Table 4 (Cont'd)

WATER	OWNERSHIP	TECHNICAL SUPPORT	YEAR TREATED	REFERENCE
Little Simon Pond	Private	LAMP/Living Lakes	1986	6
Kanacto Lake	Adk. Woodcraft Camps	Living Lakes	1986	7
Tejekna (Lindsey Pond)	Adk. Woodcraft Camps	Living Lakes	1986	7
Lake Madeleine	Litchfield Park	Living Lakes	1986	7
Heavens Lake	Litchfield Park	Living Lakes	1986	7
East Pond	Brandreth Park Assn.	Living Lakes	1987	7
Barnes Pond	Private	Living Lakes	1987	7
Wilmurt Lake	Private	-	?	-
Hamilton Lake	Private	-	?	-

Reference Key

1- Schofield et al. 1981
2- Gloss et al. 1988
3- Flick et al. 1982
4- Bisogni, Pers. comm.
5- Schofield et al. 1986
6- Procella 1987
7- Adams, Pers. comm.

appeared to successfully produce a reservoir of acid buffering capacity.

Gloss et al. (1988) have included additional data on lake neutralization projects conducted on Adirondack League Club lakes by Cornell researchers. Methods of lime application included aerial spraying, hand spreading, boat application, shoreline application, and spreading on the ice. Since liming efficiency depends in part on the application method used (Wright 1985), the actual effectiveness of these projects was variable. However, routine annual water monitoring was conducted in August for five lakes reported (Chambers, Deer, 4th Bisby, Jones, and Mountain), and these data were used to determine reliming strategies. Deer and Mountain Ponds exhibited the fastest flushing times and required annual treatments of lime in order to maintain water quality favorable for brook trout survival.

Dr. James Bisogni of Cornell University has been conducting an experimental neutralization of Wolf Pond in the northern Adirondacks. He added sodium bicarbonate (baking soda) to this private pond in July 1984 and raised the pH from 4.5 to 6.9. An additional treatment of this neutralizing agent was made during the summer of 1986. During August 1987, the pH had dropped to 5.6, and in October 1987 20 tons of sodium bicarbonate were added to one end of the pond (J. Bisogni, personal communication). Brook trout which were stocked in Wolf Pond following neutralization survived quite well and resulted in the pond being heavily fished. This study will continue to evaluate the use of sodium bicarbonate as an alternative to agricultural limestone in the treatment of acidic waters.

Two major liming research projects have been conducted recently in New York State, and these will be discussed in detail in the following section (Sec.II.C.6). The first of these was an extensive liming study conducted by Cornell University. In this study ten Adirondack ponds were treated with agricultural limestone, stocked with brook trout, and the subsequent fish survival and water quality monitored (Schofield et al. 1986). The second project has involved a more detailed study of three limed ponds, and is called the Lake Acidification Mitigation Project. This project has involved researchers from a number of universities (Porcella 1987).

In 1986 a non-profit organization named Living Lakes, Inc. was established, funded by mid-west power and coal companies, including some of the major sulfate emitting companies in the U.S. The stated purpose of Living Lakes is "an aquatic liming and fish restoration demonstration program." NYSDEC determined that there is no benefit to participation in this program, and believed that participation might hinder passage of a truly effective national emissions control program.

The NYSDEC held detailed discussions with Living Lakes during the spring of 1987. The purpose of these discussions was to evaluate whether it was feasible and advisable for NYSDEC to have Living Lakes assume the responsibility of liming and monitoring some of the lakes in the DEC liming program. Living Lakes expressed interest in such an arrangement and proposed to treat a group of five waters in 1987.

However, after careful review and consideration of all the facts, the DEC decided not to participate in the Living Lakes program. The primary reason for this decision was the fact that in addition to liming ponds, an important component of the Living Lakes program is a public information program which suggests that liming is appropriate mitigation for acidic deposition. The NYSDEC does not believe that this is the case, and was concerned that its involvement in the Living Lakes program could be misrepresented and potentially jeopardize the eventual passage of meaningful acid rain legislation.

Seven waters in the Adirondacks were limed during 1986 and one in 1987 with funding and technical assistance from Living Lakes. Two of these waters were also part of the Lake Acidification Mitigation Project which will be discussed in Section II.C.6. The remaining 6 waters were located on private lands and are listed in Table 4. Living Lakes has stated that they will continue to monitor and when necessary relime these waters at least until 1990 and possibly until 1995 if Living Lakes receives continued funding.

6. Recent Major Liming Research Projects

a. Cornell Extensive Liming Study

During 1983 Cornell University researchers began an Extensive Liming Study (ELS) to monitor the water chemistry and evaluate the response of stocked brook trout populations in Adirondack ponds which were limed and allowed to reacidify. The project has now been completed and described in detail by Schofield et al. (1986). A total of ten small, acidic lakes were treated with agricultural limestone. Five were treated during the fall of 1983; Mountain, Big Chief, Little Rock, Highrock, and Trout Ponds), and five during the fall of 1984 (Barto, Jones, Indigo, Pocket, and Silver Dollar). The waters were treated using a fixed wing aircraft at dosages calculated to raise the Acid Neutralizing Capacity (ANC) to 200 μeq/l and pH levels >6.5. Following treatment the lakes were stocked with equal numbers of two groups of Temiscamie x domestic hybrid brook trout (total of 40 fingerlings/acre). One group had been selected for increased acid tolerance in an experimental breeding program.

The treatments with agricultural limestone did raise the pH and ANC to desired levels, where they then were regulated by the thermal stratification patterns and flushing rates of the individual ponds (Schofield et al. 1986). Figure 1 shows the pH levels observed in Mountain Pond over the course of the study. The Cornell researchers found that re-acidification rates in their study ponds closely tracked the flushing rates. Little Rock Pond and Trout Pond had the fastest flushing rates and also were the first ponds to reacidify. High run-off events which occurred during times when the ponds were completely mixed were observed to result in very rapid rates of reacidification in these fast flushing ponds. The rapid reacidification of Little Rock and Trout Ponds resulted in complete mortality of the stocked brook trout populations within the first year after liming.

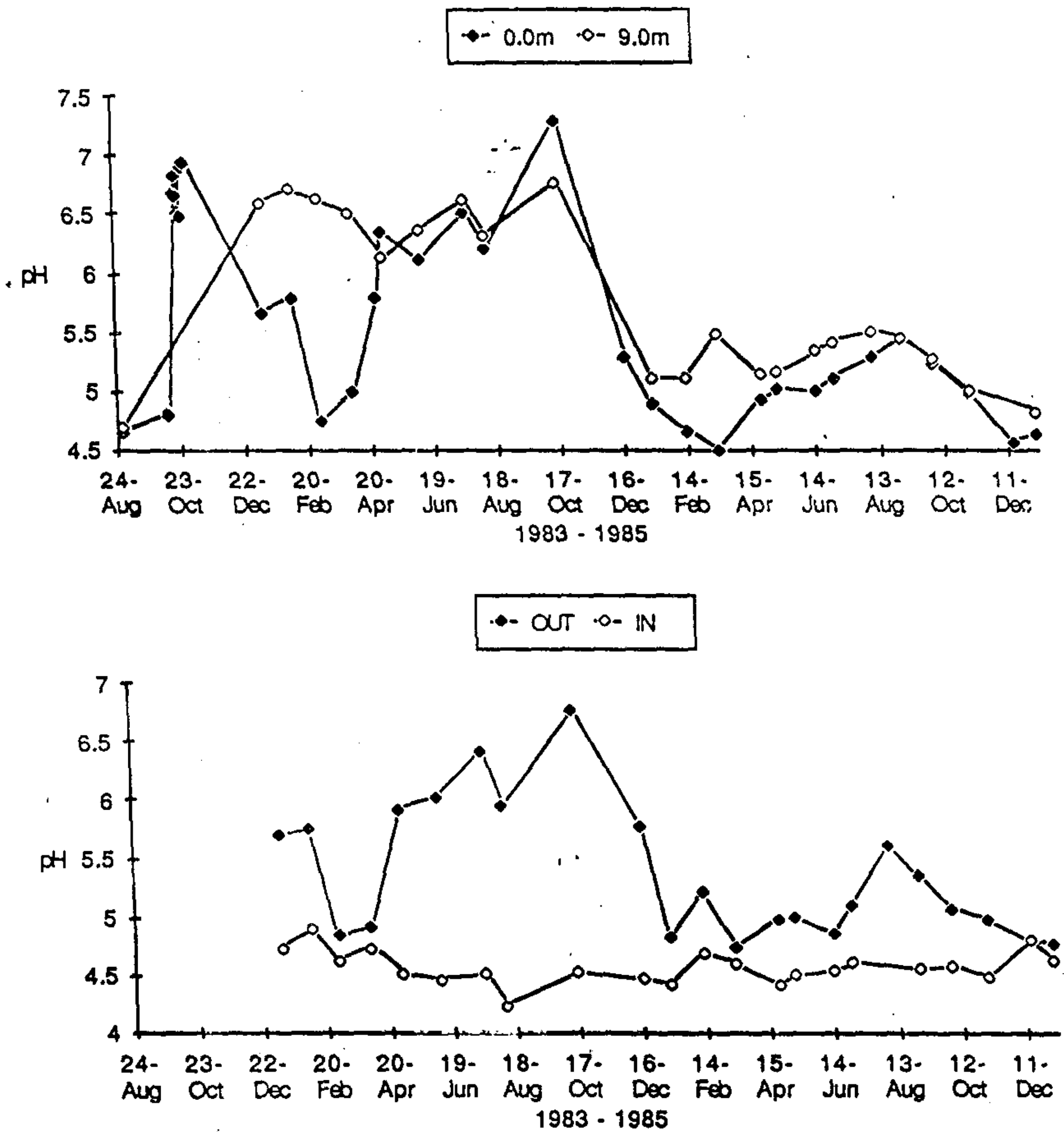

Figure 1. Temporal variations in field pH in Mountain Pond (0.0m and 9.0m), outlet, and inlet. (figure taken from Schofield et al. 1986).

Gloss et al. (1988) further analyzed the Extensive Liming Study data and compared their results with Scandinavian models of dissolution and reacidification. They found that total limestone dissolution efficiencies ranged from 17-59% in the ten ELS lakes. Dissolution of the limestone initially was generally 10-20% but limestone continued to be dissolved for 2-3 years following treatment. Total limestone dissolution efficiencies observed were comparable to levels observed in Scandinavian studies using agricultural limestone.

For the ELS lakes Gloss et al. (1988) found that the ratio of watershed area to lake volume satisfactorily predicted the rate at which calcium was lost from these systems and the rate at which they reacidified. A relatively simple dilution model of reacidification was found to accurately predict the rate at which ponds reacidified. Gloss et al. (1988) concluded that limed Adirondack lakes with flushing rates higher than 3 times per year reacidified within a year after treatment. A great many acidified Adirondack lakes exhibit flushing rates higher than 3 times per year, and the Cornell researchers state that in these lakes simple whole lake liming would not be adequate to maintain water quality suitable for the support of viable fish populations.

Fish survival was good during and following pond treatments with limestone according to Schofield et al. (1986). The two groups of hybrid brook trout stocked in the ponds after neutralization both exhibited good survival as long as the water quality remained acceptable. The study was not able to demonstrate, however, any difference in the survivorship or growth of the two groups of fish, even though the one group had been selected for increased acid tolerance by selective breeding. Schofield et al. (1986) state that in ponds which reacidify more slowly, there may yet be greater survival in the selected group of fish. Ponds which reacidify quickly however exceed the acid tolerance range of both groups of fish.

b. Lake Acidification Mitigation Project

A second major research project which began in 1983 was designed to intensively study most of the possible impacts resulting from lime applications to acidic waters. This project, referred to as the Lake Acidification Mitigation Project (LAMP) will continue until 1989 (Porcella 1987) and has involved researchers from Cornell, Syracuse, and Indiana Universities, Clarkson College, and the U.S. Geological Survey. Detailed pre- and post-liming data have been collected from three study waters (Cranberry Pond, Woods Lake, and Little Simon Pond). Cranberry and Woods were treated in May 1985; Little Simon was treated in August 1986; and Woods was retreated in September 1986. All of the treatments were made by helicopter using a high purity, finely ground calcium carbonate slurry sprayed over the surface of the water (Porcella 1987)

Cranberry Pond, which has a high flushing rate of 5.88, was observed to reacidify within seven months of treatment (Driscoll et al. 1989). The LAMP researchers anticipated that Cranberry Pond would reacidify quickly, and monitored the pond carefully during this period. Woods Lake, with a flushing rate of 2.08 also lost much of its acid neutralizing capacity during the first year and had a pH of less than 6.0 only 15 months after treatment. Part of the research plan was to maintain the water quality and fishery of Woods Lake, so reliming of this water occurred in September of 1986.

The pH levels observed in Woods Lake and Cranberry Pond following treatment and during reacidification are shown in Figure 2. Driscoll et al. (1989) found that the calcium carbonate used for the liming was so fine that it did not penetrate the thermocline of the lake. As a result the epilimnion of both waters was neutralized, but the deep waters remained acidic. A relatively small percentage (5%) of the total lake volume, however, is deep water. Complete mixing of the waters did occur in the fall, when the pH of Woods Lake was 7.0 and Cranberry Pond initially was 6.5. Figure 2 shows the rapid reacidification of Cranberry Pond during the fall of 1985, which can be attributed to its high flushing rate and the occurrence of large precipitation events.

The reliming of Woods Lake in September 1986 increased the epilimnion pH from 5.98 to 7.26 (LAMP unpublished data). The strategy of this treatment was to treat the entire lake with 12 tons of finely ground calcite powder to neutralize the surface waters, and to then treat the lake with 26 tons of more coarsely ground calcite selected to penetrate the thermocline and neutralize the bottom waters and the sediments. This strategy was selected apparently because the initial treatments with very finely ground calcium carbonate did not adequately treat the entire lake or provide any neutralization of the sediments.

Little Simon Pond was similarly treated with several sizes of calcium carbonate particles in order to achieve a uniform lake neutralization. Finely ground limestone was used to neutralize the surface waters, and medium and coarsely ground limestone was applied in order to penetrate the thermocline and neutralize the bottom waters. The pH of the epilimnion increased from 5.7 to 7.3 following treatment, and the hypolimnion pH rose from 5.4 to 6.3 (LAMP unpublished data).

The LAMP researchers also studied the effects of lake neutralization on phytoplankton and zooplankton populations. Following liming pennate diatoms appeared to increase in abundance and diversity, and in August 1985 the Woods Lake algal populations stabilized at a level higher than pre-treatment levels (Bukaveckas 1989). The researchers felt that CO_2 levels in the water may be very important in limed lakes to various species of algae and macrophytes.

Numerous changes in the zooplankton and macroinvertebrate communities were observed following the initial limings of Woods and Cranberry. However, it was not possible to separate the effects which were due to liming or to predation from fish populations now present in the lakes. There were no observed detrimental effects on zooplankton due to the reliming of Woods Lake or the treatment of Little Simon Pond (Schaffner, 1989).

Woods Lake and Cranberry Pond were both found to be fishless in LAMP pre-liming surveys. Bioassays conducted in these waters prior to

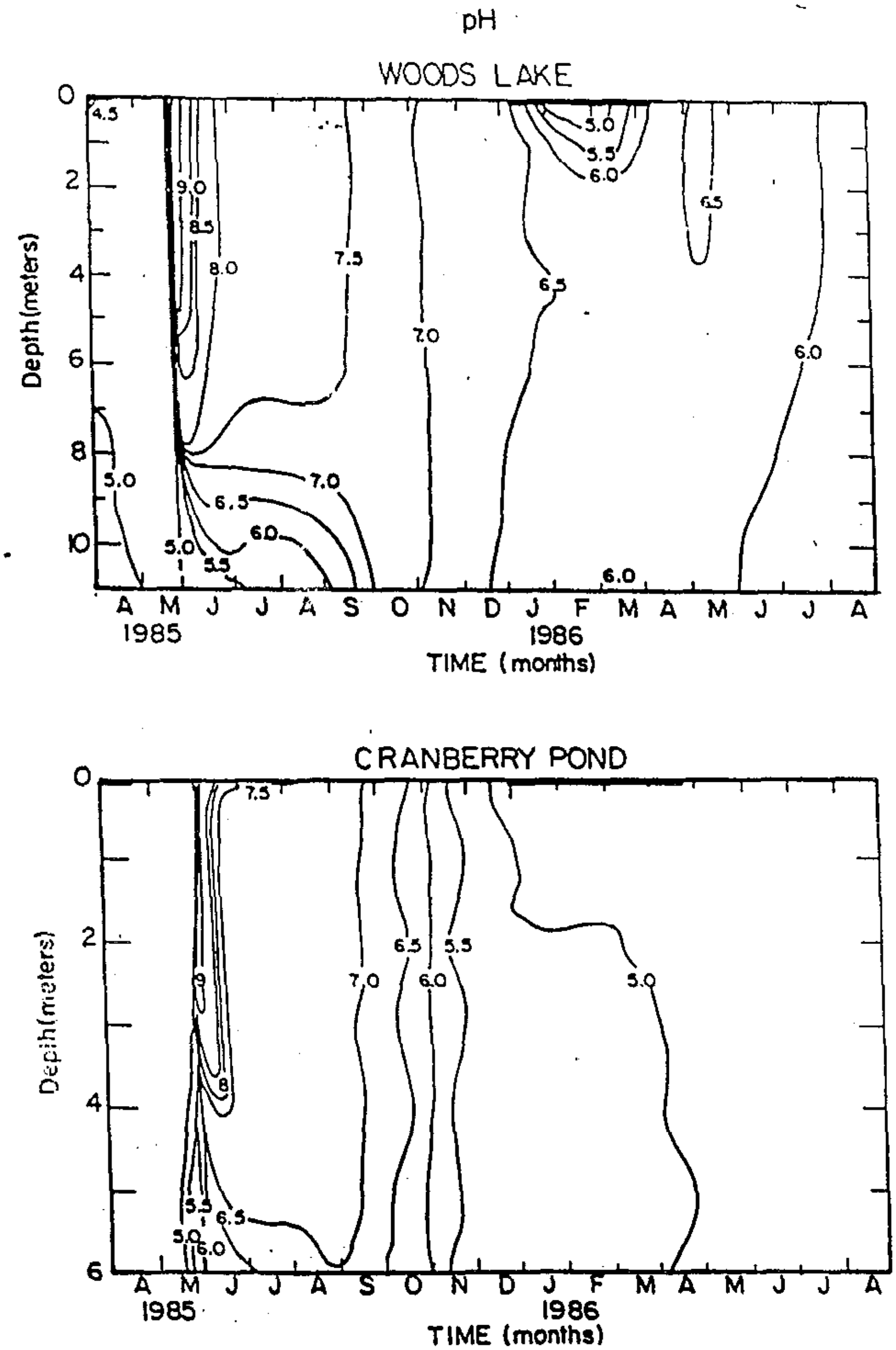

Figure 2. pH isopleths of Woods Lake and Cranberry Pond following $CaCO_3$ treatment (figure taken from Driscoll et al. 1989).

liming demonstrated their toxicity to brook trout (Gloss et al. 1987). Woods Lake was also stocked with brook trout in the fall of 1984, prior to liming, but approximately 90% of these fish died over the winter. Gloss et al. (1987) reported that neither acclimation of the fish to acid conditions, nor experimental selection of brook trout for acid tolerance improved survival.

Immediately prior to, during, and after Woods and Cranberry were limed Gloss et al. (1987b) conducted an extensive series of bioassays with brook trout. The results of these bioassays demonstrated significantly improved survival of age 0 and 1 brook trout after liming. No detrimental effects of liming on fish survival were observed.

Detailed studies of brook trout stocked in Woods Lake have shown that brook trout reproduction is limited by a lack of suitable spawning substrate and near shore acidification. Limestone gravel spawning boxes were therefore set out in the lake and were used extensively by the fish (C. Schofield, unpublished data). Brook trout which had been stocked in Woods and Cranberry following neutralization survived well, but migrated down the outlets in large numbers during the fall of 1985. After Woods Lake was relimed in 1986 and spawning boxes were put in place, relatively few fish were caught in the outlet trap. Although the levels of fish biomass and production in Woods Lake appeared comparable to other circumneutral lakes, they may not have stabilized (C. Schofield, unpublished data). The fish may not be in real equilibrium with the limed lake or with their food resource because their prey community has not yet stabilized.

Lake trout are the primary fish being studied in Little Simon Pond. Bioassay tests with yearling lake trout showed mortality prior to liming, and post liming tests showed no mortality. During the fall of 1987 numerous lake trout were trap netted, including several which appeared to be young of the year. These fish would have hatched from eggs which were spawned in the fall of 1986 (post-liming).

The LAMP research on Little Simon Pond and Woods Lake will continue until at least 1989. An extension of the LAMP research has been proposed and would involve the liming of certain drainages in the Woods Lake watershed.

D. Factors Affecting Proposed Program and Guidelines

1. Relationship to Adirondack and Catskill State Land Master Plans

Fisheries management activities by the Division of Fish and Wildlife, including the liming of waters located on forest preserve lands, will be conducted within the guidelines of the Adirondack and Catskill State Land Master Plans, DEC policies and rules and regulations. These accepted or state-of-the-art management practices, including liming, have been discussed in generic environmental impact statements on habitat and species management (Odell et al. 1979., Shepherd et al. 1980), in various strategic fisheries management plans (for example, Pfeiffer 1979, Keller 1979), and are being incorporated into Unit Management Plans within the Adirondack and Catskill Parks.

The State Land Master Plans for the Adirondack and Catskill Parks adopt the concept of resource management in principle and provide strong guidance for fish management (APA 1979, DEC 1985). Among the land classification categories considered in the plans, the most restrictive guidelines apply to wilderness areas. The primary wilderness management guideline is to achieve and perpetuate a natural plant and animal community where man's influence is not apparent. While the plans recognize wilderness areas as places where the earth and its community of life are untrammeled by man, where man is a visitor who does not remain, it also defines wilderness as areas which are protected <u>and managed so as to preserve, enhance and restore, where necessary, its natural conditions</u> (emphasis added). Indeed, the state land master plans state that fishing is "compatible with wilderness and should be encouraged as long as the degree and intensity of use does not endanger the wilderness resource itself." Liming is included as a management tool to be used in the approved Five Ponds Wilderness UMP, and its compatibility with wilderness is discussed more fully in the next section.

2. Liming in Wilderness Areas

Wilderness areas, as other areas in the state, have been adversely impacted by acidic deposition. Liming suitable candidates is a valuable management tool for reversing anthropogenic acidification and restoring these systems to a more natural wilderness ecosystem. These restored aquatic ecosystems are capable of supporting a diversity of animals and plants which characterize resources not impacted by man. This increase in diversity of organisms benefits not only the ecosystem, but also anglers, hikers, birders, and naturalists seeking a wilderness experience.

The primary objective of pond liming in wilderness areas is to *improve water quality conditions for survival, growth and reproduction* of indigenous fish species. The selection of each candidate water is guided by the five criteria presented in the proposed revised liming policy (Section I). Among these, criterion 5 deals with the past and present status of the fishery including its uniqueness and excellence as well as its importance for heritage strains, threatened or endangered fish species. Among the currently limed ponds listed in Table 1, both wilderness ponds (Horn Lake, Tamarack Pond) have been limed to preserve heritage strains of brook trout in their native habitats Among the wilderness, primitive, and canoe area ponds which are new additions to the liming program (Table 1a), all will be managed for brook trout and other indigenous fish species.

Fisheries management in wilderness areas, including liming, has a strong foundation in law, policy, tradition and resource planning. The following paragraphs are taken from a DEC policy memorandum discussing fisheries management in Wilderness areas (Jorling 1988). More detailed guidelines for management activities in wilderness, primitive, and canoe areas are included in Appendix B.

> "Legally established goals for the Forest Preserve recognize that fish and wildlife are integral to the values society places on the Preserve. Charges include management to 'foster the wild Adirondack environment and all the flora and fauna historically associated therewith' and encouragement of 'indigenous species presently restricted in numbers.'
>
> "Fisheries management activities are essential to achieve these goals and to perpetuate unique opportunities for high quality wilderness fishing experiences provided within the Adirondack and Catskill Parks. The framework for permissible management has been established in State Land Master Plans.
>
> "Fisheries management in Wilderness Areas will be conducted in accordance with these Plans and Department policies and regulations. Management objectives and strategies will be incorporated into Unit Management Plans for state lands within the Parks. Management will be designed to provide a diversity of experiences consistent with wilderness values and natural ecosystem capabilities. *Management activities will be (a) compatible with* the characteristics of wilderness, (b) conducted in an unobtrusive manner, and (c) restricted to the minimum necessary to achieve management objectives."

While pond liming has been employed to enhance survival and growth of several salmonid species, this management practice has been primarily directed at enhancement of brook trout populations and fisheries. Among New York's game fishes, this species most typifies wilderness and the wilderness angling experience. It is also a species of considerable ecological and recreational importance in the Adirondacks and has contributed significantly to the literature on the angling traditions which have been historically associated with that region (Pfeiffer 1979). Originally it was one of only two native salmonids in the interior Adirondacks, the other being the lake trout. The brook trout is the cornerstone of DEC's fisheries management activities in Adirondack wilderness.

Adirondack wilderness areas contain about 545 ponds or 11,000 acres of water. Among these brook trout are present in 174 ponds or 4600 acres. Presently designated wilderness areas contain about 40% of the number and 30% of the acreage of brook trout ponds which are available for public fishing. While more than half of the brook trout fishing opportunity in Adirondack Ponds lies outside wilderness, that found in wilderness areas is especially valuable because of the "wilderness mystique" or wilderness experience associated with these fisheries.

Among the 50 waters listed in Tables 1 and 1a, 12 are located in wilderness areas, 5 in primitive areas, 20 in wild forest areas, 2 in the canoe area and 11 on private lands which are open to public fishing. Thirty-nine of the ponds including all wilderness and primitive area ponds are located in DEC's Region 6 in areas which once provided very important brook trout pond fisheries, but which since have become severely impacted by acidification. Among the 12 ponds in wilderness areas, 9 are in the Five Ponds area, 2 in the Pepper Box area, and 1 is in the West Canada Lake area. These 12 wilderness ponds represent about 2 percent of the numbers and 3 percent of the acreage of lakes and ponds in the 15 Adirondack wilderness areas. The 5 primitive ponds are located in the primitive area north of Stillwater Reservoir. As noted previously, the 12 limed wilderness and the 5 primitive area ponds would be managed for brook trout and other indigenous fish species.

Liming of carefully selected acidified wilderness lakes and subsequent restocking with brook trout and other indigenous fish species in accordance with the proposed policy is designed to meet SLMP wilderness management guidelines. Liming improves water quality and restores conditions to more nearly approximate those which existed before acidification, especially when substantial reacidification is not permitted to occur through proper monitoring and reliming. This encourages indigenous plants and animals to survive, grow and reproduce, and fosters biological communities which more closely resemble those present before acidification. Thus liming more nearly achieves and perpetuates a natural biological community than that found after acidification, and once limed, a pond where man's influence is not visually apparent.

Subsequent management of limed ponds with brook trout and other indigenous fish species meets a second SLMP criterion: that of managing for species which are "historically associated with the Adirondack environment." Other species similarly recognized are also expected to benefit from water quality improvements resulting from liming. The discussion in Section V.B.1. in this EIS indicates that liming of acidified ponds results in an overall increase in species diversity and reductions in abundance and diversity of acidophilic species. There are few fish species that tolerate severe acidification.

At present, the most efficient way to deliver lime to wilderness ponds is via a lime bucket carried by helicopter. This can deliver up to a ton per trip (see Section II.C.3.b. for description). The average wilderness pond proposed for liming is 29 acres in size and can be limed in a day or two using the lime bucket technique. Remote liming is done during periods of low human use. During operations the helicopter does not land on the pond. In the past this has included both fall and winter applications. Recent policy changes regarding the deployment of a NYS helicopter in a liming operation has eliminated the potential for winter helicopter treatments. The operational plan now calls for fall (post Labor Day) and spring (pre Memorial Day) treatments, during periods of low human use. Based on recent experience, each application lasts about 6 years with some up to 8 years, before retreatment is required. Helicopters make noise and noise can be offensive to some. But the benefits which result from the liming are realized throughout the year, whereas the noise resulting from liming is only a factor for one or two days every few years and is confined to periods of low human use. The annual water quality sampling required by the liming policy will be conducted by hiking to each pond. These actions of helicopter use during off-peak seasons and hiking to collect water samples satisfy

SLMP guidelines of unobtrusiveness and minimum activity necessary to achieve management objectives.

Fisheries management in wilderness, primitive, and canoe area ponds focuses on species indigenous to the Adirondacks, principally brook trout, and seeks to encourage relatively low density angling. Low density angling is essential to preserve the quality of the wilderness experience. This differs from fisheries management focus in non-wilderness waters where emphasis is on a broader array of game fishes and where relatively high angler densities are compatible with management goals. Remoteness and difficulty in reaching many wilderness waters are powerful factors regulating use intensity in these ponds today.

The type of experience that should be provided in wilderness areas was discussed by Pfeiffer (1979). It is presented below because it represents an eloquent expression of the elements of a wilderness fishing experience.

> "In our discussion of wilderness concepts as they apply to the utilization of the Adirondack fisheries resource, let us first try to state and define the elements of a 'quality' wilderness fishing experience. It is my belief that such an experience is composed of three major elements and, as such, is not limited to the Adirondacks. It could apply elsewhere. First, we must insist on an esthetic aquatic setting, be it stream, river, lake or pond. Preferably, it is remote from roads, at least out of their sight and hearing. This natural locale is frequently rugged and scenic, unspoiled by recent lumbering, and is often spiced by woodsmoke from a campfire with appropriate background sound provided by the song of the whitethroated sparrow, the haunting call of a loon and the irritating buzz of mosquitos. The presence of black flies, in season, is also accepted if not appreciated. Secondly, we do not anticipate much competition from other resource users and recreationists. In fact, there should be a notable lack of concentrated angling pressure and of people in general. Finally, there should be the expectation of an angling encounter with fish which are not of recent (yearling) hatchery plantings. In most cases, our quarry will represent native species, sometimes of wild origin.
>
> "These are the chief ingredients of a 'quality' wilderness fishing experience and much of the Adirondack water resource is eminently qualified to provide the requisite scenery, solitude, and preferred fish. This is not to say that trophy-size specimens are abundantly available once we leave the traveled roads and highways. Limits of fertility and climate naturally conspire to limit growth potential but, fortunately, the light fishing pressure increases our chances in at least a few favored situations.
>
> "Thus, there still exists an enigmatic air of mystique surrounding the Adirondack fishing experience as compared to more favored, less rugged climes. This condition seems to relate, at least in part, to the aura of wilderness and human isolation which

derives from the relatively undeveloped and uninhabited aspect of the region when contrasted with the more urbanized and populated portions of the state. To many an urban resident, this chance to participate in and enjoy his sport in relative isolation represents the prime attraction which sets the Adirondacks and their fisheries resources apart. Also, the great numbers and variety of available waters allows for a wide spectrum of diversity and choice.

"Those Adirondack anglers who favor the roadside lakes and streams may still share some degree of wilderness motivation since many accessible waters still retain a scenic wilderness quality. Also, roadside waters are more amenable to intensive fish management activities so that in many cases, knowledgeable anglers can do as well in the `easy to get to' situations as the true wilderness addict achieves in his more remote setting. Many fishermen are simply too lazy or physically unable to consider a hike to inaccessible waters. In many cases, they are equipped with large, trailer mounted boats and motors which require formal boat launching facilities or, conversely, lack lightweight craft capable of easy portage. Also, let's face it, there are gregarious types of anglers who enjoy a crowded lakeside replete with cabin colonies, resorts and developed campsites."

DEC's management of wilderness waters seeks to maintain reasonable opportunities for anglers who seek that very special wilderness experience which is associated with angling in a remote, quiet and lovely place, and where the possibility of catching a beautifully-marked wild brook trout or two makes the challenge of the trip all the more worthwhile.

3. Limitations on the State Program

Most state owned waters are under the jurisdiction of the Department of Environmental Conservation. The DEC is therefore charged with the responsibility for management activities which are carried out on these waters. Private individuals or groups frequently make suggestions and work with the DEC in fisheries management, and this has been the situation with the department liming program. No liming projects, however, will be carried out by private groups on state waters without the approval of the DEC fisheries staff and without appropriate permits, as required by law. DEC staff are responsible for the long term management of the fisheries resource. Any waters under the jurisdiction of the DEC which are considered for liming by either state or private groups must be approved by DEC as part of the state liming program. This inclusion in the state program requires a long term commitment to intensively manage and monitor these waters and requires active involvement by DEC staff.

Many private waters are open to public fishing through Fish and Wildlife Management Act (FWMA) Agreements. Several of these waters have been limed and are part of the DEC liming program. Inclusion of additional FWMA waters in the DEC program will require that these ponds or lakes meet the selection criteria described in the policy. Private waters in the state which are not open to the public would not be considered for liming by the DEC, but could be limed by private individuals.

4. Factors Important in Selecting Liming Candidate Waters

The current Division of Fish and Wildlife Liming Policy is included in this EIS as Appendix A. The proposed revised liming policy is presented in Section I. The candidate selection criteria in the proposed revision were selected for a number of reasons and will be discussed in the following paragraphs.

a. Water Quality

The acidity and acid neutralizing capacity of the water are key parameters in determining whether a pond or lake should be considered for liming. Under the proposed policy, the summer surface water pH (air equilibrated) must be less than 5.7 or the ANC must be less than 20 μeq/l in order for a water to enter the liming program. These levels were selected in order to help protect sensitive systems from the more acidic spring snowmelt event. Based on data from a number of recent studies, many lakes which exhibit a summer surface pH of 5.7 or less exhibit spring surface pH levels of 5.2 or less (Figure 3). At this pH level and below brook trout may experience increased mortality (Johnson et al. 1987 and others). Since brook trout are the fish of greatest interest in most of these waters, it is important that acceptable water quality be maintained for this species.

By raising the pH criterion from the previous level of 5.5 to the proposed 5.7 the impacts of acidic episodes are recognized. However, it should be noted that lake liming will not necessarily protect the water from the impacts of episodic acidification. This topic is discussed in greater detail in Section VII. A. These episodes occur in many waters in New York State largely as a result of the acidity of precipitation. Water quality may be acceptable for a healthy biological community for most of the year, but acidic episodes during the remainder of the year may eliminate many species of acid sensitive organisms.

Monitoring of water quality by an annual summer surface sample is undoubtedly less than ideal. However water quality during the summer stratified period is relatively stable and has been used for many lake surveys (eg. ALSC 1987). In addition the pH criterion level of "5.7 or less" is based in part on a predicted spring snowmelt sample, when the toxicity may be greatest. Spring water sampling is difficult because of variability in the water chemistry and also unpredictable spring weather conditions. A summer surface water sample was felt to be adequate and feasible for the DEC liming program. More intensive sampling however, will be conducted pre- and post-liming whenever possible and considered necessary.

b. Temperature and Dissolved Oxygen

Two other parameters which are very important in evaluating the suitability of a habitat for fish are temperature and dissolved oxygen levels. A water selected as a liming candidate must either exhibit

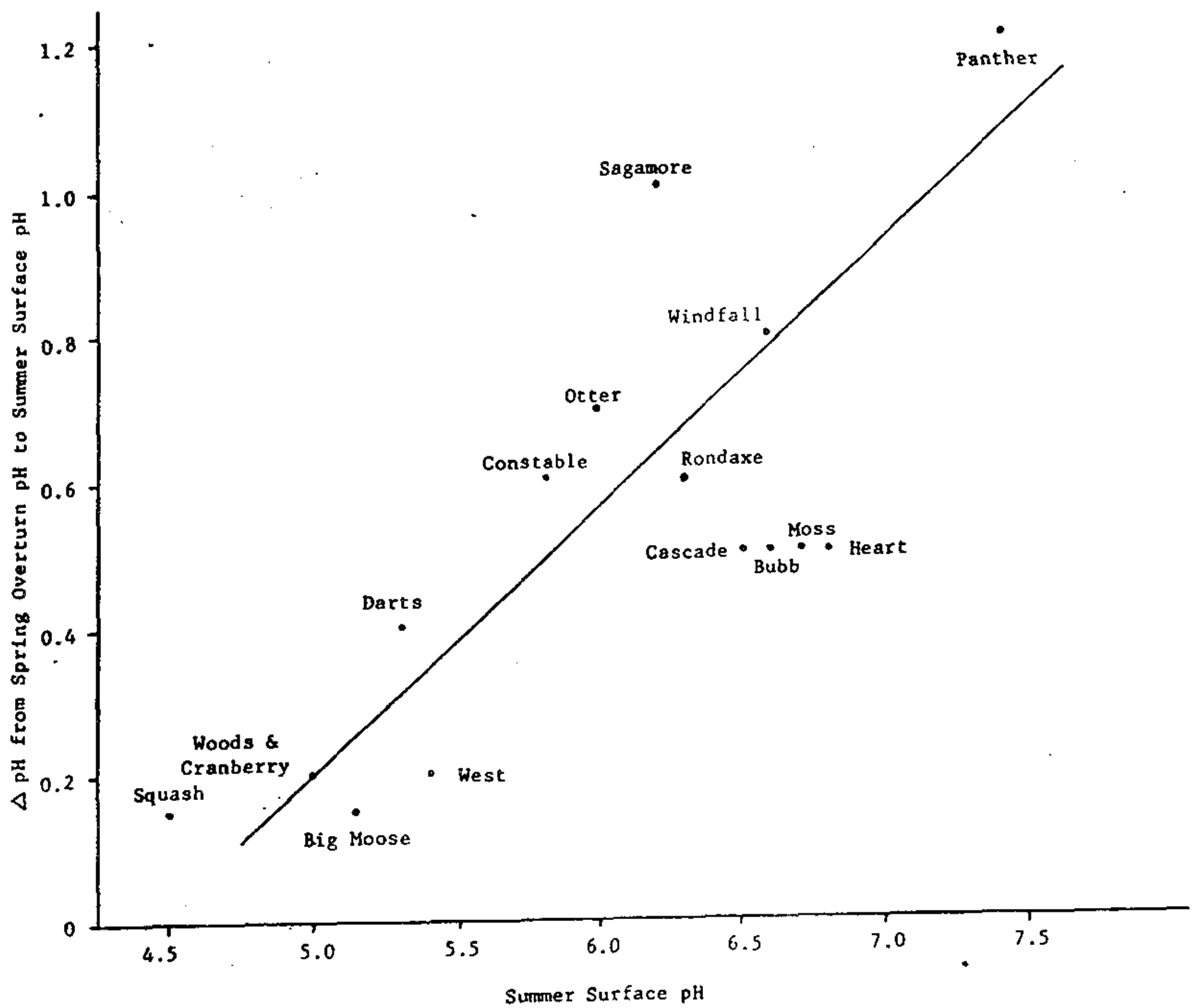

Figure 3. Relationship between summer surface pH and spring surface pH in Adirondack lakes (based on data from several references).

suitable levels of temperature and dissolved oxygen prior to liming or else be expected to become suitable as a result of the treatment. As is discussed in another section of this EIS, one effect of liming a very clear acidic water may be a reduction in the clarity of the water and therefore a decrease in the depth to which sunlight penetrates. This may result in a greater tendency for the pond to stratify and to have a cold deep water layer. As long as adequate oxygen levels are present, this would be a favorable development for brook trout, which prefer cold water.

Suitable levels of temperature and oxygen must be present in the liming candidate water throughout the year. Late summer and late winter are critical times when, after an extended period of stratification, the deeper waters may become deficient in oxygen. Late summer may also be a time when temperature levels are at their highest. For brook trout dissolved oxygen levels should generally be greater than 5 ppm throughout the year, and summer bottom temperatures should generally not be over 70°F. Fish species other than brook trout may have different dissolved oxygen and temperature requirements. Many fish can tolerate lower dissolved oxygen levels and warmer temperatures than brook trout. On the other hand round whitefish prefer colder temperatures more similar to lake trout.

The presence of refugia (springs, cold tributary streams) may also allow a brook trout population to survive by providing habitat at acceptable dissolved oxygen and temperature levels even though most of the pond is unacceptable water quality. Evidence of year round brook trout survival in the pond at some time in the past would also satisfy the dissolved oxygen and temperature requirement. This criterion is a new addition in the proposed revision of the DEC liming policy.

c. Bog Characteristics

The early liming program in New York State included the liming of a number of bog ponds. The objective was to determine whether a trout fishery could be established in these waters (Plosila 1982). Because some of these projects were only marginally successful and because of the now recognized need to maintain these unique naturally acidic ecosystems, the DEC liming program no longer includes the liming of bog waters. The impacts of acidic deposition on these naturally acidic systems are also unclear.

True bogs are isolated from ground water and rely entirely on precipitation and runoff from a small watershed. Other ponded waters however can also develop bog vegetation and tea stained water and be referred to as bogs. Smith (1966) states that bogs usually develop where drainage is blocked, and all bogs have cushion-like vegetation and an accumulation of peat. Biological activity is reduced, and organic debris is only partially decomposed to form peat. The vegetation characteristic of bogs includes <u>Sphagnum</u>, bog rosemary, Labrador tea, tamaracks, black spruce, and other species tolerant of acidic conditions.

In order to exclude naturally acidic bog waters from consideration in the liming program several factors were evaluated which could easily identify bogs. Bogs were found by the Adirondack Lakes Survey Corporation to range in true color from very clear to very colored and from low to high dissolved organic carbon. Bogs were also found to be smaller in surface area and watershed area than non-bog waters, lower in pH, and lower in acid neutralizing capacity. The range in values for pH and ANC however was quite large.

The best means of identifying waters which are naturally acidic appears to be based on the vegetation surrounding the pond or lake. In the revised liming policy a candidate water must have no more than 50% of the shoreline occupied by Sphagnum. This definition is adopted from the Adirondack Lakes Survey Corporation to identify bogs and marginal bogs. This criterion is intended to limit the liming candidate waters to those which have acidified due to acidic deposition and not to include waters which are naturally evolved acidic ecosystems.

In addition waters which have a color of greater than 75 platinum cobalt units are excluded from the program. This value is taken from U.S. Fish and Wildlife Service recommendations and from Gloss et al. (1989). The dark color of certain waters is due in most cases to naturally occurring organic acids. It is not the intent of the DEC liming program to neutralize waters high in organic acids. An additional consideration is the fact that the organic acids which color the water may also interfere with the neutralizing ability of the lime.

A recent study of the Adirondack Lakes Survey data by Munson et al. (1990) may offer an additional tool for determining whether the acidity of a pond or lake is natural (organic acid dominated) or due to acidic deposition (mineral acid dominated). The method relies on a detailed water chemistry analysis and is valid only for waters with a pH less than 5.5. Several questions which remain concerning the method are: how does the determination vary seasonally, annually, and by depth; what is the variability of the determination; and to what extent does the lake type (seepage or drainage) influence the result. Resolution of these questions may allow the DEC to better predict the source of the lake acidity and insure that waters which are naturally acidic are not selected as liming candidates.

d. Flushing Rate

The flushing rate of a body of water is a measure of how quickly water passes through the system. This factor is also often referred to as retention time, and both flushing rate and retention time may be expressed in months or years. The DEC and the Adirondack Lakes Survey Corporation have used flushing rate expressed in years, and the liming policy therefore uses these terms. Flushing rate is calculated by multiplying the watershed area (acres) times the mean annual runoff (feet) and dividing by the total lake volume (acre-feet). The higher the flushing rate the faster the water flows out the lake outlet and is replaced by run off water or inlet stream water. A flushing rate of 2.0 means that 2 lake volumes of water are replaced in the lake each year.

Schofield et al. (1986) documented that the rate at which a limed pond reacidified was best correlated with flushing rate. Gloss et al. (1987) further reported that limed Adirondack lakes with mean flushing rates greater than 3 times per year reacidified within a year after treatment. Flushing rate is therefore one of the most important factors to consider in selecting a candidate water for the liming program.

The liming policy which has been in effect since 1983 (Appendix A) required that a lake or pond must have a flushing rate of less than one time per year in order to be included in any Division of Fish and Wildlife projects. Recent information from the Cornell Extensive Liming Study (Schofield et al. 1986; Gloss et al 1987), the U.S. Fish and Wildlife Service (Brown and Goodyear 1987), and the DEC (unpublished data) have shown that lakes with flushing rates up to two times per year can be viable liming candidates. The proposed revised liming policy (Section I.) therefore has a criterion that candidates must have a flushing rate of two times or less per year. Waters with flushing rates greater than two times per year are more susceptible to acidic episodes and would require very frequent additions of lime to maintain acceptable water quality for fish life. Waters with flushing rates of two times per year or less will maintain favorable water quality for several years, during which the pH and ANC of the water will be monitored, and reliming scheduled.

It should also be noted that increasing the flushing rate criterion from one to two times per year allows the DEC to select liming candidates from a larger number of waters which have been impacted by acidic deposition. It is expected that waters with higher flushing rates are more affected by atmospheric inputs to these systems. Technologically it appears that a flushing rate of two times per year is the cutoff point where any lake above this level cannot be satisfactorily neutralized for a significant length of time. Although this change in the flushing rate criterion will increase the number of possible liming candidates, other new criteria in the revised policy (bog, temperature, dissolved oxygen) will decrease this number.

e. Heritage Fisheries

An important factor in determining whether a pond should be a liming candidate is the biological value of the fish population or fishery present in the pond. Certain waters in New York State have heritage strains of fish present which could never be replaced if the population were lost due to acidification. A heritage strain is generally defined as a wild strain of fish composed of a genetically distinct group of individuals of common origin and identified by the water(s) of origin of the parent stock (Keller 1979). The DEC usually uses the term "heritage strain" in reference to brook trout, but the term could also be used with round whitefish (an endangered species in New York) or other species. Protecting these valuable strains and populations of fish from possible loss due to acidification is an important part of the DEC liming program. Horn Lake and Tamarack Pond in the Adirondacks are both currently in the DEC liming program and both possess heritage strains of brook trout which are sustained by natural reproduction.

The criterion in the revised liming policy (Section I.) which deals with heritage strains states that a candidate water must "represent a broodstock water which contains heritage strains of fish or populations of threatened or endangered fish species which require liming for maintenance." If the candidate water does not meet this criterion, then it must meet the criterion of possessing "Unique or Important Fisheries" or the criterion for "Restoration of Natural Aquatic Ecosystems."

f. Unique or Important Fisheries

Certain waters which are near state campsites or near high population centers represent important fisheries because of their location and high use. These waters, if they experience fisheries declines due to acidification, would be high priority waters for neutralization projects. Similarly, waters which have a historic record of supporting fish and which offer a good potential for restoring an important fishery would qualify for liming. The criterion which lakes must meet if they do not possess heritage fisheries is as follows: "the candidate lake must have shown a serious decline in a unique fishery or in an historically excellent fishery as a result of acidic deposition."

In order to help insure that only suitable waters are limed, it is important that there be some historical record of fish presence in the candidate water. The above criterion therefore includes this as a requirement for candidate waters.

g. Restoration of Natural Aquatic Ecosystems

Acidic deposition has severely degraded many aquatic ecosystems by eliminating species, altering food chains, reducing species diversity, and changing the community structure. The restoration and perpetuation of natural aquatic ecosystems is viewed by the DEC as an acceptable reason for conducting a liming project. Such projects would promote the establishment of a balanced aquatic community composed of a diversity of native plants and animals. Certain waters may therefore meet the candidate selection criteria if restoration of the natural aquatic ecosystem is the primary objective of the proposed liming. In wilderness, primitive, and canoe area waters the primary purpose of aquatic resource management activities will be to perpetuate natural aquatic ecosystems.

Criterion #5 in the revised liming policy (Section I.) states that a candidate water must satisfy one of three characteristics. These have been discussed above as "Unique or Important Fisheries", "Heritage Fisheries", and "Restoration of Natural Aquatic Ecosystems." These three categories represent the different primary reasons for conducting a DEC liming project.

h. Available Funds and Staff

A factor which must be considered in selecting additional liming candidates for the DEC liming program is the long term commitment of funds and staff to these additional waters. These factors inherently limit the size of the DEC liming program. Once a water enters the program it will with very few exceptions remain in the program, will be monitored annually, and will be relimed when necessary. Lakes will not be allowed to reacidify as was the case in previous projects. Gloss et al. (1988) concluded that the DEC liming program was not very effective because lakes were allowed to reacidify and were not adequately monitored to plan for timely reliming to maintain favorable water quality. That problem will be rectified under the proposed revision of the policy.

The DEC has the actual responsibility for managing the fisheries and maintaining the water quality in lakes and ponds in the DEC liming program. However, organized sportsmans groups have made considerable contributions of time and funds for certain liming projects. If these groups are also willing to assist in water quality monitoring and reliming on a long term basis the burden on DEC would be considerably less. This possibility is a factor which will be carefully considered by the DEC.

5. Factors Important for Reliming

As was discussed above, once a pond or lake has been limed and is part of the DEC liming program, every reasonable effort will be made to prevent its reacidification to toxic levels. Summer surface (1 meter depth) water samples will be collected from all of the lakes in the liming program, and retreatments will be determined based on these samples. When the summer surface water chemistry reaches a pH (air equilibrated) of 6.0 or an ANC of 25 μeq/l, reliming will be scheduled for the following fall-winter-spring period (no liming will be conducted during the summer stratified period). These thresholds are intended to protect brook trout from exposure to toxic levels of acidity and aluminum which occur during pond reacidification. Other fish species of concern in the lake may require higher pH levels because of their greater sensitivity to acidic conditions. In the vast majority of cases brook trout will be the fish species of major interest.

The pH and ANC levels which signal the need for reliming are not intended to represent toxic conditions. The levels include a margin of safety which will allow the aquatic life in the pond to survive until reliming does occur. During this time interval several acidic episodes will most likely occur and the pond will continue to become more acidic. Every reasonable effort will be made to relime the pond as soon as logistically possible after the threshold levels have been reached.

6. Adirondack Conservation Council Task Force on Liming

The Adirondack Conservation Council consists of representatives from those counties which have land within the Adirondack Park and is concerned with Adirondack related issues and questions. In April of 1982 the liming of acidic waters became a major topic of discussion in the group and within DEC, and the Adirondack Conservation Council subsequently formed a volunteer lake liming task force. The objective of the task force was to coordinate, oversee, and assist in the approval process of volunteer lake liming projects - projects where local fish and game organizations help to initiate, fund, and actually conduct the lake liming. A set of procedures was established where the volunteer group could initiate a project by filling out specific application forms, collecting a water sample, and eventually obtaining approval from the task force and the DEC.

The task force on liming was active for several years, and a number of ponds were limed in DEC Region 5 after going through the task force approval process. The most recent date that the volunteer lake liming forms were used was 1985. Because of certain unanswered questions regarding the effects of liming and because of policy issues regarding the size of the DEC liming program, it was decided about 1984 that liming projects should be initiated by the DEC and not by sportsmens groups. The sportsmen and the DEC would continue to work closely together on the projects, but the DEC would now assume full responsibility for candidate selection. In DEC Region 6, liming projects were conducted with considerable assistance from local sportsmen, but the Adirondack Conservation Council was not directly involved. In both Regions 5 and 6 volunteer assistance on liming projects now is handled through the county federations of sportsmen. The Adirondack Conservation Council Task Force on Liming may again become active in reviewing or coordinating certain volunteer liming activities, but the volunteer lake liming forms will need to be revised to coincide with the new criteria in the revised liming policy. The long-range management of the aquatic resource and liming of waters on state land continue to be the responsibility of the DEC.

Other groups or organizations may want to suggest liming projects which are more directed towards ecosystem restoration These groups may participate in the DEC liming program by proposing sites or assisting in the funding or personnel needs of the program. As with proposals from sportsmens groups these proposals also would be required to meet all of the criteria in the proposed revised liming policy (Section I.) Planning for such liming projects should include a long term commitment to resource management and should be coordinated through the DEC Regional Supervisor of Natural Resources and include the regional fisheries staff.

7. Unit Management Plans

According to the Adirondack Park State Land Master Plan, Unit Management Plans must be developed by the DEC in consultation with the APA for each of the units of land under its jurisdiction. This assignment will eventually require that approximately 125 Unit Management Plans will have to be completed, including plans for each wilderness area, wild forest, and state park within the Adirondacks. Unit Management Plans must also be prepared and approved for units of state land within the Catskill Park.

There is a detailed procedure outlined in the State Land Master Plan for the preparation and approval process of Unit Management Plans. They should contain inventories of the natural resources and facilities in the area, assessments of the impacts from public use, and assessments of the carrying capacity of the area. Regarding the management objectives for the area, the Unit Management Plans should discuss the