Impacts of Aquatic Weeds in Water Use and Natural Systems

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Aquatic plants include microscopic algae, filamentous algae, and rooted plants that grow entirely underwater or as emergent plants in shallow water, or float on the water's surface. Carpenter and Lodge (1986) and Madsen (1997) summarized the roles they play in freshwater ecosystems. Aquatic plants aid in stabilizing sediments and in binding nutrients. They supply dissolved organic matter into the water and entrap organic material. Plant beds affect water chemistry by removing nitrate and other ions (Moss 1988). Aquatic invertebrates, which are the essential food of many fishes and semi-aquatic animals, are often more diverse or abundant in beds of aquatic plants as opposed to non-vegetated areas. Aquatic plants are often significant food sources for invertebrates, waterfowl, and some mammals. Aquatic vegetation is an important habitat for fish, both for young-of-the-year and desirable sport fish. For these reasons, aquatic plants are integral components of lake and river ecosystems and the presence of aquatic plants is desirable. However, excessive growth can have detrimental effects as well (Table 1). The following discussion of specific impacts of aquatic weeds is based on the information provided by Ross and Lembi (1985), Lembi et al. (1988), Lembi (1997), and Lembi (2003). The reader should consult these sources directly for more information.

Table 1. Negative impacts associated with excessive growth of aquatic plants

1. Prevent or restrict recreational activities, boating, fishing, and swimming.
2. Present hazards due to entanglement or slippery areas caused by algal films.
3. Cause foul taste and odors of drinking water supplies
4. Cause stunting of fish populations and "fish kills" due to decomposition.
5. Block flow in irrigation and drainage systems.
6. Cause water loss due to evapotranspiration from floating or emergent species.
7. Catch debris and sediment hastening the filling in of water bodies.
8. Prevent commercial navigation of waterways.
9. Provide habitat for disease vectors such as mosquitoes and snails.
10. Produce and release toxins into the water.
11. Lower aesthetic appeal of waterfront property reducing its value.
12. Exclude native plant species.
13. Reduce access of wildlife to wetland areas.
14. Monetary losses due to control efforts.

In habitats with high nutrient levels (usually phosphorus) excessive growth of microscopic algae may form "blooms." *Microscystis*, *Anabaena*, and *Aphanizomenon* are species of cyanobacteria or blue-green algae that are typically associated with these conditions. When the algae die, decomposition results in anoxic conditions in the lower portion of the lake. This affects fish and aquatic invertebrates. This situation may be especially serious in aquaculture systems. Microscopic algae produce and release compounds, which impart unpleasant taste and odors into drinking water supplies. In a northern California water system the number of taste and odor complaints by customers is highly correlated with the seasonal occurrence of algae blooms. Two compounds 2-methylisoborneol and geosmin have been identified and are problems when present at concentrations of 12 and 7 ng L^{-1}, respectively. The only way to remove these compounds is to use costly activated charcoal filters. Similarly, fish from aquaculture ponds may develop off-taste if geosmin is present. Then fish must be removed from the pond and transported to a clean pond where they are held for a period of time until the off-taste dissipates. Some species of blue-green algae produce toxins that may be fatal if ingested by domestic animals or may cause skin irritations. Blue-green algae may be less acceptable as food for zooplankton, which may in turn have food-chain consequences.

Filamentous algae (*Cladophora, Spirogyra, Hydrodiction*, and *Rhizoclonium*) form unsightly floating mats in shallow areas of ponds and lakes. The mats inhibit swimming and fishing. In the western U.S. these species are especially troublesome in irrigation canals where they clog intake pumps, trash racks, siphons, and drains. Lembi et al. (1988) cite examples indicating expenditures in the millions of dollars per year to control *Cladophora* in a single Arizona water delivery system, and the U. S. Bureau of Reclamation used 3000 mt of copper sulfate per year to control filamentous algae in California canals during the 1980s.

Nitella and *Chara* are green algae, which resemble rooted aquatic plants in appearance although they lack true leaves, roots, and vascular tissues. In shallow systems they may grow to the surface and interfere with boating, fishing, and swimming.

Cook (1990) defines aquatic macrophytes as vascular plants (ferns, fern allies, and seed bearing plants) whose photosynthetic parts are permanently or at least for several months of the year submerged in water or float on the surface of water. Within this group, there are three functional types: submersed plants, growing entirely underwater; emergent plants, growing in shallow areas with the underground portions underwater and with stems and leaves above the water surface; and floating plants, which have roots or root-like structures that hang into the water from the main plant body which floats on the surface of the water.

Hydrilla (*Hydrilla verticillata*), Eurasian watermilfoil (*Myriophyllum spicatum*), Brazilian elodea (*Egeria densa*), coontail (*Ceratophyllum demersum*) and various pondweeds (*Potamogeton* spp., *Stukenia pectinata*) are the most often encountered problems within this group in California and other western states. In non-flowing situations these plants grow to the surface and continue to elongate or branch so that their stems spill over and form a dense canopy of intertwined stems. If growth is extensive, these cause the problems described in Table 1. Dense canopies reduce light penetration into the water column, which can lead to reduced photosynthesis and growth by adjacent species that may not grow to the water's surface. Several studies have shown this effect when the above species were grown in combination with desirable native species (Spencer and Ksander 2000 and references therein). Reductions in growth eventually lead to elimination of native species. Madsen et al. (1991) established permanent plots in Lake George, NY and recorded the abundance of Eurasian watermilfoil and native plant species over time. Within three years, the Eurasian watermilfoil canopy increased from 25% to 97% cover. At the same time, the number of species present decreased > 50% from 21 to 9, confirming observations from many lakes invaded by this species.

Submersed aquatic plant canopies change depth profiles of temperature, dissolved oxygen (DO), and water chemistry (Frodge et al. 1990, Petr 2000). Madsen (1997) recorded hourly DO readings over a 48-day period in replicate ponds planted with Eurasian watermilfoil, hydrilla, water hyacinth, a floating-leaved pondweed, or a mix of native plants. For all ponds except the native plants, daily minimum values were near or below 5 mg L^{-1} (the level at which fish experience oxygen stress). Daily mean values were lower for the ponds planted with weedy species (water hyacinth, 4 mg L^{-1}; hydrilla, 5.9 mg L^{-1}; Eurasian watermilfoil, 7.9 mg L^{-1}; pondweed, 8.4 mg L^{-1}) than for the ponds that contained a mixture of native species (13.8 mg L^{-1}). Low oxygen levels would put fish under stress. The number of fish species present, the number of fish, and the sizes of individual fish were substantially reduced at low (0.5 mg L^{-1}) dissolved oxygen concentrations in Mercer Bayou, Arkansas (Killgore and Hoover 2001).

Submersed plant beds also influence fish populations through impacts on predator prey relations. Results from several studies indicate that the growth rate of prey fish is reduced when they are confined to macrophytes beds. Olson et al. (1995) reported that resulting high densities of bluegill have strong negative effects on young-of-the-year bass. This is because of increased competition among the immature fish for their food sources (Petr 2000). Aquatic macrophytes are also believed to reduce the probability that prey fish will encounter piscivorous predators. For example, predation rates on bluegill declined with increasing plant density (Savino et al. 1992).

Submersed plants in rivers and irrigation canals increase the bed and bank roughness increasing drag and decreasing flow (Pitlo and Dawson 1990). As plant biomass increases seasonally this effect is magnified. Plant biomass displaces part of the canal's cross sectional area resulting in higher water levels and increased likelihood of flooding.

Floating plants increase water loss through evapotranspiration. Brezny et al. (1973) reported evapotranspiration for water hyacinth was 130 to 150 % higher than evaporation from a free water surface under equivalent conditions while Timmer and Weldon (1967) reported values 370% higher than a free water surface. Floating plants clog waterways, plug water pumps, stop or slow boat traffic, close marinas, prevent access for fishing, prevent water access by waterfowl and wildlife, and causes an increase in mosquitoes. Costs of dealing with floating plants can be high. According to the *Sacramento Bee*, prior to 1984 the federal government spent $500,000 per year to haul away some 22,000 truckloads of water hyacinth in order to prevent clogging of the Tracy, CA pumping station. Since that time California has spent at least $125,000 per year to control this species in waterways of the Sacramento / San Joaquin Delta.

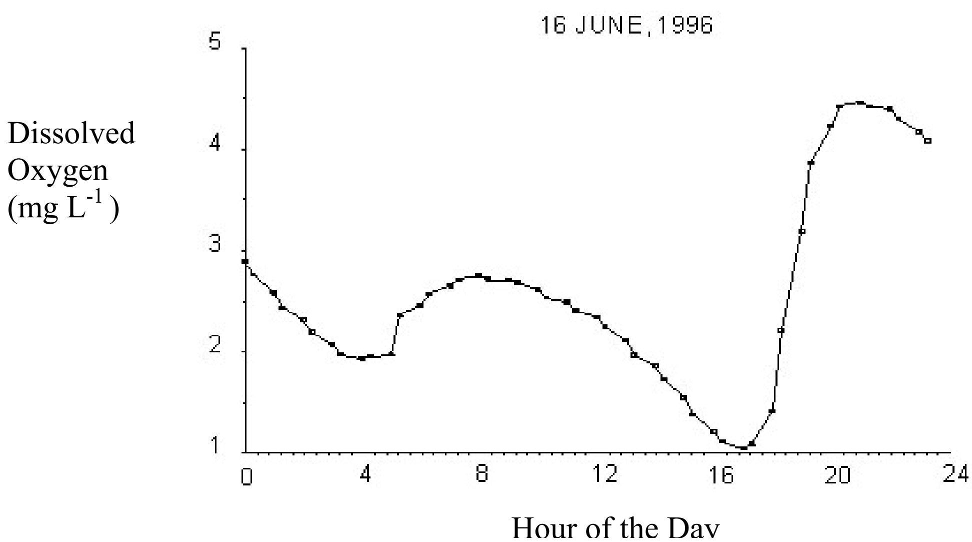

Figure 1. Diurnal changes in dissolved oxygen under a water hyacinth mat in the Consumnes River.

Abundant growth of floating plants reduces light penetration into the water column resulting in hypoxic or anoxic conditions In a Sudanese lake infested with water hyacinth DO levels were 1.8 mg L^{-1} 30 cm below the mat when there was no water current, high concentration of CO_2 were also measured. Similar measurements from the Parana River floodplain in Argentina indicated a maximum of 2.3 mg L^{-1} within the first 1 m depth, but DO values of 1 mg L^{-1} were more common (Petr 2000). Dissolved oxygen measurements taken under the edge of a water hyacinth mat in the Consumnes River, CA were lower than the level reported as causing oxygen stress to fish (Figure 1).

Emergent plants such as rushes, sedges, and alligator weed enhance water loss through evapotranspiration (Brezny et al. 1973, Boyd 1987). In irrigation canals and drainage ditches, they slow or prevent water movement increasing the likelihood of flooding. The emergent plant, giant reed (*Arundo donax*), has extensive rhizome systems, grows up to 9 m tall and forms in-stream stands that altar water flow patterns increasing bank erosion. When *Arundo* displaces native trees and shrubs that overhang the water, its more upright form provides less shading that in turn increases water temperature. This affects animals and plants living in the stream. *Arundo* is less desirable as wildlife habitat. It's biomass dries in summer and the frequency and intensity of fires increases. Because it is strongly anchored in the substrate and resists uprooting by flooding, over time this species causes riparian systems to switch from flood-dominated communities to those that are more tolerant of fire (Bell 1997).

Although not yet widespread in California, purple loosestrife (*Lythrum. salicaria)* has transformed North American wetland habitats in eastern and northern U. S. By 1959, a large percentage of shallow marshes in the lower Hudson area of New York had become solid stands of purple loosestrife and were considered degraded as waterfowl production sites. In upstate New York, it was noted that, with age, invading purple loosestrife ultimately dominated wetland habitats with tall, dense, brush like stands that were impenetrable to boats. These stands also excluded desirable waterfowl food plants. Changes in plant abundance affect wildlife distributions as well. Muskrats and long-billed marsh wrens were reported to use cattail stands almost exclusively, whereas red-winged blackbirds preferred purple loosestrife (Thompson et al. 1987).

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