- Specific locations can be targeted while preserving designated conservancy areas
- Recreational uses during harvesting may continue with little interference
- Harvested vegetation may be used as composting material.

However, harvesting can be a very slow, labor-intensive process because of seasonal factors or physical constraints. In temperate areas, harvesting is restricted to periods of favorable weather conditions and peak plant biomass. Access to sites may be limited by obstacles (e.g., docks, submerged rocks) or by water depth. Shallow beach areas often can not be harvested effectively by commercial equipment. Furthermore, only relatively small areas can be harvested by individual harvesters, causing dispute over prioritization of treated areas. Harvesting may also encourage plant colonization of new areas through vegetative fragmentation.

Because harvesting requires a large capital investment and extensive operation and maintenance, costs can be relatively high. Costs vary depending on the number of acres harvested and location of disposal sites. Although costs as low as $300/acre have been reported, harvesting by private contractors costs between $500 and $800/acre. Purchase costs for harvestors range from $27,000 to $160,000 (Ecology 1990).

Harvesting has been performed in Thurston County in recent years, costs were 300 to 350/ac.

Harvesting in Lake Lawrence, while increasing recreational use of some areas, would not control the internal and external nutrient sources that largely determine lake water quality. Therefore, harvesting alone will not improve Lake Lawrence's main water quality problems (Table 8-2), but should be continued in the lake at a more intensive level than in the past to reduce aquatic macrophyte growth in target areas. Long-term intensive harvesting can also permanently remove phosphorus from the system and decrease internal cycling. In Lake Lawrence, 800 tons of aquatic macrophytes were harvested during past years. Assuming a phosphorus content of 0.002 percent, harvesting removed 15 kg of phosphorus from the system. Using the Dillon and Rigler (1974) model, a reduction of 15 kg translates to a reduction in phsophorus concentration from the 21 ug/L predicted after dredging at 80 percent effectiveness to 20 ug/L (i.e., a 4 percent decrease). Therefore, intensive harvesting in Lake Lawrence would have some water quality benefits when used in conjunction with in-lake measures that target internal loading such as dredging or alum addition. This is particularly true if long-term harvesting in excess of 20 years is carried out.

Grass Carp

Grass carp (*Ctenopharyngodon idella* Val.) is an exotic fish originally imported from Malaysia to the United States in 1962 (Olem and Flock 1990). Because of their high growth rate and broad vegetarian diet, grass carp have been introduced to many lakes in Europe and the United States to control aquatic plants. At low stocking densities grass carp selectively graze on preferred plant species (e.g., elodea, pondweeds)and may cause less preferred species such as milfoil to increase. Overstocking can eliminate all aquatic macrophytes from a lake.

Concerns regarding grass carp introduction include:

- Potential impacts on other organisms, particularly game fish
- Enhancement of nutrient cycling and stimulation of algal blooms through grass carp grazing and digestive activities
- Delayed (2-5 years) control of aquatic plants
- Uncontrolled reproduction and infestation of nontarget areas
- Limited control of aquatic macrophytes in high use areas such as docks, boat launces, and swimming beaches.
- Highly difficult and expensive to remove excess fish
- Introduction of parasites carried by grass carp
- Preferential removal of plant species such as pondweeds and avoidance of others such as milfoil and lilies.

Some of these concerns have been resolved through the use of sterile, triploid fish an increased knowledge of appropriate stocking densities. However, because grass carp ar biological control, the effects of their use are less predictable than plant remova mechanical or chemical methods. Furthermore, grass carp need to be replaced after 10 ye

The feasibility of using triploid grass carp to control aquatic macrophytes in Lake Law was evaluated by Thomas et al. (1990). The researchers concluded that large-scale rem of aquatic macrophytes via grass carp should not be performed because the current coverage (38 percent) was optimal for large-mouth bass production. Furthermore introduction of grass carp to Lake Lawrence may increase blue-green algal problems thr grass carp digestive and feeding activities which release nutrients through sedi interactions, plant consumption, and fish waste excretion. The researchers a emphasized that grass carp would not be effective in controlling aquatic macrop around swimming beaches, docks and boat launches, and may consume plants in unde locations such as the conservancy area in the southern portion of the East Basin.

If grass carp are introduced in Lake Lawrence to control aquatic macrophytes, Thomas e (1990) recommended a conservative stocking rate of 9,045 fish to minimize adv environmental impacts. The advantages of using grass carp are that they are inexpe relative to other plant control measures. Fish can be stocked with no further mainte except replacement after 10 years. Furthermore, the fish are sterile and will eventua allowing future flexibility to restock or permit aquatic macrophyte regrowth, dependi management objectives. In terms of aquatic macrophyte control, grass carp introduct applicable to Lake Lawrence based on the edibility of its nuisance plant species and w temperatures. However, grass carp may stimulate algal production in Lake Lawrence therefore, received low scores for effectiveness and applicability (Table 8-2). Grass car were also rated low because of the potential negative impacts on the bass populatio water quality. Based on these considerations, the use of grass carp alone as a manage tool for Lake Lawrence was not considered to be a viable technique to manage lake water quality.

WATERSHED MANAGEMENT MEASURES

When developing a long-range plan for the management of lake water quality, it is critical to address external loading originating from watershed sources or activities. Watershed control measures for Lake Lawrence can be categorized into two groups based on the implementation mechanism. The first group includes basin-wide controls that can be implemented through existing or future Thurston County ordinances or policies such as requirements for drainage and erosion control, adequate wetland and stream buffer zones, improved forestry and development practices, and improved roadside ditch maintenance. The second group of watershed management measures can be categorized as developed property management. This group can be implemented through public education and awareness programs that would enhance water conservation and quality through better landscaping methods, alternative household practices, and roof drainage controls. The second group also includes improved on-site waste disposal systems. These improvements would be achieved through a combination of private, special district (e.g., a sewer district), and county efforts. All of the watershed controls discussed in this section are eligible for grant funding.

The two categories of watershed management measures were evaluated and ranked based on the criteria defined earlier (Table 8-2). A more detailed discussion of watershed measures is presented in Appendix H.

Basin-wide Controls

A number of County ordinances and policies contain water quality protection provisions (see Appendix H). The Thurston County Comprehensive Plan and Shoreline Master Program for the Thurston Region provide the framework for water resource protection during residential development and land clearing. Thurston County Zoning Ordinance contains specific chapters on land clearing, erosion control and sensitive areas protection. However, new ordinances or policies that recognize Lake Lawrence's unique water quality problems may be required to protect and enhance its water quality and community uses. The major types of watershed activities that could be addressed through county ordinances and policies are agricultural practices, development, forestry practices, and roadside ditch maintenance.

Improved Agricultural Practices

Agriculture in the Lake Lawrence watershed consists mainly of livestock grazing and hay production. Over 26 percent of the watershed is considered small farm areas of 5 to 20 acre units. Smaller tracts are used as hobby farms and larger tracts support commercial dairy operations.

Pollutants most identified with animal production and agricultural activities are sediments, nutrients, organic materials, pesticides, and pathogens. Activities that generate these pollutants include animal confinement, overgrazing of pastures; unrestricted livestock access to streams, wetlands or lakeshores; and improper application of animal wastes to pasture or hay fields.