away from the resolution of the primary cause of acidification on which there is agreement within the scientific community. A major contributor to acidification is the excessive generation of oxides of sulphur and nitrogen which are released into the atmosphere and transformed into strong mineral acids while being transported downwind from the polluting sources.

The promoters of liming as a solution to the acid rain problem also frequently neglect to mention that waters with high flushing rates are not amenable to successful mitigation by whole lake liming because of the short retention time for water in the lake or pond. Many of the acidic waters in the Adirondacks exhibit high flushing rates, and a recovery of these systems is in large part dependent on the passage of effective acid rain legislation resulting in decreases in deposition levels. Promotion of liming may draw attention away from seeking a meaningful solution to the problem.

b. Use of Aircraft and Motorized Equipment in Wilderness and Primitive Areas

Section II presented the Adirondack Park State Land Master Plan guidelines for management and use of designated state land areas, including wilderness, primitive, canoe and wild forest. Of particular relevance are the guidelines on motor vehicles, motorized equipment and aircraft in restricted land use areas. Historically, a variety of mechanized equipment have been employed to conduct liming projects including motor vehicles, helicopters, fixed-wing aircraft, snowmobiles, outboard motors and slurry pumps. In wilderness and primitive areas the use of aircraft and motorized equipment may be an adverse impact on these areas and a societal concern.

Liming projects conducted by the DEC in wilderness, primitive, and canoe areas will be carried out in the most unobtrusive manner possible and in conformance with the SLMP, pertinent policies and procedures. Use of motorized vehicles and equipment in wilderness, primitive, and canoe areas will be consistent with SLMP guidelines. Lime will be applied by helicopter and the helicopter will not be required to land on the pond. A lime bucket capable of delivering one ton of lime per trip has been designed for this purpose. Limings will be conducted during low-use periods of the year (late fall, spring) and will only be required on an average of once every six years. The noise associated with the infrequent liming is of short term duration and is considered less important than the value gained by preserving or restoring a valuable aquatic ecosystem. (See also Section II.D.2).

In wild forest areas motor vehicles are permitted where necessary to preserve and enhance the fish and wildlife resources of the area. Snowmobiles are the most commonly used vehicles for liming projects in wild forest areas. Regardless of the land classification the benefits gained from protecting or restoring a valuable fishery should be weighed against the temporary intrusion into a forest preserve area.

c. Increased Human Use of the Resource Following Liming

It is likely that a successfully limed and restocked water would lead to an increase in human use of the resource by anglers. Waters which are easily accessible would most likely receive greater use than more remote waters. Associated with the increased human use are adverse impacts such as littering, trail erosion, and other intrusions which may require additional resource management (Section VI.B.2).

In wilderness, primitive, and canoe areas the primary objective of liming projects is to restore or protect aquatic ecosystems, and it is not expected that increased use of the resource will be a problem. Where liming is employed to preserve rare genetic strains and threatened or endangered species in wilderness waters it may be necessary to limit angling in these waters to protect the fish population.

d. Concern that Liming Wilderness Waters is Worse than Leaving the Waters Acidic

One of the characteristics of a wilderness is "an area where the earth and its community of life are untrammeled by man and where man himself is a visitor." Although many of New York's wilderness waters have been adversely impacted by acidic deposition, there are concerns that liming a certain number of these impacted waters is worse than leaving them acidified. The issue is whether the nature, extent and purpose of the program are consistent with wilderness and to what extent the program impacts wilderness values. The nature of the program is intended to be consistent with State Land Master Plan guidelines and the more detailed guidelines for fisheries management in wilderness, primitive, and canoe areas (Appendix B). The extent of the program (as discussed in the revised liming policy) will be limited. The purpose of liming projects in wilderness, primitive and canoe areas is to improve water quality conditions for the survival, growth, and reproduction of fish species indigenous to the area.

Neither a limed lake nor a culturally acidified lake is in its natural primeval state, so the question is which environment is more like a truly unimpacted wilderness lake. The lake should support a natural aquatic ecosystem and also provide a "wilderness experience" for human visitors. A restored or preserved fish community resulting from a liming project would help to restore and preserve the natural ecosystem. It is possible to conduct a liming project on a wilderness water with a minimum of impact on the wilderness character of the area.

B. <u>Beneficial Impacts</u>

1. General Ecosystem Benefits

a. Adjacent Wetlands

As was discussed in the section dealing with possible adverse impacts on adjacent wetlands, the beneficial impacts also would depend on whether the wetlands were upstream or downstream of the limed water. Even wetlands close to the lake or pond may have little if any contact with the lake water because of groundwater flow paths toward the pond. It is not therefore expected that any major changes will occur in the wetlands adjacent to limed waters. However, those changes which do occur due to liming are expected to be beneficial to the community as a whole, and to be a restoration of an ecosystem similar to that found prior to acidic deposition.

The Sphagnum mosses for example, which dominate many acidic wetlands may be replaced by a more diverse plant community after liming including Lobelia, Littorella, and Isoetes (Fraser et al. 1985). "Deepwater wetlands" as defined by the APA may respond in this manner and are discussed under the heading "Macrophytes" (Section V.B.1.e). This more diverse plant community would benefit other plants and animals in the wetland. Hultberg and Anderson (1982) reported that the disappearance of Sphagnum following liming should increase the availability of nutrients and ions important to biological production.

Although areas such as a limed lake outlet may still be subject to acidic episodes (Sec. V.A.1.h.), the restoration of a circumneutral water quality would have a number of benefits throughout most of the year. The unfavorable characteristics associated with the abnormal acidic environments (low rate of decomposition, extensive algal mats, and low species diversity) would be replaced with a more normal decomposition rate, an increased availability of nutrients, and a more diverse and healthy algal and macroinvertebrate community.

b. Endangered or Threatened Species

Endangered or threatened species of animals which may be beneficially impacted by the liming of lakes include the golden eagle, bald eagle, and osprey. The common loon is listed as a species of special concern and would also be beneficially impacted. The reason liming would be advantageous to these birds is because they eat fish, and the objective of liming projects is to restore or improve fish populations which have been reduced by acidification. The liming projects would therefore increase the amount of food available and habitat suitable for these species.

Several species of salamanders (Jefferson, blue-spotted, and spotted) are listed as species of special concern primarily because of their sensitivity to acidification. The eggs of salamanders appear in particular to be sensitive to acidity (Freda and Dunson 1985). The liming of ponds or lakes could therefore beneficially affect these species by restoring habitat of suitable water quality.

The endangered round whitefish occurs in only a handful of Adirondack waters. Pfeiffer (1979) listed a total of 14 waters where round whitefish were found, half of which were private waters. One of the public waters has a pH level less than 6.0 (West Canada Lake) and is very sensitive to acidification, and liming may be a means of protecting the resident round whitefish in this lake. Pfeiffer (1979) suggested that liming may be a viable management tool for maintaining a suitable habitat for this sensitive fish.

It is uncertain which plants on the List of Endangered, Threatened, and Rare Plants in New York State would be beneficially impacted. Certain plants would most likely favor the less acidic environment following liming, but little research has been done to document the adverse or beneficial impacts of liming on these plants. As was discussed previously the Lake Acidification Mitigation Project Watershed liming component may provide some information in this regard.

c. Decomposers

Natural decomposition processes are important in an aquatic ecosystem to break down accumulated organic matter and recycle nutrients to aquatic biota. It is commonly believed that acidification decreases benthic microbial activity and that liming may beneficially restore these decomposition processes. Experimental evidence is inconclusive, however, regarding the actual impacts of acidification. Both a decrease (Traaen 1980) and no significant difference from non-acidified waters (Gahnstrom et al. 1980) have been reported. Gahnstrom et al. (1980) found that decomposition rates increased significantly following neutralization as measured by turnover rates for free glucose in surface sediments. The duration of the elevated decomposition activity is unknown, but apparently continues for at least one year after treatment (Hasselrot and Hultberg 1984). Traaen (1980) found similar evidence that bacterial decomposition of glucose and glutanic acid was increased at high pH levels. Increasing numbers of heterotrophic bacteria also were reported by Scheider and Dillon (1976) after liming lakes in the vicinity of Sudbury, Ontario.

d. Phytoplankton

Several investigators have reported fewer phytoplankton species in acidic lakes compared to circumneutral lakes (Almer et al. 1978; Dillon et al. 1979; DeCosta and Preston 1980; Eriksson et al. 1982; 1983; Hornstrom et al. 1984). It appears that a majority of the phytoplankton species are eliminated by nutrient deficiency and/or high metal concentrations, as well as the additional stress of low pH (Eriksson et al. 1982; 1983). Phytoplankton growth in acidic lakes may also be limited by low concentrations of inorganic carbon (CO_2 or HCO_3^-), therefore, liming would be an effective inorganic carbon source for increasing phytoplankton productivity (Boyd and Cuenco 1980; Hindar and Nilssen 1984).

Following liming, a gradual increase in phytoplankton biomass to pre-acidification levels and a change in species composition similar to oligotrophic circumneutral lakes has been observed (Eriksson et al. 1982; 1983; Hasselrot et al. 1984; Hasselrot and Hultberg 1984; Wilcox and DeCosta 1984; Hornstrom and Ekstrom 1985). These observations support the hypothesis that liming restores the aquatic ecosystem to that found prior to acidic deposition. In addition, several researchers have documented an increase in phytoplankton species diversity (Eriksson et al.1982; 1983; Henrikson et al. 1984; Hornstrom and Ekstrom 1985; Lazarek 1985) and an increase in primary