Abernethy, V. J., M. R. Sabbatini, and K. J. Murphy. Response of Elodea canadensis Michx. and Myriophyllum spicatum L. to shade, cutting and competition in experimental culture. Hydrobiologia. Vol. 340, no. 1-3, pp. 219-224. Dec 1996.Elodea canadensis Michx. and Myriophyllum spicatum L. are widespread nuisance aquatic plant species. Their ecology is regarded as similar. Both species have been previously classified in terms of established-phase survival strategy as "competitive disturbance-tolerant" species. Experimental data are presented to show that although this broad categorization of strategy is probably correct for the two species, it is possible to demonstrate significant differences in terms of response to disturbance and competition. Less difference was discernible in their comparative response to stress. The drawbacks of applying broad descriptive terminology when dealing with two species of similar strategy are addressed. The results help explain reports of variable success in attempting to manage these two species using disturbance-based weed control measures, and suggest that Elodea is even less susceptible to such measures than Myriophyllum.

Annadotter, H., G. Cronberg, R. Aagren, B. Lundstedt, P. Nilsson, and S. Stroebeck. Multiple techniques for lake restoration. Hydrobiologia [Hydrobiologia]. Vol. 395/396, pp. 77-85. Feb 1999.Lake Finjasjoen is a shallow, eutrophic lake (area 1100 ha, mean depth 3 m, maximum depth 13 m) in southern Sweden. In the 1920s, the lake was clear, with a summer Secci depth of about 2 m. During the first half of the 20th century, untreated sewage from the town polluted the lake. In the 1930s, the lake began to show eutrophic characteristics, and in the 1940s, the cyanobacterium Gloetrichia echinulata dominated in summer. In 1949, the first municipal sewage treatment plant was built. The treatment was, however, insufficient, since the lake continued to be the recipient of the effluent with the result that the occurrence of cyanobacteria became more frequent. Species such as Microcystis and Anabaena caused skin rash and allergic symptoms among swimmers. The phosphorus load on Lake Finjasjoen increased as the population of Haessleholm grew and reached a peak value of 65 tons/annum in 1965. In 1977, the sewage plant was rebuilt to include chemical flocculation, reducing the total external phosphorus load to about 5 tons/annum. Despite this improvement the lake did not recover from its chronic and toxic cyanobacterial blooms. Phosphorus-leaking black sediments were identified as the cause of the lake's failure to recover. Some 60% of lakebed area is covered with sediments on average 3 m thick. Dredging the sediments was started on a large scale in 1987. Five years later, 25% of the sediment area had been removed but the dredging was stopped since phosphorus continued to be released into the water from these areas. In 1992, a new restoration policy, a combination of further reduced external nutrient loading and food-web manipulation was initiated. A constructed wetland (30 ha) to reduce phosphorus and nitrogen was created in connection to the effluent from the sewage treatment plant. Protection zones along the feeder streams into Lake Finjasjoen were also established. A cyprinid reduction programme by trawling was carried out between 1992 and 1994. When it started, the fish community was composed of 90-95% bream and roach. After two years of trawling, the ratio between piscivorous and planktivorous fish was 1:1. In 1994 and 1995, the transparency increased due to a considerably reduced biomass of phytoplankton and a radically altered phytoplankton community. The monoculture of Microcystis was replaced by a diverse phytoplankton community. The increased transparency made possible the development of submerged macrophytes such as Elodea, Myriophyllum and Potamogeton. The internal loading of

phosphorus decreased dramatically in 1994 and 1995, possibly as a result of reduced sedimentation of phytoplankton.

Armellina, A. D., C. R. Bezic, and O. A. Gajardo. Propagation and mechanical control of Potamogeton illinoensis Morong in irrigation canals in Argentina. Journal of Aquatic Plant Management. Vol. 34, pp. 12-14. 1996.Aquatic weeds development and mechanical control were evaluated in irrigation canals in Viedma (Argentina). Biomass allocation strategy of Potamogeton illinoensis Morong was studied in a simple destructive experiment under outdoor tank conditions and a chain cutting experiment of weed control was done in natural situations from September 1993 to April 1994. There were no discernible effects of the spring clearance operations because of the fast regrowth from the rhizomatous system which is formed from the beginning of the season. Plant biomass shows important growth rates from plus or minus 10th November reaching almost 17 ton.ha super(-1) in April. Control of vegetative propagation by mean of rhizomes is the key point to manage the population of this weed. Chain cutting plus some other method (e.g. grass carp, herbicides) may be useful tools to solve the aquatic weed problems in the area.

Armitage, P. D., J. H. Blackburn, J. M. Winder, and J. F. Wright. Impact of vegetation management on macroinvertebrates in chalk streams. Aquatic Conservation: Marine and Freshwater Ecosystems [AQUAT. CONSERV.: MAR. FRESHWAT. ECOSYST.]. Vol. 4, no. 2, pp. 95-104. 1994.Dense growths of macrophytes are a characteristic feature of chalk streams which may cause problems both to farmers and anglers. Weed is frequently cut to reduce flooding of surrounding land and provide open water for anglers. The objective of this study was to examine short-term responses of macroinvertebrate faunal assemblages in main flow and marginal samples to both weed-cutting and the application of herbicide and to compare these with untreated controls. No statistically significant effect could be demonstrated on such faunal parameters as biotic score, richness and abundance and a multivariate analysis of all available data showed that the weed-cut and herbicide treated sites could not be distinguished from the control sites III and V on the basis of their fauna. It is suggested that for conservation purposes small-scale management with 'recovery strips' separating the treated reaches can achieve the desired objectives of avoiding flooding and providing open water for anglers with minimal effects on the river biota.

Baattrup-Pedersen, A., S. E. Larsen, and T. Riis. Composition and richness of macrophyte communities in small Danish streams - influence of environmental factors and weed cutting. Hydrobiologia [Hydrobiologia]. Vol. 495, no. 1-3, pp. 171-179. Mar 2003.The community structure and diversity of aquatic macrophytes was studied in 79 small Danish lowland streams to examine effects of regular anthropogenic disturbances and physico-chemical factors for the development of macrophyte communities. In total, 131 species were found of which 65 were found both in the stream and on the stream banks. Berula erecta, species within the genus Callitriche and Sparganium and Glyceria fluitans, dominated the macrophyte communities in the streams. A detrended correspondence analysis indicated that disturbance in terms of weed cutting was the most important factor separating the macrophyte communities. Obligate water plants and tall reed plants, both amphibious and terrestrial species, were more important in the macrophyte community in highly disturbed streams, whereas small amphibious species were more important in less disturbed streams. A direct comparison of diversity indices

between streams subjected to regular cuttings and undisturbed streams revealed that regular cuttings significantly reduced species diversity. Also the macrophyte patch complexity, expressing the spatial distribution of macrophytes on the stream bottom, was lower in disturbed streams both near the banks and in the middle of the streams. The DCA analysis also indicated that the riparian community had a significant influence on the in-stream community structure and confirmed the importance of geographical region, water temperature and other physico-chemical parameters for the macrophyte communities in Danish streams.

Baattrup-Pedersen, A., S. E. Larsen, and T. Riis. Long-term effects of stream management on plant communities in two Danish lowland streams. Hydrobiologia [Hydrobiologia]. Vol. 481, no. 1-3, pp. 33-45. Aug 2002.Submerged macrophytes grow abundantly in most shallow streams common in the cultivated lowlands of northwestern Europe. Weed-cutting has been practised for years in many of these streams to reduce the risk of flooding of adjacent land. Our objective was to quantify long-term impacts of weed-cutting on macrophyte communities in two Danish rivers. We found that the total macrophyte coverage was similar in the weed-cut and uncut reaches in the two rivers, but species richness, diversity and patch complexity were higher in the uncut reaches. The spatial distribution of macrophytes on the stream bottom was also more heterogeneous in the uncut stream reaches. We also found evidence of a strong effect of weed-cutting on macrophyte species composition. P. natans was abundant in the uncut reaches in both streams but practically eliminated in the cut reaches, despite the fact that its basic habitat requirements were met. Also, the established phase strategy of the macrophyte community was affected by weed-cutting. Species displaying characteristically ruderal traits were more abundant in the cut reaches and species with competitive abilities were only abundant in the uncut stream reaches. We suggest that important species traits in streams, where the weed is cut regularly, are associated with rapid growth and high dispersal-capacity. Our results indicate that weed-cutting can contribute significantly to a decline in species diversity in streams. To provide optimal conditions for diverse stream macrophyte communities, we therefore suggest that weed-cutting should be minimised.

Bachmann, R. W., M. V. Hoyer, and D. E. Canfield, Jr. The restoration of Lake Apopka in relation to alternative stable states. Hydrobiologia [Hydrobiologia]. Vol. 394, no. 1-3, pp. 219-232. 1999.Lake Apopka (Florida, USA) changed in 1947 from being a clear, macrophyte-dominated lake, used primarily for fishing, into a turbid algal lake with a poor fishery. The lake has resisted various efforts to reverse the change and restore the previous state. The restoration approach emphasizes the reduction in phosphorus inputs to reduce algal blooms and clear the water. We examined the question of whether a deep-lake approach with nutrient reductions is going to work on this large (area 124 km super(2)) and shallow (mean depth 1.7 m) lake, or if techniques such as drawdowns or wind barriers developed for shallow lakes using the theory of alternative stable states are more applicable. The assumptions upon which the current restoration is based are not supported. The poor transparency is due more to resuspended sediments than plankton algae, so the current Secchi disk depth of 0.23 m is predicted to increase to 0.34 m with any reasonable reduction in algal levels. The failure of the macrophytes to become reestablished probably is due more to unstable sediments than lack of light reaching the lake bed, and the marsh flow-way developed by the St Johns River Water Management District will be ineffective in removing particles from the lake. It would take more than

300 years to remove the fluid mud and more than 800 years to remove the rest of the low density sediments. We conclude that the loss of macrophytes in Lake Apopka is an example of a forward switch in the theory of alternative stable states, and that it will take more than a nutrient reduction program to bring about the reverse switch to a macrophyte state. We suggest an alternative approach using wave barriers to create refuges for plants, macroinvertebrates, and fish to restore Lake Apopka's largemouth bass fishery.

Best, E. P. H. The impact of mechanical harvesting regimes on the aquatic and shore vegetation in water courses of agricultural areas of The Netherlands. Vegetatio. Vol. 112, no. 1, pp. 57-71. 1994.It was demonstrated that a mechanical harvesting regime can influence the species composition of ditch vegetation at the community level. This effect, however, was very small compared with those of other factors such as the between-site and the within-site spatial variation, and several soil and water quality parameters. Cutting in November had the largest effect, in that it caused the greatest extremes in species cover. The vegetation was composed of 136 plant species. The semi-aquatic and aquatic species were less numerous than the terrestrial ones (52 versus 84). The total number per vegetation type and site ranged from 5 to 49; that of persistent plant species, from 4 to 22. Only 16% of the species was significantly influenced by the mechanical harvesting regime. The significant effects of the mechanical harvesting regime on plant species were related to plant-inherent factors. Mechanical harvesting repeated within a year, on one hand, opened up the vegetation, 1) freeing sites for colonization of new species, 2) improving the light climate for seedlings which had already colonized; on the other hand, it exhausted (carbohydrate) reserves of solitary species. Mechanical harvesting once a year in November had a contrasting effect in that it caused suffocation of the shore vegetation in spring by the not yet decomposed plant material harvested in autumn. The highest species richness was attained for the aquatic vegetation: on sand by cutting three times per year (in May, July and September), and on peat by cutting once a year (in November); and for the shore vegetation: on sand once a year (in May) and two times per year (in May and July), and on peat once a year (in May or November).

Boylen, C. W., L. W. Eichler, and J. W. Sutherland. Physical control of Eurasian watermilfoil in an oligotrophic lake. Hydrobiologia. Vol. 340, no. 1-3, pp. 213-218. Dec 1996.The introduction of Eurasian watermilfoil (Myriophyllum spicatum) into oligotrophic waters of high water clarity in temperate zones of North America has produced growth in excess of 6 m depth and yearly biomass approaching 1000 g m super(-2) dry weight. From its initial observation in Lake George, New York, USA in 1985, by 1993 milfoil had spread to 106 discrete locations within the lake. A 7-year study of one site having no management showed milfoil to grow expansively, suppressing native plant species from 20 in 1987 to 6 in 1993 with the average number of species m super(-2) quadrat declining from 5.5 in 1987 to less than 2 in 1993. Management of milfoil by means of hand harvesting, suction harvesting and benthic barrier has reduced the number of unmanaged sites from 106 in 1993 to 11. One year post-treatment at sites utilizing suction harvesting, showed a greater number of native species at all sites than pretreatment with a substantial reduction in milfoil biomass. At sites where benthic barrier was removed 1-2 years after installation, milfoil had recolonized 44% of grid squares within 30 days. Ninety days after barrier removal 74% of grid squares contained milfoil and one year later 71% of the grids supported milfoil. During the first year following mat removal, the average number of species m super(-2) peaked at 4.7 and

stabilized at 4.5 during the second year. Hand harvesting by SCUBA in areas of limited milfoil growth (new sites of infestation and sites of former treatment) was found to reduce the number of milfoil plants present in subsequent years. Hand harvesting did not eliminate milfoil at any of the sites and regrowth/colonization necessitated reharvesting every 3 or more years. Results of evaluations of physical plant management techniques indicate that (1) an integrated program utilizing different techniques based on plant density reduced the growth of milfoil and (2) long term commitment to aquatic plant management is necessary since none of the techniques employed singly were found to eliminate milfoil.

Brouwer, E., and J. G. M. Roelofs. Oligotrophication of acidified, nitrogen-saturated softwater lakes after dredging and controlled supply of alkaline water. Archiv fuer Hydrobiologie [Arch. Hydrobiol.]. Vol. 155, no. 1, pp. 83-97. Aug 2002.After acidification of shallow softwater lakes as a consequence of atmospheric sulphur and nitrogen deposition, the concentrations of nitrogen and carbon dioxide in the water layer are raised and the cation reserves in the sediment are depleted. Liming can counteract acidification, but can also lead to further nutrient mobilisation. Controlled supply of calcareous groundwater is an alternative method to restore the pH and alkalinity of the water layer. Sediment removal and subsequent restoration of pH leads to a reversal of the nutrient status towards pre-acidification levels. However, rapid re-acidification may occur as a consequence of supplying water from the catchment which is acid and rich in nitrogen. After three years of repeated groundwater supply, the base saturation of the sediment was higher than that of adjacent reference lakes where the sediment had been removed simultaneously. This base saturation is possibly a key factor in the prevention of re-acidification. During a five-year period after the start of groundwater supply, CO sub(2) and nitrogen concentrations in the water layer decreased and were not higher compared to adjacent reference lakes. Characteristic softwater macrophytes returned, but not in the reference lakes.

Bunn, S. E., P. M. Davies, D. M. Kellaway, and I. P. Prosser. Influence of invasive macrophytes on channel morphology and hydrology in an open tropical lowland stream, and potential control by riparian shading. Freshwater Biology [FRESHWAT. BIOL.]. Vol. 39, no. 1, pp. 171-178. Feb 1998.1. The catchments of many tropical lowland streams in far north Queensland have been extensively cleared for the cultivation of sugar cane to the extent where very little of the native riparian vegetation remains. Stream channels are often choked by a matrix of introduced pasture grass (Brachiaria mutica, or para grass) and accumulated sediment from cropland erosion. 2. Detailed transects across Bamboo Creek, a fourth order cane-land stream, revealed an estimated sediment load of 20 000 t km super(-1). This has resulted in an estimated 85% reduction in the predicted bankful discharge of the original stream channel. Channel capacity has been reduced from 2.3 times to 0.3 times the predicted Q sub(50) flood discharge of 140 m super(3) s super(-1). 3. Shade cloth treatments of 50% and 90% across the stream were used to mimic the effect of shading by riparian vegetation. Three months of shading resulted in a substantial reduction in the height and standing biomass of para grass in both shade treatments, compared to open plots (0% shade). The most dramatic effect was in the 90% treatment, where a mean reduction of 63% in height and 52% in total biomass was recorded. This was despite high net primary production of para grass in the open plots of 2.8 g dry wt m super(-2) day super(-1), which resulted in a overall increase of 11% and

28% in plant height and total biomass, respectively. 4. These data suggest that restoration of native riparian vegetation will be an effective long-term means of controlling invasive macrophytes in disturbed cane-land stream channels. Reduction of excessive macrophyte growth and the mobilisation of accumulated sediment are essential to the restoration of natural hydrological and ecological processes.

Catling, P. M., and I. Dobson. The biology of Canadian weeds. 69. Potamogeton crispus L. CAN. J. PLANT SCI. Vol. 65, no. 3, pp. 655-668. 1985.A review is provided of information on the biology of curly-leaved pondweed (Potamogeton cripsus L.). This submersed aquatic behaves as a winter annual through the production of summer-dormant apices. These germinate in the fall giving rise to an overwintering plant with narrow, acute, flat-margined leaves. In spring, the winter foliage disintegrates and larger leaves with serrulate, undulate margins and round tips begin to develop. Fruit is produced and the development of dormant apices is completed mostly by late June. An introduced species, curly-leaved pondweed had spread through much of the U.S. by 1950. It is now well established in southern Ontario and is one of the province's major nuisance aquatics. Curly pondweed has potential uses in waterfowl management and compositing. Where the plant is a problem in Ontario, mechanical harvesting techniques of control have been used effectively.

Catling, P. M., K. W. Spicer, M. Biernacki, and J. L. Doust. The biology of Canadian weeds. 103. Vallisneria americana Michx. Canadian Journal of Plant Science/Revue Canadienne de Phytotechnie [CAN. J. PLANT SCI./REV. CAN. PHYTOTECH.]. Vol. 74, no. 4, pp. 883-897. 1994.American wild celery (Vallisneria americana Michx.) is a native submerged aquatic plant that differs from other ribbon-leaved aquatics in having leaves with a well-defined midvein and paler zones on either side of a central dark band. In southern Ontario and Quebec the dense leaf growth, and in particular the floating plants dislodged from the sediment, impede water traffic and restrict water-based recreation. Mechanical harvesting may be the best method of control in most situations. American wild celery is beneficial as an important food source for waterfowl and other wildlife, as cover and spawning area for fish, and may also be used as fertilizer and to feed livestock. There is also potential for increased use in biomonitoring. Widespread in eastern North America, it reaches its northern limit in southeastern Canada. It is introduced in British Columbia and the northwestern United States, and has also recently been reported from the southwestern United States, Mexico, the Carribean islands, northern Central America, southeast Asia and Australia. American wild celery occurs in alkaline to slightly saline waters with pH > 6, at depths of 0.3-7 m, and in a variety of sediment types. Clonal growth is extensive. Parent rosettes can each produce 20 or more new shoots within a season. These develop from buds at the tip of stolons, some of which overwinter as turions. Pollination takes place on the surface of the water with free-floating male flowers tipping into the surface depression created by the larger, attached female flowers. Fruits mature under the water.

Collett, L. C., A. J. Collins, P. J. Gibbs, and R. J. West. Shallow Dredging as a Strategy for the Control of Sublittoral Macrophytes: A Case Study in Tuggerah Lakes, New South Wales. AUST. J. MAR. FRESHWATER RES. Vol. 32, no. 4, pp. 563-571. 1981.The effects of dredging the nearshores of the Tuggerah Lakes, on the central coast of New South Wales, to depths of 1 multiplied by 0, 1 multiplied by 4 and 1 multiplied by 8m, were investigated as a means of controlling aquatic macrophytes (Zostera

capricorni and Ruppia megacarpa). The effects of this management strategy on the macrobenthic fauna and macrophyte growth were also evaluated. Recolonization of dredged plots by most of the 63 zoobenthic species present in control plots had occurred within 8 months of the treatment. All species of macrophytes had re-established in the shallowest (1 multiplied by 0 m) plot within 4 months but had failed to colonize the deeper plots up to 12 months after dredging. The removal of growing macrophytes from the water by dredging as a means of enhancing the shoreline is discussed, as are constraints relating to this method.

Coops, H., E. H. van Nes, M. S. van den Berg, and G. D. Butijn. Promoting low-canopy macrophytes to compromise conservation and recreational navigation in a shallow lake. Aquatic Ecology [Aquat. Ecol.]. Vol. 36, no. 4, pp. 483-492. Dec 2002.The shift from a turbid-water state to a clear macrophyte-dominated state in the shallow lake Veluwemeer (The Netherlands) has led to nuisance for recreational navigation. The nuisance concerns the dense beds of Potamogeton perfoliatus in particular, whereas the low-canopy forming charophytes cause much less harm. On the other hand, the importance of macrophyte cover for the stability of the clear-water state has been recognised. To assess the potential of mechanical removal of dense macrophyte beds, several cutting regimes were simulated in a mixed vegetation of P. perfoliatus and Chara aspera, using the individual-based model Charisma. These species occupy a wide range of water depths between 0.5 and 2.5 m, with C. aspera dominating the shallower zone and P. perfoliatus dominating the deeper zone; intermediary is a zone where either species may dominate as alternative equilibria. Both the cutting height and timing affected the amount of biomass present in summer. The effect of cutting was more profound for treatment later in the season. With a cutting level above the Chara-canopy, the simulations showed an increased biomass of C. aspera and reduction of P. perfoliatus. In the zone of alternative equilibria, it was possible to provoke a sustainable shift from P. perfoliatus dominance to C. aspera dominance. To achieve this, annual repetition of cutting for a number of years was necessary. A harvesting regime aimed at shifting the vegetation dominance from P. perfoliatus towards C. aspera could be an option for management of the lake, since it holds the perspective of decreased management effort after a number of years. Moreover, removing only high-canopy vegetation implies high conservation values and recreational use can be combined.

Crowell, W., N. Troelstrup, Jr., L. Queen, and J. Perry. Effects of harvesting on plant communities dominated by Eurasian watermilfoil in Lake Minnetonka, MN. Journal of Aquatic Plant Management. Vol. 32, pp. 56-60. 1994.Extensive mechanical harvesting has been used in 5,746 hectare Lake Minnetonka, Minnesota since 1989 to control populations of Eurasian watermilfoil (Myriophyllum spicatum). Approximately 47% of the 544 infested hectares were harvested during the summer of 1990. We measured effects of one series of harvests in five separate locations in Lake Minnetonka. Plant relative growth rates were greater ($p = 0.001$) in 54 m super(2) harvested plots than in adjacent reference plots. The increased growth rate did not result in harvested areas having greater canopy density or higher total shoot biomass than adjacent reference areas. Harvesting reduced total shoot biomass and plant abundance at the water surface for up to 6 weeks following harvest. Eurasian watermilfoil was the dominant plant in all areas, although its presence in an area was not correlated with high total shoot biomass in that area. Total shoot biomass was positively correlated with both water clarity and

percentage of sediment organic matter and negatively correlated with the percentage of clay in the sediments.

Dall'Armellina, A., A. Gajardo, C. Bezic, E. Luna, A. Britto, and V. Dall'Armellina. Mechanical aquatic weed management in the lower valley of the Rio Negro, Argentina. Hydrobiologia. Vol. 340, no. 1-3, pp. 225-228. Dec 1996.A major irrigation system in the Lower Valley of the Rio Negro, Argentina, has been invaded by aquatic plants, with Potamogeton illinoensis Morong dominant in irrigation channels and Potamogeton pectinatus L. dominant in drainage channels. Although several other macrophytes are present, problems are largely caused by the dominant species. Results are presented for plant biomass response to weed control treatments using a chain-cutting method in the principal irrigation channel of the system. Peak above-ground biomass of Potamogeton illinoensis was reduced by about 38% by this physical control regime. The treated populations regrew rapidly after spring clearance, but did not regrow after subsequent mid- and late-season clearance operations, even though untreated population biomass remained high during this period. The highest density of Potamogeton illinoensis ramets was found in treated areas. Chain- cutting produced no discernible effect on dissolved oxygen, water temperature, water conductivity, pH or light extinction coefficient compared with untreated check sectors of the channel.

Dijk, G., A. W. Breukelaar, and R. Gijlstra. Impact of light climate history on seasonal dynamics of a field population of Potamogeton pectinatus L. during a three year period (1986-1988). Aquatic Botany [AQUAT. BOT.]. Vol. 43, no. 1, pp. 17-41. 1992.The impact of light climate during the growing season and light climate history on the growth and survival of a Potamogeton pectinatus population was studied in a eutrophic shallow lake, Lake Veluwe (Netherlands), during the period 1986-1988. Four different light conditions were created in an experimental setup by manipulating the photon flux density using artificial shading (three levels of artificial shading and one control situation without artificial shading), during the growing season of 1986. During the growing season of 1987, part of the P. pectinatus vegetation in the experimental setup was artificially shaded in the same way as in 1986, while another part was not shaded. No artificial shading was applied at all during the growing season of 1988. It is concluded that light climate is a dominant factor in controlling the biomass and tuber bank dynamics of a P. pectinatus population in Lake Veluwe. Additionally, water quality and meteorological characteristics are involved.

Doyle, R. D., and R. M. Smart. Competitive reduction of noxious Lyngbya wollei mats by rooted aquatic plants. Aquatic Botany [Aquat. Bot.]. Vol. 61, no. 1, pp. 17-32. May 1998.Establishment of native emergent or floating-leaved plants appears to offer natural and effective means to minimize the nuisance impacts of the mat-forming cyanobacterium Lyngbya wollei. This research has identified two species (Pontederia cordata and Potamogeton nodosus) which offer the potential for long-term competitive control of nuisance L. wollei mats in shallow waters. Both species significantly impacted the distribution and total mass of L. wollei mats within planted experimental plots compared to adjacent unplanted control plots. The established plants forced a redistribution of the L. wollei biomass within the water column, preventing the formation of the characteristic summertime floating mats, the most objectionable of the many nuisance aspects of this species. In addition, the L. wollei biomass was reduced by more than 50% in planted plots. This reduction in mass may have been related to reduced light

and nutrient availability within the vegetated plots. In addition, oxygenation and acidification of the benthic region may have promoted the decomposition and remineralization of the nuisance mat.

Dunderdale, J. A. L., and J. Morris. The economics of aquatic vegetation removal in rivers and land drainage systems. Hydrobiologia. Vol. 340, no. 1-3, pp. 157-161. Dec 1996.One purpose of river maintenance within Britain is to deliver given standards of land drainage service relating to the control, within acceptable limits, of flooding and waterlogging on riparian, mainly agricultural land. Aquatic weed removal is a major maintenance activity. Authorities responsible for cost-effective river maintenance need to determine the extent and timing of vegetation removal in channels of various types. The impact of maintenance is being studied on 12 sites in five regions of the National Rivers Authority (NRA) in England and Wales. The impact of differing maintenance regimes on flooding and waterlogging and the consequences for agricultural performance are assessed. The longevity of maintenance in terms of the time taken for the "without" maintenance watercourse condition to be reinstated following maintenance has been determined for gravel, sand and silt bed rivers on which vegetation cutting has been performed. The estimated benefits of river maintenance are set against costs to help formulate best maintenance strategies and prioritize and justify maintenance works.

Eichler, L. W., R. T. Bombard, J. W. Sutherland, and C. W. Boylen. Recolonization of the littoral zone by macrophytes following the removal of benthic barrier material. Journal of Aquatic Plant Management [J. AQUAT. PLANT MANAGE.]. Vol. 33, pp. 51-54. 1995.Removal of benthic barriers one to two years following installation allowed a systematic study of macrophyte recolonization. Within grids installed in the barren zone, species presence and relative abundance were recorded at 30-day intervals through two growing seasons. At each site, colonization of the 18 m super(2) grid system was observed, with typically 9 to 12 species found 30 days post benthic barrier removal. Sixty days posts barrier removal (August), both the number of species (averaging 4.7 m super(2)) and plant cover peaked (49% cover). A decline in species number and average percent cover observed after 120 days (October) was related to seasonal patterns of growth and die back of annual species. In the second growing season, the number of species stabilized while overall average percent cover (areal coverage) continued to increase. Eurasian watermilfoil colonized all sites, with 71% of all grid squares containing milfoil by the end of the second growing season, representing an average percent cover of 13.6% while total community percent cover averaged 74%. Removal of benthic barrier allowed for the rapid recolonization of both native species and Eurasian watermilfoil.

Engel, S. Ecological impacts of harvesting macrophytes in Halverson Lake, Wisconsin. Journal of Aquatic Plant Management. Vol. 28, no. 1, pp. 41-45. 1990.Mechanical harvesting removed 50 to 70% of submersed macrophyte standing crop in June and July 1980 and 1981 from Halverson Lake, a 4.2-ha impoundment in southwestern Wisconsin. Coontail (Ceratophyllum demersum) and Berchtold's, curly-leaf, and sago pondweeds (Potamogeton spp.) together comprised about 75% of total standing crop and covered 40 to 70% of the lake bed for three summers before harvesting. Macrophytes quickly regrew after the June 1980 harvest, reaching preharvest biomass within a few weeks and even becoming denser. Species composition shifted a year later to dominance by water stargrass (Heteranthera dubia). It continued to dominate until 1988 when the pondweeds

took over. Bluegills (Lepomis macrochirus), largemouth bass (Micropterus salmoides , and macroinvertebrates (mostly snails and chironomid larvae) were also removed during harvesting. But harvesting had little effect on phytoplankton, though blooms of bluegreen algae (chiefly Anabaena and Microcystis) were least dense when water stargrass remained dominant.

Engel, S., and S. A. Nichols. Lake sediment alteration for macrophyte control. Journal of Aquatic Plant Management. Vol. 22, pp. 38-41. 1984.The bottom of Marion Millpond, Wisconsin was partly blanketed with sand, gravel and plastic liners to control macrophytes by altering sediment texture and preventing roots from contacting the sediments to extract nutrients. Other areas were dredged to expose nutrient-poor soil. For the first two summers after treatment, filamentous algae invaded the blankets and Chara spread to both dredged and blanketed areas. By the third summer the vegetation changed to broad-leaved pondweeds (Potamogeton spp.) on the dredged areas and to naja (Najas flexilis (Willd.) Rostk & Schmidt) and elodea (Elodea canadensis (Michx.) on the blanketed areas. By the seventh year, all areas were densely covered with coontail (Ceratophyllum demersum L.), watermilfoil (Myriophyllum exalbescens Fern.) and pondweeds. Dredging and covering sediments, consequently, proved ineffective for long-term vegetation control in the pond.

Everitt, D. T., and J. M. Burkholder. Seasonal dynamics of macrophyte communities from a stream flowing over granite flatrock in North Carolina, USA. Hydrobiologia. Vol. 222, no. 3, pp. 159-172. 1991.Seasonal distribution and abundance of benthic macrophytes were characterized from second- and third-order segments of a stream flowing over granite flatrock in the southeastern U.S. 18 genera were identified over 2 annual cycles including macroalgae (60% or the total), angiosperms (30%), and bryophytes (10%), Light availability as affected by riparian shading was a major factor influencing community structure. Based on strong agreement among two-way indicator species analysis, detrended correspondence analysis and cluster analysis, four communities were identified characteristic of distinct light regimes and seasons. In shaded sites the red alga Lemanea australis was dominant during cool seasons, and the aquatic moss Fontinalis was dominant during warm seasons. By contrast, in open sites L. australis and the angiosperm Podostemum ceratophyllum were co-dominant during cool seasons, P. ceratophyllum was also dominant in warm seasons. The prolific macrophyte communities followed a pattern of broad seasonal maxima for dominant species along with rapid fluctuations in ephemerals. The community dynamics suggest that competitive interactions control space partitioning among macrophytes on the granite flatrock.

Fernandez-Alaez, M., C. Fernandez-Alaez, E. Becares, M. Valentin, J. Goma, and P. Castrillo. A 2-year experimental study on nutrient and predator influences on food web constituents in a shallow lake of north-west Spain. Freshwater Biology [Freshwat. Biol.]. Vol. 49, no. 12, pp. 1574-1592. Dec 2004.1. A 2-year study was carried out on the roles of nutrients and fish in determining the plankton communities of a shallow lake in north-west Spain. Outcomes were different each year depending on the initial conditions, especially of macrophyte biomass. In 1998 estimated initial 'per cent water volume inhabited' (PVI) by submerged macrophytes was about 35%. Phytoplankton biomass estimated as chlorophyll a was strongly controlled by fish, whereas effects of nutrient enrichment were not significant. In 1999 estimated PVI was 80%, no fish effect was observed on phytoplankton biomass, but nutrients had significant effects. Water

temperatures were higher in 1998 than in 1999. 2. In the 1998 experiment, cladoceran populations were controlled by fish and cyanobacteria were the dominant phytoplankton group. There were no differences between effects of low (4 g fresh mass m super(-2)) and high (20 g fresh mass m super(-2)) fish density on total zooplankton biomass, but zooplankton biomass was higher in the absence of fish. With the high plant density in 1999, fish failed to control any group of the zooplankton community. 3. Total biovolume of phytoplankton strongly decreased with increased nutrient concentrations in 1998, although chlorophyll a concentrations did not significantly change. At higher nutrient concentrations, flagellate algae became more abundant with likely growth rates that could have overcompensated cladoceran feeding rates. This change in phytoplankton community composition may have been because of increases in the DIN : SRP ratio. Both chlorophyll a concentration and total phytoplankton biovolume increased significantly with nutrients in the 1999 experiment. 4. A strong decline of submerged macrophytes was observed in both years as nutrients increased, resulting in shading by periphyton. This shading effect could account for the plant decline despite lower water turbidity at the very high nutrient levels in 1998.

Fox, A. M., and K. J. Murphy. The efficacy and ecological impacts of herbicide and cutting regimes on the submerged plant communities of four British rivers. 1. A comparison of management efficacies. Journal of Applied Ecology. Vol. 27, no. 2, pp. 520-540. 1990.Replicated field trials to compare the effects on aquatic weed communities of physical (weed cutting) and chemical (diquat-alginate) management techniques were carried out in 4 U.K. rivers. These rivers varied in water quality but all supported macrophyte communities that included species of Ranunculus subgenus Batrachium . The labour-intensive cutting treatments in 2 of the rivers removed most of the Ranunculus from the centres of the channels. Diquat-alginate was very effective in removing Ranunculus from the shallow, swiftly flowing and moderately calcareous (60-80 mg/l) River Petteril and Mouse Water. The herbicide appeared to be ineffective in the River Windrush, but in the River Coln, of similar size and calcium content (110 and 120 mg/Ca, respectively), a large proportion of the predominant Ranunculus was removed.

Fox, A. M., and K. J. Murphy. The efficacy and ecological impacts of herbicide and cutting regimes on the submerged plant communities of four British rivers. 2. A multivariate analysis of the effects of management regimes on macrophyte communities. Journal of Applied Ecology. Vol. 27, no. 2, pp. 541-548. 1990.Macrophyte abundance scores derived from percentage frequencies from permanent transects in 4 rivers were subjected to DECORANA and TWINSPAN multivariate analyses. The resulting ordination and classification sorted the samples very clearly by site and by sampling time. No pattern distinguishing the effects of cutting and chemical herbicides was observed. The ordination suggested that several water chemistry parameters might be influencing the plant communities at each site. The value of the multivariate approach for short and longer-term management studies on river vegetation is discussed.

France, R. L., and P. M. Stokes. Isoetid-zoobenthos associations in acid-sensitive lakes in Ontario, Canada. Aquatic Botany. Vol. 32, no. 1-2, pp. 99-114. 1988.The macrophyte and associated epiphytic invertebrate community were quantitatively sampled within the littoral zones of 18 oligotrophic lakes in south-central Ontario. Densities for 7 of 10 benthic taxa were significantly greater within Eriocaulon septangulare dominated mats compared with clusters of Lobelia dortmanna overlying sand beach. The

microdistribution and abundance of amphipods was dependent on, and significantly correlated with, isoetid biomass. The depth distribution of littoral invertebrates was also closely associated with the attenuation of macrophyte biomass. Estimates of mean annual biomass ranged from 91.5 to 475.3 g dry wt m super(-2) for Eriocaulon , and from 44.9 to 192.1 g dry wt m super(-2) for Lobelia . Biomass showed no trend in relation to lake pH within the range 5.6-6.7, nor to total phosphorus in water from 5 to 14 mg m super(-3).

Gabor, T. S., and H. R. Murkin. Effects of clipping purple loosestrife seedlings during a simulated wetland drawdown. Journal of Aquatic Plant Management. Vol. 28, no. 2, pp. 98-100. 1990.Control of purple loosestrife (Lythrum salicaria) has achieved marginal success to date. Drawdowns or dewatering of wetland basins to re-establish desirable plant species and improve overall productivity may only increase loosestrife densities and compound infestation problems. Although seed germination and seedling establishment has been studied under laboratory conditions, little is known about natural establishment patterns following a drawdown. Our objectives were to monitor loosestrife seedling establishment following a simulated wetland drawdown and to determine the effect of clipping all existing seedlings at pre-determined intervals following drawdown.

Garbey, C., G. Thiebaut, and S. Muller. Impact of manual spring harvesting on the regrowth of a spreading aquatic plant: Ranunculus peltatus Schrank. Archiv fuer Hydrobiologie [Arch. Hydrobiol.]. Vol. 156, no. 2, pp. 271-286. Jan 2003.R. peltatus is a native aquatic plant which is spreading in poorly mineralised waters in the Northern Vosges, NE France. In order to regulate its spread, different dates and frequencies of harvests in spring and summer were tested. Their impact on the biomass, the regrowth strategy of R. peltatus, and the plant community, was evaluated. Harvesting caused a reduction in the biomass of R. peltatus. Two or three harvests did not regulate R. peltatus biomass more efficiently than one harvest. One harvest is most efficient if performed in April or in May, depending on what degree of regulation is wanted. The plant regrew from the pool of roots and seeds developing into new individuals and the branching of existing fragments located in the soil. This regrowth strategy varied according to the frequency and the date of harvest. The rooting capacity of R. peltatus was not impacted. However, its flowering was totally inhibited by the harvests. Furthermore, the harvesting had a very variable effect on the relationship between R. peltatus and E. nuttallii which is an invasive species in this area. Thus, harvesting could be a good tool to reduce the spread of R. peltatus, but it might favour the dominance of another nuisance-causing species, E. nuttallii.

Garner, P., J. A. B. Bass, and G. D. Collett. The effects of weed cutting upon the biota of a large regulated river. Aquatic Conservation: Marine and Freshwater Ecosystems [AQUAT. CONSERV.: MAR. FRESHWAT. ECOSYST.]. Vol. 6, no. 1, pp. 21-29. Mar 1996.The effects of macrophyte removal from a regulated reach of the River Great Ouse, UK, were recorded. The relationship between macrophyte cover, zooplankton distribution and 0+roach Rutilus rutilus (L.) distribution, diet and growth, were compared before, directly after, and over several weeks following weed-cutting operations. Both zooplankton and fish were significantly associated with the macrophyte zone before weed cutting. It is suggested that this zone provides high food densities and refuge during periods of elevated flows. Removal of all but a 2 m marginal strip of the macrophyte zone led to a rapid decline in the mean densities of planktonic Cladocera, probably as a result of increased washout, fish predation and starvation. This was accompanied by a

rapid decline in the growth rate of the roach, which were forced to feed on the less nutritious aufwuchs. It is suggested that river management involving weed cutting adjacent to one bank in alternate years would be sufficient to prevent loss of channel capacity and would provide a refuge for fish and zooplankton.

Gerber, K., and G. C. Smart, Jr. Effect of Hirschmanniella caudacrena on the submersed aquatic plants Ceratophyllum demersum and Hydrilla verticillata. Journal of Nematology. Vol. 19, no. 4, pp. 447-494. 1987.In vitro pathogenicity tests demonstrated that Hirschmanniella caudacrena is pathogenic to Ceratophyllum demersum (coontail). Symptoms were chlorotic tissue, deformed stems, and, finally, death of the plant. Inoculum densities of 500 nematodes per 5-cm-long cutting in a test tube containing 50 ml of water resulted in death and decay of some of the cuttings within 8 weeks; 100 nematodes killed the plants in 12 weeks, and 50 and 25 nematodes killed them in 16 weeks. A second test conducted outdoors in glass jars containing 3 liters of water and two cuttings weighing a total of 15 g fresh weight showed damage, but results were not statistically significant. Hydrilla verticillata inoculated with H. caudacrena was not affected seriously.

Gizinski, A., A. Kentzer, and M. Rejewski. Why does Druzno Lake (Poland) still exist? On the conditions of the pond ecosystem sustainability. Hydrobiologia. Jan 1997.Druzno Lake is a semi-natural, hypertrophic basin located on the Zulawy polders (delta of Vistula). Its area is 13-29 km super(2), with a mean depth of 1.25 m. The lake is extremely polymictic and of throughflow character: the water retention time is very short (20 days!). Almost 90% of the bottom is overgrown by macrophytes. The productivity, especially of phytoplankton, is very high. The main factors of ecosystem stability are: There are very good oxygen conditions in the lake. Organic matter undergoes quick mineralization. Due to frequent resuspension and intensive throughflow a considerable part of the mineral and organic seston is 'exported' out of the lake. By dredging the navigable channel, additional amounts of suspended matter have been exported out of the system. Therefore these technical treatments slow down the processes of shallowing and aging of the lake and support the lake's existence.

Gonzalez Sagrario, M. A., E. Jeppesen, J. Goma, M. Soendergaard, J. P. Jensen, T. Lauridsen, and F. Landkildehus. Does high nitrogen loading prevent clear-water conditions in shallow lakes at moderately high phosphorus concentrations? Freshwater Biology [Freshwat. Biol.]. Vol. 50, no. 1, pp. 27-41. Jan 2005.1. The effect of total nitrogen (TN) and phosphorus (TP) loading on trophic structure and water clarity was studied during summer in 24 field enclosures fixed in, and kept open to, the sediment in a shallow lake. The experiment involved a control treatment and five treatments to which nutrients were added: (i) high phosphorus, (ii) moderate nitrogen, (iii) high nitrogen, (iv) high phosphorus and moderate nitrogen and (v) high phosphorus and high nitrogen. To reduce zooplankton grazers, 1 super(+) fish (Perca fluviatilis L.) were stocked in all enclosures at a density of 3.7 individuals m super(-2). 2. With the addition of phosphorus, chlorophyll a and the total biovolume of phytoplankton rose significantly at moderate and high nitrogen. Cyanobacteria or chlorophytes dominated in all enclosures to which we added phosphorus as well as in the high nitrogen treatment, while cryptophytes dominated in the moderate nitrogen enclosures and the controls. 3. At the end of the experiment, the biomass of the submerged macrophytes Elodea canadensis and Potamogeton sp. was significantly lower in the dual treatments (TN, TP) than in single

nutrient treatments and controls and the water clarity declined. The shift to a turbid state with low plant coverage occurred at TN >2 mg N L super(-1) and TP >0.13-0.2 mg P L super(-1). These results concur with a survey of Danish shallow lakes, showing that high macrophyte coverage occurred only when summer mean TN was below 2 mg N L super(-1), irrespective of the concentration of TP, which ranged between 0.03 and 1.2 mg P L super(-1). 4. Zooplankton biomass and the zooplankton : phytoplankton biomass ratio, and probably also the grazing pressure on phytoplankton, remained overall low in all treatments, reflecting the high fish abundance chosen for the experiment. We saw no response to nutrition addition in total zooplankton biomass, indicating that the loss of plants and a shift to the turbid state did not result from changes in zooplankton grazing. Shading by phytoplankton and periphyton was probably the key factor. 5. Nitrogen may play a far more important role than previously appreciated in the loss of submerged macrophytes at increased nutrient loading and for the delay in the re-establishment of the nutrient loading reduction. We cannot yet specify, however, a threshold value for N that would cause a shift to a turbid state as it may vary with fish density and climatic conditions. However, the focus should be widened to use control of both N and P in the restoration of eutrophic shallow lakes.

Gulati, R. D., and E. van Donk. Lakes in the Netherlands, their origin, eutrophication and restoration: state-of-the-art review. Hydrobiologia [Hydrobiologia]. Vol. 478, no. 1, pp. 73-106. Jun 2002.This article starts with a brief description of the origin and eutrophication of shallow Dutch lakes, followed by a review of the various lake restoration techniques in use and the results obtained. Most freshwater lakes in the Netherlands are very shallow (<2 m), and owe their origins to large-scale dredging and removal of peat during the early 17th century. The lakes are important to the hydrology, water balance and agriculture in the surrounding polder country. The external input to the lakes of phosphorus (P) and nitrogen (N) and of polluted waters from the rivers and canals have been the major cause of eutrophication, which began during the 1950s. In addition, more recently climate changes, habitat fragmentation and biotic exploitation of many of these waters have probably led to loss of resilience and thus to accelerated eutrophication. Lake eutrophication is manifested essentially in the poor under-water light climate with high turbidity (Secchi-disc, 20-40 cm) caused usually by cyanobacterial blooms (e.g. Oscillatoria sp.), and loss of littoral vegetation. Lake recovery is also invariably afflicted by in-lake nutrient sources. These include P loading from the P-rich sediments, mineralization in the water and release by the foraging and metabolic activities of the abundant benthivorous and planktivorous fish, mainly bream (Abramis brama). A variety of restoration techniques have been employed in the Dutch lakes: hydrological management, reduction of P in the external loads, in-lake reduction or immobilisation of P, and complementary ecological management. This last involves biomanipulation, or the top-down control of the food web. Hydrological management has resulted in an improvement in the lake water quality only in a few cases. The failure of lake restoration measures (e.g. in the Loosdrecht lakes, described as a case study) has led water managers to use biomanipulation in other lakes under restoration. Lake biomanipulation principally involves reducing the existing planktivore population, bream in most cases, and introducing piscivores such as northern pike (Esox lucius). Lake Zwemlust is discussed as a case study, with brief mention of some other small lakes which have been biomanipulated. The restoration studies reveal that decrease of P to low

levels is no guarantee that cyanobacterial populations will also follow suit. This is because cyanobacteria can withstand great variation in their P content and thus in their C:P ratios. Thus, for a unit weight of P, the Cyanobacteria can yield relatively more biomass and cause greater turbidity than, for example, 1reen algae, which have relatively lower C:P ratios. This is possibly an explanation for the success of these filamentous Cyanobacteria in many Dutch lakes, and the failure of restoration endeavours. In general, the achievements of restoration work in the Dutch lakes, especially those using biomanipulation measures, are questionable: there are probably more examples of failures than of successes. The failures are generally linked not only to insufficient or no decrease at all in the autochthonous or in-lake nutrient loadings, but also to rapid increase of the planktivorous fish in the years following their reduction. A 75% reduction in the existing planktivore population has often been used as an arbitrary yardstick for effective reduction, but may not be sufficient. However, fish stock reductions to <50 kg FW ha super(-1) and maintenance at that level might have a greater chance of success, though maintaining the existing fish population at preconceived levels is difficult since for reasons not yet fully understood, piscivores, pike in particular, fail to develop sizeable populations. Studies so far have helped us recognise that for sustainability of the positive effects on water quality, `natural development' should be central to future lake restoration programmes.

Havens, K. E., B. Sharfstein, A. J. Rodusky, and T. L. East. Phosphorus accumulation in the littoral zone of a subtropical lake. Hydrobiologia [Hydrobiologia]. Vol. 517, no. 1-3, pp. 15-24. Apr 2004.In situ mesocosm experiments were performed under summer (1997) and winter (1999) conditions in the littoral zone of a subtropical lake in Florida, USA. The objective was to quantify phosphorus (P) accumulation by various components of the community after adding pulsed doses of dissolved inorganic P. A short-term experiment also was done to quantify the rate of P loss from the water column, with simultaneous use of an inert tracer to confirm that P depletion was not due to leakage of the tanks. In the experiments, added P was rapidly removed from the water; samples collected 3-4 days after adding spikes of near 100 mu g l super(-1) P contained little or no soluble reactive P. In the short-term experiment, we documented that the half-life of added P was approximately 6-8 h in the water column, and that the tanks were not exchanging water with the surrounding lake. Little of the added P ended up in plankton, rooted vascular plants, or sediments. The main sink for P was periphyton, including surface algal mats, benthic algal mats and detritus, and epiphyton. In the summer 1997 experiment, the periphyton was intimately associated with a non-rooted plant (Utricularia), which also may have sequestered P from the water. Structure of the littoral community varied between summer and winter, and this influenced which periphyton component accounted for most of the P removal. In regard to P mass balances, we accounted for 54% of the added P in 1997, when coarse sampling was done. In 1999, when there was more detailed sampling of the community, 92% of the added P was located in various community components. Subtropical littoral periphyton can be a large sink for P, as long as depth and underwater irradiance conditions favor its growth.

Hearne, J. W., and P. D. Armitage. Implications of the annual macrophyte growth cycle on habitat in rivers. Regulated Rivers: Research & Management [REGUL. RIVERS: RES. MANAGE.]. Vol. 8, no. 4, pp. 313-322. 1993.The continuity equation, Manning's equation and an empirically determined relationship between channel

roughness and the biomass of macrophytes were used to simulate the effects of weed growth in contrasting channels. Two indices of wetted available habitat, velocity and depth were chosen to illustrate the role of macrophyte in maintaining and modifying instream habitat with particular reference to chalk streams. Plant growth maintained depth within the channels and its effect was modified by channel shape and slope. Weed cutting resulted in very sudden changes in depth and velocity and the loss of a large volume of water from the river. The results indicate that macrophyte growth could be used to maintain wetted habitat while allowing more abstraction, but more data are required on the long-term effects of implementing such policies.

Hellsten, S., C. Dieme, M. Mbengue, G. A. Janauer, N. den Hollander, and A. H. Pieterse. Typha control efficiency of a weed-cutting boat in the Lac de Guiers in Senegal: a preliminary study on mowing speed and re-growth capacity. Hydrobiologia [Hydrobiologia]. Vol. 415, pp. 249-255. 15 Nov 1999.Prolific growth of Typha australis in the lower part of the Senegal River and the Lac de Guiers resulted from changed ecological conditions following the construction of two high dams in the Senegal River. Fluctuation of the water level has decreased markedly and the water has changed from brackish to fresh as the inflow of salt water from the ocean is prevented. The efficiency of a hydraulic weed cutting boat (model Conver 480 H) has been tested in various plots in the Lac de Guiers. This lake, connected with the Senegal River, is economically very important as it is the city of Dakar's major drinking water supply and also provides irrigation water for vast agricultural areas. Cutting, performed at 20 cm and 50 cm below the water surface, was very effective in removing Typha stands. However, due to the excessively thick stems of the Typha plants, cutting took much more time compared to similar operations in Europe. It was estimated that approximately 35 h were required to clear one ha of dense Typha stands. Directly after cutting re-growth was observed during a relatively brief period (approximately three months), however, subsequently all newly formed growth tips in the plots had suddenly disappeared. It was concluded that this sudden collapse was linked to a destruction of the root zone due to anoxic conditions. Eventual re-growth was relatively slow as after one year the plots were still largely free from Typha plants. Efficiency of mowing was not related significantly to depth of cutting.

Henry, C. P., and C. Amoros. Restoration ecology of riverine wetlands. 3. Vegetation survey and monitoring optimization. Ecological Engineering. Vol. 7, no. 1, pp. 35-58. Sep 1996.A restoration experiment was carried out in a former channel of the Rhone River, France. To evaluate restoration success or failure, aquatic vegetation was surveyed monthly from March to October, one year prior to and 2 years following restoration. This was done in both the channel restored by the dredging of fine organic nutrient-rich sediments and in a similar reference channel. Whereas both species richness and total vegetational cover per transect of aquatic vegetation showed the same temporal pattern each year in each zone, these two variables exhibited a different pattern in the restored channel after restoration. Species richness generally increased continuously during the first year following restoration, then followed a seasonal pattern during the second year. Total vegetational cover was very low the first year following restoration and remained low afterwards, except in the upstream zone of the restored channel, which was fully colonized by aquatic vegetation the second year. Post-restoration changes were thus very clear in the upstream zone of the restored channel. A multivariate analysis depicted

changes in the floristic composition: whereas vegetation composition was quite stable in the reference channel, eutrophic species were replaced by mesotrophic species in the restored channel.

Hey, R. D., G. L. Heritage, and M. Patteson. Impact of flood alleviation schemes on aquatic macrophytes. Regulated Rivers: Research & Management [REGUL. RIVERS: RES. MANAGE.]. Vol. 9, no. 2, pp. 103-119. 1994.Geomorphological, engineering and ecological surveys were carried out at 18 flood alleviation schemes in the UK to evaluate their environmental performance. As no pre-scheme river corridor surveys had been carried out at any of the sites to enable the environmental impact to be directly assessed, controls were established in natural sections adjacent to five of the engineered reaches. A space-time substitution enables the pre-scheme conditions to be estimated for comparison with the engineered reach. The physical characteristics of the channel at bankfull conditions exert a strong influence on plant community composition. Paired assessments were carried out for engineered/control reaches on five rivers and this revealed which species and habitats were most affected by various engineering treatments. The general conclusion was that dredging, widening and straightening rivers reduces the number of desirable species, whereas two-stage channels and schemes involving the construction of flood banks at the edge of the meander belt maintained the richness and preserved and enhanced the occurrence of key species. Data from every cross-section, engineered and control reaches, enabled a model to be developed relating species occurrence to physical habitat features. This can be used to predict, at the stage of appraisal or design of a project, the likely response of the river to any particular engineering works. Given information on the existing condition in the river, it enables the environmental impact of the scheme, in terms of its effect on river bed plant species, to be assessed.

Hootsmans, M. J. M. Modelling Potamogeton pectinatus: for better or for worse. Hydrobiologia [Hydrobiologia]. Vol. 415, pp. 7-11. 15 Nov 1999.The SAGA plant growth model is introduced in connection with integrated weed management. SAGA describes the seasonal development of Potamogeton pectinatus L. The model is mainly driven by light climate characteristics (water layer extinction, periphyton shading) and their effects on plant photosynthesis and tuber production. It could be a tool for evaluating several weed control methods (mowing, shading, grazing) as it was calibrated and validated quite well for a vegetation growing in Lake Veluwe (The Netherlands). The SAGA model was used to provide management advice for a P. pectinatus vegetation growing profusively in two Argentine irrigation schemes. The model's re-calibration to local conditions was hampered by some unexplained variation in seasonal biomass cycle data. Nevertheless, the results obtained were considered quite acceptable for comparative scenario analysis. The simulated vegetation dynamics suggest that the mowing regime currently applied in the channels is not an optimal solution. Neither is an artifically increased turbidity, created by the introduction of benthivorous common carp (Cyprinus carpio L.). Their combination, however, may lead to quite satisfactory results, allowing a repetition of the mowing operation to be postponed by two years. Direct grazing of the vegetation by grass carp (Ctenopharyngodon idella Val.) also proved a potential management tool with substantial effect.

Hootsmans, M. J. M., A. A. Drovandi, N. Soto Perez, and F. Wiegman. Photosynthetic plasticity in Potamogeton pectinatus L. from Argentina: Strategies to survive adverse light conditions. Hydrobiologia. Vol. 340, no. 1-3, pp. 1-5. Dec

1996.Argentine Potamogeton pectinatus L. was grown in The Netherlands under laboratory conditions at four light intensities (50, 100, 150 and 200 mu E/m super(2)/s), and photosynthetic performance was evaluated after about 1, 2 and 3 months of growth. At these moments, chlorophyll-a and -b and tissue N and P content were also determined. During the growing period, plant lengths and number of secondary shoots were measured. In the field in Argentina, photosynthetic performance of P. pectinatus was also measured at different light intensities created by artificial shading at various times during the growing season. Field and laboratory photosynthetic results were in good agreement. P. pectinatus showed a significant plasticity in its photosynthesis, rather than in morphology. A fairly constant maximum photosynthetic rate with reduced light enabled the plants to maintain net production rates rather unaffected at low light intensities. Still, it can be predicted that increasing turbidity from 1-2/m at present to 3/m could lead to a strongly light-limited growth which should reduce the present weed problem considerably. Such a turbidity increase might be achieved by the introduction of a fairly dense bottom-feeding fish population like Common carp (Cyprinus carpio L.).
Hroudova, Z., A. Krahulcova, P. Zakravsky, and V. Jarolimova. The biology of Butomus umbellatus in shallow waters with fluctuating water level. Hydrobiologia. Vol. 340, no. 1-3, pp. 27-30. Dec 1996.Butomus umbellatus L. is a plant species typical of littoral communities of river and stream shores. It can form continuous stands in shallow reservoirs with fluctuating water level. Their expansion is promotely by: (a) intensive vegetative reproduction of plants, (b) crowded sprouting from rhizome fragments on emerged pond bottom, (c) shallow water layer in the year following summer drainage. Expansion of B. umbellatus depends on ploidy level: two cytotypes were found in the Czech and Slovak Republics, differing in their reproductive ability. Seed production of triploids is strongly limited (they are self-incompatible within clones), while diploids can be fully fertile. Nevertheless, even in diploids, the efficiency of seed reproduction under natural conditions is low. Triploids spread by intensive vegetative reproduction, which is decisive for clonal growth of populations and their regeneration after scraping of bottom surface. During seasonal development, maximum of aboveground biomass is produced in early summer, while underground biomass increases till autumn. Growth of the plants is limited by cutting before maximum underground biomass is attained, or by duck grazing.
Irfanullah, H. M. Factors influencing the return of submerged plants to a clear-water, shallow temperate lake. Aquatic Botany [Aquat. Bot.]. Vol. 80, no. 3, pp. 177-191. Nov 2004.Lack of submerged vegetation was studied in a small, shallow, alkaline, clear-water lake with high nitrate concentration (mean 9 mg NO sub(3)-N L super(-1)) and profuse filamentous green algae (FGA) (mainly Spirogyra sp.). A laboratory microcosm and two lake enclosure experiments were carried out using Elodea nuttallii (Planchon) St John. E. nuttallii grew about 1.7 times as well in sediment from its place of origin compared with sediment from the lake. Differential water quality had no effect, and neither sediment nor water prevented growth in the lake. Nutrient addition reduced plant growth by more than 55% because of shading from epiphytic filamentous green algae (shoot dry weight versus epiphytic algal dry weight, r =-0.491, P < 0.05). Transplanted Elodea plants grew better in enclosures in the lake than in laboratory conditions with lake water and sediment (P < 0.001, t-test). Rare Elodea individuals in the lake indicate the presence of plant propagules in the lake sediment, but excessive growth of filamentous green algae (summer mean 3.2 g dry weight m super(-2)) significantly hamperd plant growth (shoot

length reduced from 29 plus or minus S.E.M. 1 to 25 plus or minus 1 cm) and bird herbivory significantly reduced survival (from 82 [plus-or-minus- sign] 7 to 40 plus or minus 6%) and shoot growth (from 78 [plus-or-minus- sign] 6 to 18 plus or minus 5 cm) and thus eliminates establishment of even modest plant beds. Fish disturbance and sediment stability were not important. Restoration of submerged plants may require reduction of nitrate input, control of filamentous green algae and protection from birds.

Jeppesen, E., M. Sondergaard, B. Kronvang, J. P. Jensen, L. M. Svendsen, and T. L. Lauridsen. Lake and catchment management in Denmark. Hydrobiologia [Hydrobiologia]. Vol. 395/396, pp. 419-432. Feb 1999.The majority of Danish lakes are highly eutrophic due to high nutrient input from domestic sources and agricultural activities. Reduced nutrient retention, and more rapid removal, in catchments as a result of agricultural drainage of wetlands and lakes and channelisation or culverting of streams also play a role. Attempts have recently been made to reduce nutrient loading on lakes by intervening at the source level and by improving the retention capacity of catchment areas. The former measures include phosphorus stripping and nitrogen removal at sewage works, increased use of phosphate-free detergents, and regulations concerning animal fertiliser storage capacity, fertiliser application practices, fertilisation plans and green cover in winter. In order to improve nutrient retention capacity of catchments, wetlands and lakes have been re-established and channelised streams have been remeandered. In addition, cultivation-free buffer strips have been established alongside natural streams and there has been a switch to manual weed control. These measures have resulted in a 73% reduction of the mean total phosphorus concentration of point-source polluted streams since 1978; in contrast, there has been no significant change in the total nitrogen concentration. Despite the major reduction in stream phosphorus concentrations, lake water quality has often not improved. This may reflect a too high external or internal phosphorus loading or biological resistance. Various physico-chemical restoration measures have been used, including dredging and oxidation of the hypolimnion with nitrate and oxygen. Biological restoration measures have been employed in 17 Danish lakes. The methods include reducing the abundance of cyprinids, stocking with 0 super(+) pike (Esox lucius) to control 0 super(+) cyprinids, and promoting macrophyte recolonization by protecting germinal submerged macrophyte beds against grazing waterfowl and transplanting out macrophyte shoots. In several lakes, marked and long-lasting improvements have been obtained. The findings to date indicate that fish manipulation has a long-term effect in shallow lakes, providing nutrient loading is reduced to a level so low as to ensure an equilibrium lake water phosphorus concentration of less than 0.05-0.1 mg phosphorus l super(-1). If nitrogen loading is very low, however, positive results may be obtained at higher phosphorus concentrations. Macrophyte refuges and transplantation seem to be the most successful as restoration measures in the same nutrient-phosphorus regime as fish manipulation.

Jorga, W., W. D. Heym, and G. Weise. Shading as a measure to prevent mass development of submersed macrophytes. INT. REV. GESAMTEN HYDROBIOL. Vol. 67, no. 2, pp. 271-281. 1982.Relations between the biomass of submersed macrophytes and irradiance are investigated. Light intensity ratio, L sub(h)/L sub(vt)*, at a water depth of 35 cm forms a good basis for assessing the potential growth of submersed macrophytes because it seems to permit their optimum development in the small slow running waters of the plain that were studied. The provision of shade from the banks, which can be done

only on one side due to the necessity of maintaining the waters, restricts mass development of submersed macrophytes to less than 250 g dry weight multiplied by m super(-2).

Kaenel, B. R., C. D. Matthaei, and U. Uehlinger. Disturbance by aquatic plant management in streams: Effects on benthic invertebrates. Regulated Rivers: Research & Management [Regul. Rivers: Res. Manage.]. Vol. 14, no. 4, pp. 341-356. Jul-Aug 1998.The effect of aquatic plant removal on benthic invertebrates and their habitat was studied in two macrophyte-rich streams of the Swiss Plateau. In each stream, habitat conditions (macrophyte biomass, current velocity, water depth) and invertebrate densities were monitored in a control reach and in a reach where plants were removed by cutting. Biological samples were taken and physical parameters measured on three dates before and six dates after plant removal in both reaches. Responses to plant removal were similar in both streams; macrophyte cutting initially decreased mean plant biomass (ca. 85%) and total number of invertebrates (ca. 65%). Variation between replicates was, however, higher in one of the streams, causing fewer effects on plants and invertebrates to be statistically significant. Plant cutting affected mainly taxa that used macrophytes as habitat (e.g. Simuliidae, Chironomidae), whereas highly mobile taxa (e.g. Ephemeroptera) and taxa living on or within the bed sediments (e.g. Trichoptera, Bivalvia) were less affected. Taxa that decreased after plant removal recovered within 4-6 months, although recovery of macrophytes was quite different in both streams. Invertebrate recovery also seemed to be seasonally dependent, with cutting having a less severe impact during summer than spring. Our results suggest that macrophytes in streams should be removed only in summer, preferably leaving some plant beds to act as refugia for phytophilous invertebrates.

Kilbride, K. M., and F. L. Paveglio. Integrated pest management to control reed canarygrass in seasonal wetlands of southwestern Washington. Wildlife Society Bulletin [Wildl. Soc. Bull.]. Vol. 27, no. 2, pp. 292-297. 1999.Reed canarygrass (Phalaris arundinacea L.) is an exotic, invasive species that threatens to degrade wetlands throughout North America. Although efficacies of control methods for canarygrass have been studied in the Midwest, little information is available regarding efficacies for treatments in the Pacific Northwest. Consequently, we investigated efficacies of integrated pest management techniques to control canarygrass in seasonal wetlands of southwestern Washington. We evaluated mechanical (disking or mowing), chemical (Rodeo super(registered)), and combinations of disking and Rodeo along with water-level control for 3 growing seasons. Stem densities of canarygrass were reduced most by spraying and disking with a follow-up application of Rodeo during the next growing season. Disking with a follow-up application of Rodeo during the next growing season generally had similar canarygrass control as the most efficacious treatment. Canarygrass that germinated and grew from viable rhizomes following draw-down after the initial Rodeo application or disking made a follow-up treatment with herbicide imperative for effective control. To prevent canarygrass re-infestation, treatments should not be initiated until the ability to manage consistent water levels throughout the winter and early spring exists for a wetland.

Kimbel, J. C., and S. R. Carpenter. Effects of Mechanical Harvesting on Myriophyllum spicatum L. Regrowth and Carbohydrate Allocation to Roots and Shoots. Aquatic Botany. Vol. 11, no. 2, pp. 121-127. 1981.A July harvest of Myriophyllum

spicatum L. disrupted seasonal patterns of total nonstructural carbohydrate (TNC) allocation between the roots and shoots, relative to that of plants on an unharvested control plot. Biomass, TNC plant super(-) super(1), and TNC m super(-) super(2) were lower in the harvested plot 11 months after the harvest. A summary of literature data indicates that regrowth diminishes as harvests occur later in the growing season, perhaps because late harvests alter TNC storage more effectively.

King, J. J. The impact of drainage maintenance strategies on the flora of a low gradient, drained Irish salmonid river. Hydrobiologia. Vol. 340, no. 1-3, pp. 197-203. Dec 1996.In 1990, the Central Fisheries Board initiated research on how drainage maintenance practices and strategies might be modified to enhance the salmonid carrying capacity of the affected water while maintaining an acceptable degree of conveyance. Much of the maintenance requirement was caused by dense in-channel weed beds impeding discharge and facilitating siltation. The impact of various maintenance regimes on the aquatic flora was examined in the course of pilot studies on channels of base width 3-9 m. The findings from one of these, the R. Tullamore Silver which chokes annually with Sparganium erectum L., are presented. Overdigging the centre of the channel and placement of spoil at the margins confined S. erectum to a narrow marginal zone and facilitated development of a submerged, open-water flora.

Lazarek, S. Benthic microbial mats in acidified lakes. Svensk Botanisk Tidskrift. Vol. 81, no. 4, pp. 225-227. 1987.Underwater surveys were carried out from 1981 through 1985 in an acidified lake (Haestevattnet) in SW Sweden in order to evaluate long-term changes in benthic vegetation. The structure of benthic microbial mats and their expansion in acidified lake are discussed. It is likely that the decline of native isoetid vegetation in acidified lakes is linked to the expansion and persistence of benthic microbial mats.

Madsen, J. D. Waterchestnut seed production and management in Watervliet Reservoir, New York. Journal of Aquatic Plant Management [J. AQUAT. PLANT MANAGE.]. Vol. 31, pp. 271-272. 1993.Most waterchestnut (Trapa natans L.) control programs have found that traditional plant harvesting was largely unsuccessful (Elser 1966), although the states of New York and Vermont have maintained a long-term harvesting program of Lake Champlain (Countryman 1977). Recent efforts at the Watervliet Reservoir employed a high-speed cutting technique using an airboat. This study reports on the effectiveness of these cutting efforts to reduce the seed bank of the waterchestnut population in Watervliet Reservoir.

Mathis, M. J., and B. A. Middleton. Simulated Herbivory and Vegetation Dynamics in Coal Slurry Ponds Reclaimed as Wetlands. Restoration Ecology [Restor. Ecol.]. Vol. 7, no. 4, pp. 392-398. Dec 1999.The biodiversity of coal slurry ponds can be inhibited, at least in part, by dense stands of Phragmites australis. In this study, we demonstrate that species richness can be increased in coal slurry ponds if the dominant species (P. australis and Typha latifolia) are removed and that underwater herbivory simulated by cutting will kill emergents. The study was conducted in the greenhouse and the field in both flooded and drawndown conditions. Stems of plants of P. australis and T. latifolia were cut in a greenhouse and the cut plants of both species showed a decline in survivorship (25 and 42% survival, respectively) whereas all uncut plants survived. In a reclaimed coal pond at Pyramid State Park, Illinois, neither P. australis nor T. latifolia survived cutting underwater, but all of the uncut plants survived. Regrowth measured as total biomass of

stems was less among flooded versus freely drained plants (0.3 and 2.6 g biomass, respectively). Cut versus uncut plants, combining freely drained and flooded, had less below-ground biomass (99.4 and 254.4 g, respectively). In the greenhouse study, oxygen levels in rhizomes subsequent to cutting were measured using an oxygen electrode and millivolt meter. Oxygen levels in P. australis were lower in cut versus uncut plants both in flooded (15.0 vs. 16.3% ambient O sub(2), respectively) and freely drained conditions (14.5 vs. 15.0%, ambient O sub(2), respectively). Similar responses to cutting were demonstrated by T. latifolia. In an unreclaimed coal slurry pond with monospecific stands of P. australis, plant species richness increased in cut plots as compared to uncut plots (29 vs. 2 species, respectively) between March and September, 1995. This study demonstrated that species richness can be increased in coal ponds by mechanical cutting and this potentially by herbivory; however, the additional species were mostly exotics.

McCormick, P. V., and J. A. Laing. Effects of increased phosphorus loading on dissolved oxygen in a subtropical wetland, the Florida Everglades. Wetlands Ecology and Management [Wetlands Ecol. Manage.]. Vol. 11, no. 3, pp. 199-215. Jun 2003.The Florida Everglades is an oligotrophic, phosphorus (P)-limited wetland that is experiencing eutrophication as a result of P-enriched agricultural runoff. Effects of P enrichment on diel water-column dissolved oxygen concentration (DO) profiles were measured along nutrient gradients downstream of agricultural discharges in two northern Everglades marshes and in field enclosures (mesocosms) exposed to different P loading rates. Reference (i.e., water-column TP < 10 mu g/L) areas in the marsh interior were characterized by strong diel fluctuations in DO, and aerobic conditions generally were maintained throughout the diel cycle. Enriched stations (water-column TP elevated to between 12 and 131 mu g/L) were characterized by dampened diel fluctuations and reduced DO, and the extent of these changes was correlated strongly with marsh P concentrations. Mean DO declined from between 1.81 and 7.52 mg/L at reference stations to between 0.04 and 3.18 mg/L in highly enriched areas. Similarly, minimum DO declined from between 0.33 and 5.86 mg/L to between 0 and 0.84 mg/L with increasing enrichment, and the frequency of extremely low DO (< 1 mg/L) increased from between 0 and 20% to as high as 100% in the most enriched areas. Diel oxygen profiles in P-enriched mesocosms declined progressively with time; all loading treatments exhibited similar DO during the 1st year of P loading, but concentrations declined significantly at higher loads by year 3. Reductions in water-column DO with increased P enrichment were associated with reduced oxygen production by submersed periphyton and macrophytes and increased sediment oxygen demand. Increased emergent macrophyte cover in enriched areas likely contributed to these changes by shading the water-column, which inhibited submerged productivity, and by providing inputs of nutrient-rich detritus, which increased oxygen demand. Declines in marsh DO are associated with other ecological changes such as increased anaerobic metabolism and an increase in invertebrate taxa that tolerate low DO. While background oxygen concentrations in wetlands can be lower than those in lakes and rivers, declines in water-column DO caused by eutrophication can result in biological impacts similar to those in other aquatic ecosystems.

Mikol, G. F. Effects of harvesting on aquatic vegetation and juvenile fish populations at Saratoga Lake, New York. Journal of Aquatic Plant Management. Vol. 23, pp. 59-63. 1985.Mechanical harvesting conducted in June and August of 1981 and 1982 only

reduced total plant biomass initially, relative to control areas. Regrowth of the predominant species, Eurasian watermilfoil (Myriophyllum spicatum L.), reached pre-harvest levels within 30 days after both June and August harvestings. Total plant biomass in harvested areas peaked later than control area vegetation both years. The ratio of the average annual biomass of the harvested area to the control area was the same both years (0.73), despite significant decreases in overall average total plant biomass in 1982. The harvesting operation removed primarily bluegill sunfish (Lepomis macrochirus) and to a lesser degree, largemouth bass (Micropterus salmoides), yellow perch (Perca flavescens) and pumpkinseed sunfish (Lepomis gibbosus). Harvesting effectively removed approximately 3% of the total standing crop of juvenile fish in both June 1981 and 1982, and approximately 2 to 8% in August of both years.

Monahan, C., and J. M. Caffrey. The effect of weed control practices on macroinvertebrate communities in Irish canals. Hydrobiologia. Vol. 340, no. 1-3, pp. 205-211. Dec 1996.Macroinvertebrates in aquatic habitats form an integral part of the diet of many freshwater fish. It is therefore important to understand the effects that weed control practices have on this community in canal fishery watercourses. The principal forms of weed control operated in the Grand and Royal Canals include mechanical cutting, using a variety of boat-mounted and land-based apparatus, and chemical treatment using dichlobenil. The community composition and relative abundance of macroinvertebrates in control, mechanically cut and dichlobenil treated canal sites was recorded on three to five occasions between 1993 and 1994. The results indicated that Asellus aquaticus was the dominant organism at all canal locations. The land-based Mowing Bucket effected the greatest reduction in macroinvertebrate numbers in the immediate aftermath of the cut. This reflects the capacity of the machine to cut vegetation to canal bed level, thereby removing any substrate for colonisation. At all eight sites examined, macroinvertebrate numbers increased relatively rapidly following treatment and no adverse effect on dependent fish life resulted. The Office of Public Works policy of removing obstructive vegetation from a central navigation channel, while preserving weeded marginal fringes, minimises the impact of weed control operations on the macroinvertebrate fauna.

Murphy, K. J., A. M. Fox, and R. G. Hanbury. A multivariate assessment of plant management impact on macrophyte communities in a Scottish canal. Journal of Applied Ecology. Vol. 24, no. 3, pp. 1063-1079. 1987.A series of aquatic weed control trials was conducted in the Union Canal, Scotland (boat traffic < 500 boat movement per ha per year) during 1977-84. The data were used to test the suitability of a multivariate approach for assessing the impacts of plant management on canal macrophyte communities. The procedures detrended correspondence analysis (DCA), and two-way indicator species analysis (TWINSPAN), revealed some fairly subtle trends of plant community change. These were related to the environmental impacts of weed control by herbicides and cutting, and (in a few cases) to shading of submerged macrophytes by accumulations of surface-floating plants.

Nichols, S. A., and R. C. Lathrop. Impact of harvesting on aquatic plant communities in Lake Wingra, Wisconsin. Journal of Aquatic Plant Management [J. AQUAT. PLANT MANAGE.]. Vol. 32, pp. 33-36. 1994.An area in Lake Wingra with a history of mechanical harvesting was compared to other areas in the lake with no known management history. Although species diversity and taxa richness in three out of four

unharvested areas were greater than in the harvested area, no differences in diversity or plant biomass could be attributed solely to the harvesting regime. Differences appeared to be more closely related to an increase in coontail (Ceratophyllum demersum L.) growth after the Eurasian watermilfoil (Myriophyllum spicatum L.) decline of the mid-1970s. Besides Eurasian watermilfoil and coontail, curlyleaf pondweed (Potamogeton crispus L.), northern watermilfoil (M. sibiricum Komarov), and sago pondweed (P. pectinatus were important members of the vegetation.

Odland, A. Development of vegetation in created wetlands in western Norway. Aquatic Botany [AQUAT. BOT.]. Vol. 59, no. 1-2, pp. 45-62. Nov 1997.The Myrkdalen Lake, western Norway was subjected to a permanent 1.4 m drawdown in June 1987. After the drawdown, channels and artificial islands were constructed within the exposed floodplain system. Two permanent transects were established within this man-made environment, and these have been analyzed annually until 1995. The quadrats lie all on the same type of substrate, are at different elevations in relation to the water-level. This paper describes vegetation development on these newly created islands. The investigation shows major vegetational changes during the eight year period. Two main processes have taken place, vegetation zonation and primary succession. The first year after the construction, most of the created sites had a similar floristic composition, regardless of elevation. Major dominants during the first three years (e.g., Subularia aquatica, Marchantia polymorpha, Blasia pusilla, and numerous acrocarpous mosses) disappeared or were greatly reduced, and they were gradually replaced by species which were climax species in the wetland communities before the drawdown (e.g., Carex rostrata, C. vesicaria, Phalaris arundinacea, Salix nigricans). The main vegetational change occurred between the third and the fourth year. After three years characteristic vegetation zones were differentiated, with aquatic plants and helophytes in the lowermost parts, and willow shrubs in the uppermost parts of the islands.

Olson, M. H., S. R. Carpenter, P. Cunningham, S. Gafny, B. R. Herwig, N. P. Nibbelink, T. Pellett, C. Storlie, A. S. Trebitz, and K. A. Wilson. Managing macrophytes to improve fish growth: A multi-lake experiment. Fisheries [FISHERIES]. Vol. 23, no. 2, pp. 6-12. Feb 1998.Macrophyte harvesting often has been suggested as a way to improve fish growth and size structure in lakes with high densities of submergent macrophytes and stunted fish populations. However, previous experimental tests have provided no clear consensus on whether the technique works for management. We conducted a series of whole-lake manipulations to test the effects of macrophyte removal on growth of bluegill and largemouth bass. We selected four lakes in southern and central Wisconsin for experimental manipulation and nine others for controls. In August 1994, we removed macrophytes from approximately 20% of the littoral zone by cutting a series of evenly spaced, deep channels throughout each treatment lake. In the first year after manipulation, we observed substantially increased growth rates of some age classes of both bluegill and largemouth bass in treatment lakes relative to controls. Growth rates of other age classes were less responsive to manipulation. We observed increased bluegill and largemouth bass growth despite rapid regrowth of macrophytes in our treatment lakes. By May 1996, fewer than 25% of the channels remained. Our results suggest that harvesting macrophytes in a series of deep channels may be a valuable tool for integrated management of fish and macrophytes.

Peterson, S. A. Lake Restoration by Sediment Removal. Water Resources Bulletin [WATER RESOUR. BULL.]. Vol. 18, no. 3, pp. 423-435. 1982.Fresh water lake sediment removal is usually undertaken to deepen a lake and increase its volume to enhance fish production, to remove nutrient rich sediment, to remove toxic or hazardous material, or to reduce the abundance of rooted aquatic plants. Review of more than 60 projects and five case histories reveals that the first three objectives are usually met through sediment removal. The technique is recommened for deeping and for long range reduction of phosphorus release from sediment. Sediment removal to control toxic materials is possible with minimal environmental impact when proper equipment is used, but it may more than double the cost. Lack of definitive information about rooted plant regrowth rates in dredged areas prohibits explicit recommendations on sediment removal to control plant growth.

Ramaprabhu, T., P. Kumaraiah, S. Parameswaran, P. K. Sukumaran, and S. L. Raghavan. Waterhyacinth control by natural water level fluctuations in Byramangala Reservoir, India. Journal of Aquatic Plant Management. Vol. 25, pp. 63-64. 1987.A case of how natural drawdown and sudden flooding brought about the control of waterhyacinth (Eichhornia crassipes) in the tropical Byramangala reservoir in Karnataka State, India, while studying the role of the plants in the abatement of pollution through the uptake of heavy metals, pesticides and detergents discharged into the reservoir by several industries in Bangalore is reported in this communication.

Reaves, R. P., and M. R. Croteau-Hartman. Biological aspects of restored and created wetlands. Proceedings of the Indiana Academy of Science. Vol. 103, no. 3-4, pp. 179-194. 1994.Wetland biology typically is hydrologically driven. The hydrology of created and restored wetlands frequently differs from that of natural systems, and the resulting floral and faunal composition of the wetland may also differ. In general, restored wetlands are more similar to natural wetlands than are created wetlands, and the biota of restored wetlands will more closely resemble that of natural wetlands. Created wetlands vary greatly from natural wetlands in both the hydroperiod and the quality of the water moving through them. Consequently, created wetlands are often biologically quite distinct from natural wetlands. Substantial efforts to restore wetlands throughout the United States have been taking place since the mid-1980s. The goals of wetland restoration are to 1) improve water quality, to 2) control stormwater, and to 3) provide habitat for a variety of plants and animals. Numerous species of plants and animals, including many endangered or threatened species, are dependent upon wetland habitats. Following restoration of the hydrologic regime, native aquatic plants return to restored wetlands within one year. As the water regime and plant cover become established, the wetlands are colonized by a variety of animals, including aquatic invertebrates. Use of the wetland system by wildlife is directly related to the size of the wetland, but distance between wetlands may affect the occurrence of taxa that have restricted dispersal ability. Unlike most natural wetlands, artificially created wetlands may have constant water regimes that can influence the floral composition of the system. Wetland plants that need periods of drawdown are often eliminated with time. The biology of wetlands created for wastewater treatment is also greatly influenced by influent water quality. Wastewater often contains high levels of organics and ions that stress both the plants and the animals. If the system is used for the primary or secondary treatment of wastewater, the invertebrate assemblage will shift to pollution-tolerant species. Even created wetlands

utilized for tertiary wastewater treatment may be subjected to water of lower quality than natural wetlands, and they may experience a lesser shift toward pollution-tolerant species. However, increased nutrient inputs can lead to greater productivity in wastewater treatment wetlands than is found in comparable natural wetlands. Wildlife and avian use of constructed wetlands are directly related to the size of the facility. Large systems attract a greater diversity of birds. These treatment systems may provide major bird-watching areas for the people they serve. Large waste treatment wetlands also harbor significant numbers of amphibians, reptiles, and wetland-utilizing mammals. Small wetlands that serve only a single family farm will be utilized less by wildlife but can still provide usable habitat.

Richardson, S. M., J. M. Hanson, and A. Locke. Effects of impoundment and water-level fluctuations on macrophyte and macroinvertebrate communities of a dammed tidal river. Aquatic Ecology [Aquat. Ecol.]. Vol. 36, no. 4, pp. 493-510. Dec 2002.A freshwater headpond was created in 1968 when a causeway was built across a tidal portion of the Petitcodiac River, New Brunswick, Canada. In the 32-year history of this tidal barrier, there have been numerous water-level drawdowns to manage risk of flooding (relatively minor and of short duration) and to permit passage of anadromous fishes past the dam structure (often of several weeks duration). Following five years of routine management to prevent flooding, there were three major water-level drawdowns that fully exposed the littoral zone to air for varying lengths of time during the spring of 1997 (7 days), 1998 (19 days), and 1999 (55 days). The 1998 and 1999 drawdowns resulted in significant decreases in biomass of macrophytes and benthic macroinvertebrates in the littoral and sublittoral zones, compared to 1997. The largest decrease occurred between 1997 and 1998 when populations of most species were largely eliminated. The remaining species were those resilient to prolonged exposure to the atmosphere. The only macrophyte to increase in biomass over the three years was Polygonum lapathifolium, which formed impenetrable mats in 1999. Hexagenia limbata in the sublittoral zone was the only benthic invertebrate species to increase in biomass. The age distribution of the eastern floater (Pyganodon cataracta) population suggested that a major drawdown accompanied by salt-water intrusion had eliminated the entire freshwater community in 1988. The goals of allowing passage of anadromous fishes past the dam structure and the development of a stable, artificial, freshwater-lake community appear to be incompatible.

Robinson, G. G. C., S. E. Gurney, and L. G. Goldsborough. Response of benthic and planktonic algal biomass to experimental water-level manipulation in a prairie lakeshore wetland. Wetlands. Vol. 17, no. 2, pp. 167-181. Jun 1997.The quantitative contribution of benthic (periphytic) and planktonic algae to primary production in prairie wetlands is largely unknown, as is their response to the fluctuations in water level that characterize such systems. We measured the biomass (chlorophyll-a m super(-2) of wetland area) of phytoplankton, epipelon, epiphyton, and metaphyton in Delta Marsh, Manitoba as part of a five-year study in which diked, drawn down cells were reflooded to the normal level of the wetland, or to a depth 30 cm or 60 cm deeper. Our objective was to investigate the effects of flooding depth on algal biomass and the relative contributions by each of the four algal assemblages. Floating metaphyton mats flourished in all cells after flooding, contributing about 87% of total algal biomass. Epiphytes contributed 11% of biomass, and epipelon and phytoplankton each contributed 1%. Emergent macrophyte density was

reduced by flooding, leading to increases in open water area. The wetland cells changed gradually over the study period from an early "open wetland" to a "sheltered wetland." In late stages of the study, phytoplankton became more abundant as the cells proceeded to a "lake wetland" state.

Rozas, L. P., and T. J. Minello. Effects of structural marsh management on fishery species and other nekton before and during a spring drawdown. Wetlands Ecology and Management [Wetlands Ecol. Manage.]. Vol. 7, no. 3, [vp]. Sep 1999.We sampled experimental research areas in the Barataria Basin of Louisiana, USA to examine the effects of structural marsh management on habitat use by small nekton (< 100 mm Total Length or Carapace Width). The research areas consisted of two control (unmanaged) marshes and two impounded (managed) marshes; managed areas were surrounded by levees with water-control structures constructed by the U.S. Department of Interior, National Biological Survey. We sampled nekton with 1-m super(2) enclosure samplers in 1995 just as a drawdown was initiated (March) and after two months of drawdown (May); a drawdown is an active management technique in which water is allowed to flow out of, but not back into, the impoundment. Samples were collected randomly from all available habitat types (shallow open water, submerged aquatic vegetation (SAV), and intertidal marsh) in the managed and unmanaged areas. In March, the densities of resident taxa (e.g., Lucania parva rainwater killifish and Palaemonetes paludosus riverine grass shrimp), which complete their life cycles within the estuary, were significantly greater in the managed areas compared to the unmanaged areas.

Ruley, J. E., and K. A. Rusch. An assessment of long-term post-restoration water quality trends in a shallow, subtropical, urban hypereutrophic lake. Ecological Engineering [Ecol. Eng.]. Vol. 19, no. 4, pp. 265-280. Oct 2002.City Park Lake is a shallow urban hypereutrophic lake located in Baton Rouge, Louisiana, with a surface area of 0.23 km super(2) and a mean depth of 1.2 m. By the late 1970s, the lake had become highly eutrophic and suffered from frequent and severe algal blooms and fish kills. A major restoration effort was undertaken in 1983 that consisted of dredging and the repair of sewage infrastructure. Immediate improvements in water quality were observed following restoration; algal blooms and fish kills were virtually eliminated for nearly a decade. However, large floating mats of filamentous algae periodically occurred during the early 1990s. Results of a water quality sampling program conducted in 2000 and 2001 indicated that phosphorus has once again reached pre-restoration levels, and nitrogen levels have decreased well below those observed during pre-restoration years. Whereas phosphorus-limited conditions predominated in the years preceding the 1983 restoration, results of the 2000-2001 sampling program indicate that the lake has become nitrogen-limited with respect to photosynthetic activity. This trend in nutrient levels has likely influenced the recent predominance of filamentous over unicellular species of algae observed during the last decade. Nearly 4 years of drought-like conditions beginning in 1998 have resulted in an overall increase in the hydraulic retention time of the lake. This condition has resulted in organic staining of the lake waters, or the development of a tea-like color due to the decomposition of organic compounds. This phenomenon has played a major role in inhibiting the sunlight available for filamentous algal growth since 1998 and the absence of filamentous algae during the 2000-2001 sampling program.

Sabbatini, M. R., and K. J. Murphy. Submerged plant survival strategies in relation to management and environmental pressures in drainage channel habitats. Hydrobiologia.

Vol. 340, no. 1-3, pp. 191-195. Dec 1996.The abundance of submerged weeds, in relation to management regime and environmental factors, was surveyed during 1992 and 1993 in drainage channels located in four geographically-distinct areas of Britain. The aim of the study was to ascertain, using a multivariate approach, the degree to which species survival strategy and vegetation could be related to disturbance and stress pressures on plant survival. Indices of disturbance and stress were constructed from combined environmental data for each site. A species ordination using Canonical Correspondence Analysis showed that the combined disturbance variable explained more of the variability that did stress. Two main groups of species could be distinguished. The larger group scored low on the disturbance gradient and these species, with different tolerances to stress (especially light-limitation), appeared to be those better-adapted to habitats with low disturbance (e.g. Potamogeton pectinatus and Potamogeton lucens). The smaller group comprised species which tended to occur in sites with higher disturbance (e.g. regular cutting) such as Callitriche stagnalis. Using the terminology of strategy theory, most of the dominant species could be classed as 'competitive/disturbance tolerators (CD)' or variants of this established-phase strategy. The limitations are discussed of applying the strategy approach at species level in a defined habitat-type which shows a high degree of uniformity between sites, such as artificial drainage channels.

Sagova-Mareckova, M. Interactions between crayfish, benthic invertebrates, macrophyte roots and sediment in a littoral zone. Archiv fuer Hydrobiologie [Arch. Hydrobiol.]. Vol. 155, no. 4, pp. 645-665. Nov 2002.The littoral zone is subject to both top-down and bottom-up control. In an experiment in Trout Lake, Wisconsin, plant roots were seen to be the central component of interactions with crayfish and macrobenthos. Consequently, crayfish predation and feeding of benthic macroinvertebrates were examined with respect to the presence or absence of plant roots. Six sets of three cages, 1 without crayfish, 1 with three times natural crayfish number (6 ind. per m super(2)) and 1 wall-less reference were placed on lake bottom in the littoral zone. Each cage was divided to halves with the benthos in one half being fed and not being fed in the other half. Each half was further halved to two quarters with macrophytes in one quarter being cut in the other not being cut. Three samples of macrobenthos were taken from each quarter in July and August 1991. Crayfish impact on benthic organisms was significant in August regardless of the presence or absence of plant roots. Feeding significantly influenced chironomid size in July, also without any interaction with plant roots. Macrophyte cutting negatively affected invertebrate abundance and it was significant both in July and August. The results confirmed the importance of plant roots for invertebrates abundance. Presence of live plant roots seemed to be an important factor for structuring the benthic invertebrate community apart from the well-known effects of feeding and predation.

Scheffer, M. The effect of aquatic vegetation on turbidity; how important are the filter feeders? Hydrobiologia [Hydrobiologia]. Vol. 408/409, pp. 307-316. Aug 1999.A review of the literature suggests that aquatic macrophytes can enhance water clarity and reduce phytoplankton biomass through shading, reduction of nutrient availability, excretion of allelopathic substances and reduction of resuspension. In addition, vegetation fields are reported to enhance grazing on phytoplankton by providing a day-time refuge against fish predation for planktonic filter feeders such as Daphnia and by providing a suitable habitat for macrophyte associated filter feeders such as Sida crystallina, Eurycercus lamellatus

and Simocephalus velutus. I use a graphical and a simple mathematical model to explore how top-down control by these grazers may interact with the effect of reduced phytoplankton production due to the other factors mentioned. The analysis suggests that grazing tends to be an all-or-none effect, driving phytoplankton to a very low biomass once a certain threshold level of grazing pressure is exceeded. This threshold level is predicted to increase with the productivity of the phytoplankton. Thus, the model suggests that, in plant beds, productivity reducing factors such as shading and reduced nutrient concentrations can pave the way for top-down control of phytoplankton even by a relatively moderate population of filter-feeders, and that phytoplankton biomass will decrease sharply beyond a critical macrophyte (or grazer) density. Indeed such a discontinuous response is observed in field experiments. Also, the idea that filter feeding cladocerans such as Daphnia play a key role is in line with the observation that brackish lakes where Daphnia does not thrive tend to be turbid despite the often dense weed beds.

Scheffer, M., S. Szabo, A. Gragnani, E. H. Van Nes, S. Rinaldi, N. Kautsky, J. Norberg, R. M. M. Roijackers, and R. J. M. Franken. Floating plant dominance as a stable state. Proceedings of the National Academy of Sciences, USA [Proc. Natl. Acad. Sci. USA]. Vol. 100, no. 7, pp. 4040-4045. 1 Apr 2003.Invasion by mats of free-floating plants is among the most important threats to the functioning and biodiversity of freshwater ecosystems ranging from temperate ponds and ditches to tropical lakes. Dark, anoxic conditions under thick floating-plant cover leave little opportunity for animal or plant life, and they can have large negative impacts on fisheries and navigation in tropical lakes. Here, we demonstrate that floating-plant dominance can be a self-stabilizing ecosystem state, which may explain its notorious persistence in many situations. Our results, based on experiments, field data, and models, represent evidence for alternative domains of attraction in ecosystems. An implication of our findings is that nutrient enrichment reduces the resilience of freshwater systems against a shift to floating-plant dominance. On the other hand, our results also suggest that a single drastic harvest of floating plants can induce a permanent shift to an alternative state dominated by rooted, submerged growth forms.

Shireman, J. V., D. E. Colle, and D. E. Canfield, Jr. Efficacy and cost of aquatic weed control in small ponds. Water Resources Bulletin. Vol. 22, no. 1, pp. 43-48. 1986.Twenty, 0.2 hectare ponds were utilized for a four-year evaluation of three aquatic vegetation control techniques: a combination of inorganic fertilization and mechanical harvesting, aquatic herbicides, and grass carp (Ctenopharyngodon idella). Vegetation levels were maintained for less than 30 days after mechanical harvesting. Submersed mascrophytes were not completely eliminated with herbicides, but the herbicide treatments utilized were effective at maintaining aquatic vegetation above 30 percent pond volume occupation. Grass carp consumed all species of submersed vegetation at the stocking densities used in this study. Fertilization costs were $608/hectare/year, and mechanical harvesting costs were $1979/hectare/year, resulting in a total aquatic vegetation treatment cost of $2587/hectare/year. Herbicide costs for the different treatment levels ranged from $417/hectare/year to $1339/hectare/year over the four-year period. Grass carp were the most economical vegetation control measure tested, with costs ranging from $159/hectare/year to $248/hectare/year for the four-year study.

Stokes, P. M. Ecological effects of acidification of primary producers in aquatic systems. Water, Air, & Soil Pollution [WATER AIR SOIL POLLUT.]. Vol. 30, no. 1-2. 1986.For

each of the aquatic communities of the phytoplankton, the periphyton and the macrophytes, recent studies of community structure related to acidification are reviewed. While biomass and productivity do not generally decrease, there are rather consistent decreases in species richness and profound changes in species composition as pH decreases. Implications for the aquatic ecosystem as a result of these structural changes include loss of resilience in the plant communities, habitat effects related to excessive growth of periphyton and macrophytes, modification of nutrient cycling by the benthic mats, and alteration of the food base for grazers.

Sundblad, K. The effects of cutting frequency on natural Glyceria maxima stands. Aquatic Botany. Vol. 37, no. 1, pp. 27-38. 1990.Reed sweetgrass, Glyceria maxima , is potentially suitable for concomitantly accomplishing wastewater nutrient removal and biomass production. Effects of two different harvest frequencies on shoot and rhizome growth during 2 consecutive yrs were investigated in 2 fertilized natural stands. 3 Plots (20 and 24 m super(2)) were used in each stand and were treated as follows: unharvested; 2 harvests/yr; or 3 harvests/yr. Harvesting 2 or 3 times/yr affected the stands to about the same degree. The harvested biomass was significantly lower in Year 2 with 60 and 75% of that in the first year. In the harvested stands the rhizome biomass decreased significantly during the 1st yr. There was a strong relationship between the amount of non-structural carbohydrates stored in the rhizomes in Nov of Year 1 and the number of shoots with basal diam > 5 mm in Jun of Year 2. Results imply that harvesting G. maxima) either 2 or 3 times/season will cause a decrease in shoot biomass even in highly productive stands. A sustained high biomass yield may be promoted by continuous application of nutrients.

Thomas, J. D., and P. W. G. Daldorph. Evaluation of bioengineering approaches aimed at controlling pulmonate snails: The effects of light attenuation and mechanical removal of macrophytes. Journal of Applied Ecology. Vol. 28, no. 2, pp. 532-546. 1991.The effects of the following perturbations on populations of freshwater gastropods were investigated experimentally: light exclusion with black polythene; introduction of the floating plant Hydrocharis morsus-ranae ; and mechanical removal of macrophytes. Experiments were conducted in enclosures (3 multiplied by 5 x 2 m), positioned along the margin of a drainage channel. Although the two treatments involving shading with black polythene and mechanical removal resulted in the virtual disappearance of the macrophytes, their effects on the physicochemical environment were very different. The structure of the remaining plant community was unaffected by the introduction of H. morsus-ranae . The total numbers of Bithynia tentaculata, Lymnaea peregra and Physa fontinalis , as well as their population densities in the inner zone of the enclosures were significantly reduced in the black polythene treatment, compared with the controls.

Ussery, T. A., H. L. Eakin, B. S. Payne, A. C. Miller, and J. W. Barko. Effects of Benthic Barriers on Aquatic Habitat Conditions and Macroinvertebrate Communities. Journal of Aquatic Plant Management [J. Aquat. Plant Manage.]. Vol. 35, pp. 69-73. Jul 1997.Physical and chemical conditions of sediments and benthic community composition were evaluated under synthetic fabric barriers, used to control aquatic macrophytes in confined areas. Macroinvertebrate density declined by 69% within 4 weeks at Eau Galle Reservoir, WI. Within a few weeks of placement at ponds near Dallas, TX, invertebrate densities declined by more than 90%. At Eau Galle Reservoir, benthic barriers apparently blocked sedimentation and caused an increase in NH sub(4) and a decline in dissolved

oxygen to near zero beneath the fabric. Barriers reduced macroinvertebrate taxa richness at both locations. Community effects were most severe in warm water; Chironomidae was eliminated by barriers at the Texas ponds. Barriers substantially reduced macroinvertebrate density and altered community composition; however, biotic conditions in affected areas recovered rapidly after barrier removal.

van Dijk, G. M., and W. van Vierssen. Survival of a Potamogeton pectinatus L. population under various light conditions in a shallow eutrophic lake (Lake Veluwe) in The Netherlands. Aquatic Botany. Vol. 39, no. 1-2, pp. 121-129. 1991.In Lake Veluwe, an eutrophicated shallow lake in The Netherlands, light conditions significantly affected the total biomass production of a Potamogeton pectinatus vegetation. A negative correlation was recorded between the annual biomass production and the mean daily photon flux densities in an experimental setup in which the photon flux densities were experimentally manipulated (four different levels of artificial shading) and the photoperiod was relatively unaffected. At the lowest mean photon flux density, the maximum total biomass was reached earlier in the growing season (end of Jun) than at the other photon flux densities (mid-Aug). Tuber production started at the same time in all conditions (mid-Jun). The number of tubers produced per gram ash-free dry weight of above-ground biomass was highest for the conditions with the lowest mean daily photon flux density. However, the total number of tubers per square metre recorded at the end of the growing season was highest for the control (no artificial shading).

Wilcock, R. J., M. R. Scarsbrook, J. G. Cooke, K. J. Costley, and J. W. Nagels. Shade and flow effects on ammonia retention in macrophyte-rich streams: implications for water quality. Environmental Pollution [Environ. Pollut.]. Vol. 132, no. 1, pp. 95-100. Nov 2004.Controlled releases of NH sub(4)-N and conservative tracers (Br super(-) and Cl super(-)) to five reaches of four streams with contrasting macrophyte communities have shown differing retentions, largely as a result of the way plants interact with stream flow and velocity. First-order constants (k) were 1.0-4.8 d super(- 1) and retention of NH sub(4)-N was 6-71% of amounts added to each reach. Distance travelled before a 50% reduction in concentration was achieved were 40-450 m in three streams under low-flow conditions, and 2400-3800 m at higher flows. Retention (%) of NH sub(4)-N can be approximated by a simple function of travel time and k, highlighting the importance of the relationship between macrophytes and stream velocity on nutrient processing. This finding has significant management implications, particularly with respect to restoration of riparian shade. Small streams with predominantly marginal emergent plants are likely to have improved retention of NH sub(4)-N as a result of shading or other means of reducing plant biomass. Streams dominated by submerged macrophytes will have impaired NH sub(4)-N retention if plant biomass is reduced because of reduced contact times between NH sub(4)-N molecules and reactive sites. In these conditions water resource managers should utilise riparian shading in concert with unshaded vegetated reaches to achieve a balance between enhanced in-stream habitat and nutrient processing capacity.

Wilcock, R. J., M. R. Scarsbrook, K. J. Costley, and J. W. Nagels. Controlled release experiments to determine the effects of shade and plants on nutrient retention in a lowland stream. Hydrobiologia [Hydrobiologia]. Vol. 485, no. 1-3, pp. 153-162. Oct 2002.Understanding nutrient uptake and retention in streams remains an important challenge for lotic scientists. In this study a series of pulse and continuous releases of

dissolved nutrients were made to shaded and unshaded (reference) reaches of a small lowland stream to determine whether suppression of macrophyte growth by riparian shade impaired nutrient retention. The nutrients were dissolved reactive phosphorus (DRP), total ammoniacal nitrogen (NH sub(4)-N) and nitrate nitrogen (NO sub(3)-N). Nutrient reductions ranged from 100% of DRP when stream water was anoxic, to 5-10% for NH sub(4)-N and NO sub(3)-N in the reference reach. Nutrient removals were affected by travel times in each reach. Percentage removals of NH sub(4)-N (46 plus or minus 10) and NO sub(3)-N (52 plus or minus 14) were higher in the shaded reach than in the swifter moving reference reach (15 plus or minus 8 and 16 plus or minus 10, respectively). DRP (%) removals were 75 plus or minus 7 and 57 plus or minus 12 for the shaded and reference reaches, respectively. The presence of emergent marginal macrophytes (Persicaria hydropiper) increased stream velocity in the reference reach by reducing the effective channel cross-section area. Shading reduced plant biomass, increased the channel cross-section and lowered velocity in the experimental reach, effecting dramatic reductions in nutrient concentrations over short distances. The opposite effect is more typical for larger, swifter streams having dense stands of submerged macrophytes, where lowering channel plant biomass will cause increased velocities and lower relative nutrient losses. Riparian shade does not necessarily impair nutrient uptake from small streams. Where invasive marginal species such as P. hydropiper dominate headwater streams shade may be beneficial to the protection of downstream waters from eutrophication. Where reduction of nutrient fluxes from small streams is a key objective for protection of downstream waters, active management of streams should seek to increase travel times, allowing greater potential for nutrient uptake. This will need to be weighed against the need for effective drainage in pastoral areas where reduced travel times are usually sought.

Wright, J. F., R. T. Clarke, R. J. Gunn, J. M. Winder, N. T. Kneebone, and J. Davy-Bowker. APPLIED ISSUES: Response of the flora and macroinvertebrate fauna of a chalk stream site to changes in management. Freshwater Biology [Freshwat. Biol.]. Vol. 48, no. 5, pp. 894-911. May 2003.Temporal changes in a series of habitats and their macroinvertebrate assemblages were examined on a 50-m section of a chalk stream in Berkshire, England between June 1975-79 and June 1997-2001.The site was part of a trout fishery in 1975-79, when river management included instream weed cutting together with control of bankside trees and riparian vegetation. Management ceased in the 1980s and by 1997-2001, the site was heavily shaded by trees and riparian vegetation.The mean area of instream macrophytes decreased by 50% between the first and second sampling period. In contrast, gravel and silt increased and invading marginal vegetation formed a new habitat.Changes in macroinvertebrate family richness between sampling periods were scale dependant. Although there were, on average, significantly more families in individual replicates in 1975-79 than in 1997-2001, total family richness for the site in each year did not differ significantly between sampling periods.Sixty families of macroinvertebrates were recorded during the study, 50 in both sampling periods, 53 in 1975-79 and 57 in 1997-2001. This small increase in site family richness may be due to the invading marginal plants.Total macroinvertebrate abundance was significantly lower in the second sampling period. A major drought in 1976 resulted in significantly higher densities of macroinvertebrates, partly through the exploitation of epiphytic diatoms by chironomid larvae. A drought in 1997 failed to elicit a similar response because of the

limited macrophytes and diatoms under heavy shading by trees and marginal vegetation.Significant increases in important shredders and decreases in some scrapers between the early and later sampling years largely reflected changes in available food resources.Whereas macroinvertebrate family richness has been conserved under the recent 'no management' regime, the site is now less attractive as a fishery because of poor access and lower densities of some macroinvertebrates taken by brown trout.