrikson and Oscarson 1984; Hornstrom and Ekstrom 1985). This change in phytoplankton composition occurs more rapidly in shallow lakes with short retention times. Sometimes the recolonization takes a long time and, in a few cases, species which disappeared during the acid period have not reappeared following liming (Renberg and Hellberg 1982; Hultberg and Andersson 1982). However, in many limed Swedish lakes, neutralization had very little effect until the phosphorus concentration in the water column increased significantly. Phosphorus concentrations usually increased the second year following autumnal and vernal lake circulation periods, resulting in increased phytoplankton productivity (Eriksson et al. 1982; 1983).

e. Macrophytes

A plant commonly found in acidified lakes is Sphagnum spp., which together with Mougeotia and other benthic algae often form felt-like mats on the lake bottom (Grahn et al. 1974). Following liming, Sphagnum and other benthic algal mats disappear rapidly, especially when lime is applied directly to the mats (Hultberg and Andersson 1982). Because of their strong ion exchange capacity and their absorption of sediment nutrients, the disappearance of Sphagnum following liming should increase the availability of nutrients and ions important to biological production (Hultberg and Andersson 1982). This probably benefits plant species such as Lobelia, Littorella, and Isoetes (Eriksson et al. 1982; 1983) and allows them to colonize the areas previously dominated by the Sphagnum mats (Hultberg and Andersson 1982; Lindmark 1984). For most macrophytes common in oligotrophic lakes, however, liming has little or no effect (Eriksson et al. 1983).

f. Zooplankton

Zooplankton responses to neutralization have been investigated more thoroughly than decomposers. Zooplankton in acidified waters are generally represented by only a few species, the rotifers and copepods being the least affected by acidification (Eriksson et al. 1982; Hasselrot et al. 1984; Hasselrot and Hultberg 1984). Typically, in the short-term, most of the dominant species prior to treatment are dominant and increase in abundance after liming (Eriksson et al. 1982; 1983). Therefore, a significant increase in the abundance of rotifers often occurs following neutralization (Eriksson et al. 1983; Henrikson et al. 1984; Hasselrot et al. 1984).

Crustacean zooplankton generally respond in a similar manner to the rotifer community: increased abundance and species richness following liming (Hultberg and Andersson 1982; Eriksson et al. 1982; Hasselrot et al. 1984). An exception to this was noted for lakes limed in the proximity of Sudbury, Ontario (Yan and Dillon 1984). In these lakes the crustacean zooplankton population decreased for a brief period following neutralization, probably due to a rapid rise in pH from the neutralizing product ($Ca(OH)_2$). Acid tolerant species such as Bosmina coregoni and Eudiaptomus gracilis decline in abundance, and are replaced by less tolerant species such as Daphnia cristata, Bythotrepes longimanus, and Ceriodaphnia quadrangula (Hultberg and Andersson 1982).

The most important factor responsible for change in zooplankton community structure seems to be an increased supply of suitable food for filtering species (Eriksson et al. 1983). Elevated pH, lower concentrations of toxic metals, and secondary ecological effects (e.g., increased predation from fish) probably play an important role, particularly for specific species and lakes.

g. Benthic Invertebrates

The benthic community may be considerably altered when an acidic lake is neutralized. In acidified lakes the benthic fauna both on littoral and profundal sediments are often dominated by chironomid larvae. Groups which are stressed or depauperate in acidified lakes include Ephemeroptera, Plecoptera, Gastropoda, and Lamellibranchiata (Grahn et al. 1974). Liming benefits these benthic invertebrates by restoring the ecosystem with suitable water quality.

Liming produces changes in the benthic community which continue for several years after treatment. The biomass of chironomids often decreases substantially (Hultberg and Andersson 1982), possibly as a result of the decreased precipitation of humic substances, an important nutrient for chironomid larvae (Eriksson et al. 1983). In contrast, Hultberg and Hasselrot (1981) observed in Lake Stora Holmevatten, Sweden, an increase in abundance of chironomids following liming. In a number of Scandinavian investigations, most benthic fauna increased in abundance after liming with acid-sensitive species often reappearing (Eriksson et al. 1982; Hasselrot et al. 1984; Hasselrot and Hultberg 1984; Raddum et al. 1984; 1985; Brettum and Hindar 1985).

Short-term effects of liming seem to favor an increase in abundance of benthic fauna in littoral zones, as opposed to the profundal zones of lakes (Eriksson et al. 1982; 1983; Hasselrot et al. 1984; Raddum et al. 1984; Brettum and Hindar 1985). In some Scandinavian studies there was a reported decrease in the number of species in profundal portions of limed lakes (Raddum et al. 1984; Brettum and Hindar 1985). This negative effect has been attributed to factors such as temperature, oxygen conditions, or precipitation of metals (e.g., aluminum) in the profundal areas (Wright and Skogheim 1983; Raddum et al. 1984).

Hasselrot et al. (1984) reported that long-term development of benthic fauna occurred more rapidly in the littoral zone of limed lakes than the profundal zone, largely due to an increased chironomid larvae biomass. Because microbial activity often increases with the addition of alkaline materials, the decomposition rate of organic matter is improved and detritivores such as chironomids, oligochaetes, ephemeropterans, and the isopod Asellus aquaticus are favored (Eriksson et al. 1982; 1983; Brettum and Hindar 1985). Species of the orders Odonata, Trichoptera, and Megaloptera often exhibit little change following liming. The abundance of these species is primarily dependent on the intensity of predation from fish. For example, populations of Sialis lutaria increased in limed lakes without fish, but not in lakes where fish were present (Eriksson et al. 1983).

h. Fish

It is clear that the liming of acidic waters has a definite beneficial impact on fish. Liming projects would not be conducted if it were not for the fact that liming has been demonstrated as a means of managing acidic waters to improve fish survival. Beneficial impacts on fish have been documented in both lakes and streams in a number of different states and countries and with many different species of fish. Fraser and Britt (1982) reviewed much of the literature available up until that point in time. They reported on projects where the following species of fish were favorably affected by liming: lake trout, brook trout, arctic char, rainbow trout, brown trout, Atlantic salmon, cisco, northern pike, smallmouth bass, European perch, roach, and others. These studies included both naturally occurring and introduced fish populations.

In Canada Booth et al. (1986) reported that lake trout were successfully restocked in Bowland Lake following a whole-lake liming project. Gunn and Keller (1984) discussed several liming projects in the Sudbury, Ontario area where crushed limestone was used to reduce the mortality rates of the early life stages of salmonids. They created microhabitats of neutralized water which allowed eggs and fry to survive the otherwise acidic and toxic water quality.

Hasselrot and Hultberg (1984) report that in all the Swedish projects where liming created favorable water quality, successful reproduction and recruitment of fish populations occurred shortly after treatment. In Swedish lakes which had lost their fish populations, liming projects created conditions where fish were either successfully stocked or successfully reinvaded from neighboring lakes. Eriksson and Tengelin (1987) showed that gill net catches of perch, Perca fluviatilis, in eight Swedish lakes increased significantly, while catches in unlimed control lakes did not change. Fraser et al. (1985) in their review of Scandinavian liming literature, reported that Norway has also shown positive fish population responses.

In New York State most of the liming projects currently conducted by the DEC are done to promote brook trout fisheries in lake environments. Early projects conducted by the Department in the 1960's included waters where dissolved oxygen was a problem, and liming did not always produce acceptable fish habitat. The proposed revision of the Division of Fish and Wildlife Liming Policy (Section I.) includes criteria to exclude waters which do not have satisfactory oxygen levels and to also exclude naturally acidic waters (included in the early program). Liming projects conducted by DEC will generally be one of three types. First are projects which restore the water quality for stocked fish, so that these fish can now survive in the lake or pond which was impacted by acidic deposition. The second type of liming projects are those which aim to preserve and protect valuable heritage strains of fish (Horn Lake and Tamarack Pond brook trout) or endangered fish species. These projects therefore do not include stocking but hope to improve the water quality so that natural reproduction and survival of all life stages are possible. The third type of liming projects are those where restoration of the natural aquatic ecosystem is the primary objective.

Two major liming research projects have been conducted in New York State recently and provide quantitative research data documenting the beneficial impact of liming on fish populations. These projects were discussed in detail in Section II.C.6. Both the Extensive Liming Study (ELS) and the Lake Acidification Mitigation Project (LAMP) included in situ bioassays of fish in the study lakes both before and after the liming. In all cases the survival of these fish was dramatically increased by the liming. In many cases prior to liming all of the test fish died within 4 days, while after liming survival was near 100% for the duration of the bioassays (Schofield et al. 1986). It is clear that liming can produce water quality which will permit fish survival in water which was lethally toxic to them prior to treatment.

The Cornell Extensive Liming Study used liming methods comparable to those used by DEC - agricultural limestone and similar application rates. The results from the ELS are therefore quite comparable to those expected in DEC liming projects. Annual survival of stocked brook trout was relatively high (40- 80%) in the lakes which maintained circumneutral water quality during the first year after liming (Schofield et al. 1986). Ponds which had flushing rates less than 3 times per year showed a sustained survival of the stocked trout longer than one year. Growth of the stocked fish after liming was found to be rapid at first as the brook trout fed on the abundant acid tolerant macroinvertebrates found in acidic, fishless ponds. Growth slowed however as these food resources were depleted. Schofield et al. (1986) found that both growth and condition of stocked trout appeared to be sensitive indices of both physiological acid stress and possible changes in food availability. It may be found that in limed New York waters fish food organisms such as Asellus sp. should be stocked in order to provide a more diverse food resource. In Sweden Asellus aquaticus and Lymnaea peregra have been stocked to increase the fish food available in limed lakes (Hasselrot and Hultberg 1984).

i. Amphibians

The beneficial impacts of liming on amphibian populations have not been well documented. However, it is expected that a restored circumneutral environment would be more favorable for most amphibians than an acidified environment. As was discussed in a previous section on the effects of acid deposition on amphibians, several species have been negatively impacted by the acidification of their environment. The liming of acidic ponds would create habitats which could now support a number of amphibian species. Growth of tadpoles would also be better in the more circumneutral habitat (Freda and Dunson 1985).

Although the liming of ponds and lakes would not influence the acidity of vernal ponds and ponds formed from melting snow, the shoreline habitats surrounding the limed pond would be improved. Jefferson, blue-spotted, and spotted salamanders may be able to find suitable areas at the edges of a limed pond to lay their eggs. These salamanders are known to be sensitive to acidic water conditions. (Freda and Dunson 1985; Clark and Hall 1985).

j. Wildlife

Although not well documented, the liming of a lake and the restoration or protection of a fish population would be expected to have definite beneficial impacts on many wildlife species. Fish eating birds such as eagles, osprey, and loons would benefit from an increase in suitable habitat with adequate food resources. Similarly mink and otter would be expected to utilize the limed lake which previously could not support a fish population. A viable fish population in a lake therefore supports not only a recreational fishery, but also a diverse and important wildlife community.

Numerous species of ducks would also be beneficially affected by liming and by the restoration of a circumneutral environment. As was presented in the section on acidic deposition impacts on wildlife, ducklings are in most cases negatively impacted by acidification. Liming will create an environment with a greater diversity of food organisms for ducks, including foods rich in calcium which are important to both egg-laying females and ducklings (McNicol et al. 1987). Des Granges and Hunter (1987) presented data on a productive lake in Quebec which was limed and which exhibited excellent duckling growth and survival.

k. Water Quality

An obvious consequence of liming is a resulting increase in pH and restoration of circumneutral water quality. The actual response of pH is dependent on the characteristics of the neutralization product used. Inputs of strong base (e.g., $Ca(OH)_2$) can result in pH values greater than 10 (Schafran et al. 1982). Use of agricultural limestone, as in the DEC liming program, does not result in such high pH values and does not therefore cause a pH shock to aquatic biota. The actual rate and magnitude of pH increase depends on the initial acidity of the water, the particle size of the $CaCO_3$, and the time of water contact. Therefore, the application of bases of varying solubility to surface water results in sharp pH increases with a maximum value obtained shortly after addition. This increase is normally followed by a decline in pH due to atmospheric CO_2 influx. When equilibrium with CO_2 is approached, stabilization of pH is obtained (Driscoll and Schafran 1984).

Concentrations of Ca^{+2} and ANC increase following liming. The magnitude of these increases depend on the initial water chemistry and solubility of the liming product used.

Elevated concentrations of Al, Mn, and Zn are generally observed in acidic Adirondack surface waters (Driscoll et al. 1982; Driscoll et al. 1984; White and Driscoll 1986). Following neutralization, concentrations of these metals generally decrease (Scheider et al. 1975; Yan et al. 1977; Driscoll et al. 1982). pH increases following neutralization, facilitate the hydrolysis and precipitation of aluminum. Decreases in concentration of other metals may be due to direct hydrolysis and precipitation or adsorption on particulates formed by base addition (Driscoll et al. 1982).

1. Species Diversity

Acidic environments generally have fewer species of animals and plants than more circumneutral environments (Fraser et al. 1985). This decrease in species diversity in acidic environments is due both to the reduced diversity of the habitat and to the sensitivity of many plants and animals to acidic conditions. There are few organisms which actually prefer an acidic environment over one which is circumneutral. The liming of an acidic lake generally promotes decompositional processes, increases the number of zooplankton and phytoplankton species, increases the number of benthic invertebrates, and reestablishes a habitat which is suitable for fish life (Hasselrot and Hultberg 1984).

Once a pond or lake has been limed and restored to a suitable environment for fish life, the objective of future limings would be to maintain and protect this restored environment. These future limings would not therefore have the same impact on the system as the initial conversion from acidic to circumneutral. Waters which are part of the DEC liming program will be maintained so that the water quality remains favorable, and a diverse assemblage of species can become established. Similarly the waters which are limed to protect heritage strains of trout will be maintained with favorable water quality, which will support many species of plants and animals.

The stability of the ecosystem as a whole is improved by increases in the species diversity of limed waters. Although the lake may still be subjected to acidic episodes due to snowmelt or large precipitation events, the adverse impacts would be greater if the lake were not limed. It may take several years for certain organisms to become established following liming, but the presence of certain acid sensitive insects, fish, and wildlife in a limed water is a real positive impact of a lake neutralization project. A diverse habitat, increased species diversity, and more complex food chains are important parts of a healthy ecosystem and would be beneficial impacts which would develop following liming.

2. Fisheries Benefits

Liming provides a direct short term (3 to 6 years) benefit to the fisheries resource by producing water quality suitable for fish survival. Pond liming experiences within the Adirondacks have demonstrated this benefit both in the protection of existing fish populations, and when followed by re-stocking, the restoration of lost fish populations. Blake (1981) reported 35 of 50 New York ponds limed prior to 1980 showed measurable improvements in water quality and trout survival. Many of these ponds were completely barren of fish life immediately prior to treatment, but after treatment produced excellent fisheries. Since 1980, approximately 33 ponds (838 acres) have been limed (or re-limed) by the DEC and cooperating volunteer groups. Post liming, the majority of these waters have shown improved water quality, and enhanced survival and growth of fish populations.

Pond liming, on a case by case basis, provides no long term benefits to the fisheries resource. Individual lime treatments generally have a useful life of three to six years. The liming program, however, can be considered as providing long term benefits. As a limed pond is periodically re-limed (as per the Division of Fish and Wildlife Liming Policy) to maintain satisfactory water quality parameters, the protection of its fisheries from acidification problems is perpetuated indefinitely. This benefit is magnified for those limed Adirondack waters which contain viable populations of Heritage strains of brook trout. These strains (considered endangered in some cases) are very important, and their loss would be irretrievable.

3. Economic Benefits

Liming, in spite of its often high costs, has been shown to be an economically feasible management tool for short term water chemistry improvement of acidified waters (Blake 1981). The major cost components include agricultural lime (up to one ton per acre), personnel and equipment to move the lime. Blake (1981) reported liming costs of $53 per acre for accessible ponds, and $138 per acre for remote ponds. The substantially higher cost for remote ponds is a direct result of the need for a helicopter (at $250 per hour in 1980) or other aircraft on these projects. More recent data, from ponds limed in Region six between 1984 and 1988, indicate an average treatment cost of $53 per acre for accessible ponds, and $264 per acre for remote waters.

The benefits of pond liming can be based partly on increased angler use and their resulting financial expenditures. Other benefits include the preservation of native brook trout strains in some waters and the restoration of aquatic ecosystems degraded by acidic deposition. In wilderness and primitive areas the primary resource management objective is to perpetuate natural aquatic ecosystems, including the perpetuation of indigenous fish species on a self-sustaining basis. The economic benefits of such ecosystem restoration are not easily quantified, but would be in addition to estimated benefits due to restoration of the fishery. Societal benefits of restoring degraded ecosystems are discussed in Section V.B.4.

Although angler survey data are not available increased angler use of limed ponds is expected. The amount of increase would be expected to vary with the accessibility of the pond. In wilderness and primitive areas the amount of increase is not expected to be major. Acidified lakes with little or no fish survival usually do not support quality fisheries and represent a lost angling opportunity. Menz and Mullen (1984) estimated annual net economic losses to licensed NY anglers from acidification of Adirondack waters ranging from $1.7 to $3.2 million, or 93 to 119 thousand angler days of recreation. These losses lead to less angler expenditures, and negatively impact regional economies in the range of $1 to $2 million annually (Menz 1981). A limed lake, with satisfactory pH and associated water chemistry, allows fish to survive and grow, and thus, provides a fishery. During the effective life of a lime treatment, the level of angler use of a limed water is assumed to be similar to that of non-acid impacted waters of the same size class and fish species composition. Experience suggests that angler use of limed ponds is highest shortly after treatment.

Pfeiffer (1979) estimated angler use of brook trout ponds at 10 trips per acre per year in 1979, and predicted an expansion of this use to more than 13 trips per acre by 1992. He did not differentiate between remote and accessible waters. We would expect lower angler use of remote waters, so for the purposes of calculating cost benefits of liming remote waters we estimate 7 trips per acre per year (approximately half the level of use for accessible waters). While supporting data are not available, it is believed that since 1979, use of accessible brook trout ponds has increased, at least to the predicted 13 trips per acre per year. Based on the 1976-77 New York Angler Survey, Kretser and Klatt (1981) estimated per trip coldwater pond angler expenditures at $33.70 (1981 dollars). Utilizing the Consumer Price Index, these expenditures can be adjusted to approximately $42 per trip (1988 dollars). Combining the use estimate of 13 trips per acre per year for accessible waters and 7 trips per acre per year for remote waters, with the angler expenditure figure of $42 per trip, the value of an acre of limed pond in 1988 can be calculated. Using an estimate of the total acreage of productive limed waters in NYS (58 acres remote waters, 530 acres accessible waters) the expected 1988 benefit from the DEC Liming Program, in terms of angler expenditures, is $306,432.

Comparing the cost of pond liming with the angler expenditures over an expected 3 year life of treatment, Blake (1981) reported a favorable cost benefit ratio for accessible ponds of 1 to 9.7. This was considered acceptable, and demonstrated the economic feasibility of pond liming as a fisheries management tool. Treatment cost data from more recent liming projects in the "accessible" category show an improved cost-benefit ratio of 1 to 12 (Table 8). The improved economic benefit is obvious despite the addition of stocking and water chemistry monitoring costs which were not included in Blake's earlier analysis. Had these additional costs not been included, the estimated 1988 cost-benefit ratio would have shown a much more dramatic improvement relative to Blake's (1981) estimate.

The latest cost-benefit ratio for remote liming projects is also favorable, at 1 to 6 (Table 8). This contradicts earlier beliefs that remote liming projects, with high treatment costs associated with expensive helicopter time, provide poor benefits. Blake (1981) reported a cost-benefit of 1 to 0.9. The new cost/benefit ratio is based on an estimate of 7 angler trips per acre, which is

Table 8 - Costs and benefits for 10 Region 6 limed ponds treated and monitored between 1984 and 1988. Costs adjusted to 1988 dollars. Annual costs based on six year life of treatment for both remote and accessible waters.

	Remote Ponds	Accessible Ponds
COSTS:		
Treatment		
Number of projects	2	8
Number of acres	58	179
Average cost per acre	$264	$53
Total treatment cost	$15,299	$9,537
Annual treatment cost (/6)	$2,550	$1,590
Water Chemistry Monitoring		
Collect sample (each,on foot)	$220	$120
Analyze sample (per pond,lab)	$18	$18
Total ponds	2	8
Annual Monitoring cost	$476	$1,104
Stocking		
Cost per 1000 brook trout		$644
Number stocked per year		8,160
Annual cost per acre	0	$29
Annual stocking cost	0	$5,255
Total Annual Costs	$3,026	$7,949
BENEFITS:		
Angler Expenditures		
Angler trips per acre	7*	13*
Total acres	58	179
Total angler trips per year	406	2,327
Expenditures per trip	$42**	$42**
Annual angler expenditures	$ 17,052	$97,734
Cost-Benefit Ratio 1:	6	12

* Pfeiffer (1979).
** Expenditures derived from Kretser and Klatt (1981).

approximately half the estimated angler trips per acre for accessible waters.

These improvements can be attributed to several factors. The first, and most notable, is extended life of treatment. Blake (1981) reported a 3-year life of treatment for both remote and accessible waters. Recent observations indicate an increase in longevity to an average of more than six years for accessible and remote waters combined. At present, the time between treatments for waters in the liming program is ranging from 4 to 12 years for accessible waters, and 3 to 9 years for those in remote locations. The cost data reported in Tables 7 and 8 are based on a conservative 6-year life of treatment estimate.

Extended treatment longevity provides obvious economic benefits. If the trend towards improvement continues, so will the benefits, but if the average life of liming treatments starts to shorten as a result of increased levels of acidic atmospheric deposition, the benefits will diminish accordingly.

The second factor which cuts the costs of recent liming projects is reduced dosage rates (as low as one half ton per acre) associated with re-treatment projects. Approximately 50 percent of the projects initiated in Region 6 since 1980 were re-treatments. All of these demonstrated satisfactory water chemistry improvement following re-treatment at this dose. The longevity of treatment also appears acceptable at this reduced dosage rate.

Thirdly, reduced application costs (to DEC) have been realized by using volunteer supplies, equipment and labor (see V.B.4, Societal and Other Benefits), and by the development of more efficient application equipment and techniques. An improved helicopter lime delivery system which was tested and approved by DEC at Brewer Lake in 1988, is expected to overcome the technical problems associated with helicopter liming projects in the past. More efficient remote liming treatments will use less helicopter time per acre, thus providing for even better cost-benefit ratios.

Finally, improved economic benefits can be attributed to increased angler expenditures. 1980 angler expenditures were $9.56 and $10.51 per trip for accessible and remote brook trout ponds respectively (Blake 1981). Estimates for 1988 show an increase in angler expenditures (derived from Kretser and Klatt 1981), to $42 per angler trip.

Stocking costs are a substantial part (over 60%) of the annual expenses for managing accessible limed ponds (Table 7). These costs (estimated at $29 per acre per year in 1988) include expenses for both rearing and the actual stocking process. Stocking costs do not apply to the two remote waters currently included in the DEC Liming Program, since the brook trout populations are maintained by natural reproduction within those systems. DEC's management objectives for these two remote waters focus on the protection of NSA (natural spawning adequate) brook trout populations. Maintaining these natural populations is a high priority goal in the DEC's fisheries management plan for the Adirondacks (Pfeiffer 1979, Keller 1979).

The proposed expansion of the DEC liming program (See Section II.B.3) requires a modification relative to stocking costs. Most of the waters recommended for liming under this new proposal are essentially fishless, due to acidification (Table 1-a). Following liming, these waters (remote and accessible) will require stocking, at least initially, to establish or enhance their brook trout and other indigenous fish populations. In wilderness, primitive, and canoe areas the management objective will be to perpetuate natural aquatic ecosystems, including perpetuation of indigenous fish species on a self-sustaining basis. In these waters maintenance stocking may not be required on an annual basis. Table 9 details the projected costs for this program, with stocking costs included for both remote and accessible waters.

4. Societal and Other Benefits

The effects of pond liming, although short term, provide certain societal benefits. The most obvious is the improvement or establishment of sportfisheries in acidified waters. Pond liming has been shown to immediately transform many acidified lakes, barren of fish life, to productive fisheries (Blake 1981, Pfeiffer and Festa 1980, Webster and Flick 1978). Re-liming has maintained the productivity of many of these waters, and their fisheries. It is clear that providing a sportfishery (by liming) where none could exist (because of acidification) directly benefits anglers of NYS and provides economic benefits to local communities and businesses. The opportunity to successfully fish on many acid impacted coldwater ponds can be directly credited to the pond liming program.

Society also benefits from the restoration of degraded acidified ecosystems to viable aquatic ecosystems capable of supporting diverse animal and plant communities. For hikers, campers, photographers and others interested in conservation, restoring a viable aquatic ecosystem is of critical importance. Society places great value on viable healthy ecosystems and the opportunity to encounter wildlife in its natural surroundings. Ponds which have become fishless due to acidic deposition offer limited opportunities for such encounters, whereas limed ponds are capable of supporting a diverse community including otters, osprey, loons, and other acid sensitive biota. In wilderness areas the primary objective of liming projects is to perpetuate natural aquatic ecosystems.

Pond liming also represents a positive action in the acid rain picture. Pond liming activities often attract media attention, and provide opportunities to educate and increase the public's awareness of the acidification problem. Increased public awareness, and the perception of pond liming's immediate benefits, have inspired volunteers to step forward and take an active part in the DEC liming program. Largely, volunteers have supplied needed personnel and equipment, and in some instances, lime has been donated. Volunteering to assist with pond liming has become so popular in the last 10 years,

Table 9 Projected Division of Fish and Wildlife Liming Program costs thru the year 2000, for the current 32 pond program and the new program expansion to 50 waters. Costs based on 1988 estimates (Table 7). Projected costs reflect anticipated Consumer Price Index increases.

Annual Liming Program Cost Projection

	Remote	Accessible	Combined
Current Program			
No. waters - acreage	2-58	30-530	32-588
1988 Cost Per Acre	$ 52	$ 46	$ 46
1988 Total Annual Cost	$ 3,026	$ 24,192	$ 27,218
1993 Cost Per Acre (1)	$ 62	$ 55	$ 56
1993 Total Annual Cost	$ 3,631	$ 29,030	$ 32,661
2000 Cost Per Acre	$ 75	$ 65	$ 66
2000 Total Annual Cost	$ 4,297	$ 34,450	$ 38,649
New Expanded Program (1993)			
No. waters - acreage	17-580	33-602	50- 1,182
1993 Cost Per Acre (1)	$ 86 (2)	$ 54	$ 74
1993 Total Annual Cost	$ 55,680	$ 32,508	$ 88,188
2000 Cost Per Acre	$ 117 (2)	$ 65	$ 90
2000 Total Annual Cost	$ 67,860	$ 39,130	$ 106,380

(1) Current planning calls for phase in of all proposed candidates for the expanded program by 1993.

(2) Includes stocking costs ($29/acre - 1988). All waters added under expansion program will need stocking to re-establish lost brook trout populations. Successful re-establishment to NSA status may reduce or eliminate the need for annual stockings.