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Status of Aquatic Vascular Plants in Iowa's Natural Lakes

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Conversion of wetlands to agricultural land during the settlement of Iowa has resulted in a significant decline in the total area of lake habitat in the state. This reduction in area, combined with the degradation of remaining sites, resulted in dramatic reductions in aquatic vascular plant populations associated with Iowa's natural lakes. While declines in plant species inhabiting fen, bog, seepage, prairie pothole, and marsh type wetlands have been extensively documented, few quantitative data exist for lake type wetlands. During the summer of 1996, a total of 86 natural lakes in Iowa were surveyed for aquatic vascular plants. Many of the lakes surveyed exhibited sparse populations of aquatic macrophytes and extremely low species diversities. Data were compared with research conducted in 1915 by Pammel for the Iowa State Highway Commission, and declines in species richness were noted for 12 of the 15 lakes compared. Possible causes for the decline in aquatic macrophytes in Iowa lakes are included.

INDEX DESCRIPTORS: aquatic macrophytes, aquatic vascular plants, Iowa wetlands.

Aquatic vascular plants represent an addition to the various forms of flora and fauna that were addressed by the 1980 Iowa Academy of Science symposium on Iowa's declining flora and fauna. During that symposium, only brief remarks were made concerning the status of this floristic group (Bishop 1981). For this reason, it is appropriate to begin consideration of the aquatic vascular plants of Iowa's lakes with a short introduction concerning the general status of hydrophytic plants in Iowa. A complete listing of Iowa's hydrophytic plants can be found in Lammers and van der Valk (1977, 1978).

Iowa's hydrophytic plants can be grouped into three general categories based on the habitat type in which they are found. These groups include fen, bog, and other seepage wetland species; marsh and prairie pothole wetland species; and lake, pond, and riverine wetland species. While this is a somewhat arbitrary classification system, it works well for the purpose of evaluating the current status of hydrophytic plants in Iowa.

Fen, bog, and other seepage wetland habitats have always been uncommon in Iowa. While the total presettlement acreage is unknown, it was probably less than several thousand acres (Anderson 1996). Due to the limited occurrence of fen, bog, and other seepage wetland habitats in presettlement Iowa, site specific species were never abundant. With the settlement of Iowa, many of these sites have been severely degraded or destroyed, resulting in the loss of populations of already uncommon plant species. Because of this fact, 37 species from these habitats were originally listed by Roosa and Eilers (1978) as threatened, endangered, or extirpated in Iowa. Despite postsettlement degradation and loss of this habitat type, quality sites such as Silver Lake Fen in Dickinson County and Dead Man's Lake at Pilot Knob State Park in Winnebago and Hancock Counties still remain today with rich and diverse floral communities. Due to the unique nature of fen, bog, and seepage wetland habitats and the highly specialized flora that inhabit them, these wetlands have been extensively studied and the status of the hydrophytic plants associated with them has been well documented (Pearson and Leoschke 1992). The future of the plants inhabiting these types of wetlands depends on the protection, management, and prevention of loss of remaining sites. This is critical as the potential for restoration of fen, bog, and seepage wetlands is extremely low.

In contrast, marsh and prairie pothole wetland habitats were more common in presettlement Iowa. Records from county surveys conducted from 1832 to 1859 indicated 484,782 acres of this type of habitat (Anderson 1996). However, because many small marshes and wet prairie areas were not mapped during these surveys; this acreage value was no doubt underestimated. Bishop and van der Valk (1982) placed the area estimate at 2,000,000 acres which represented a more likely total. Conversion of these wetlands to agricultural lands significantly reduced the total area of marsh and prairie potholes in Iowa. Bishop (1981) estimated that only 15,651 acres of prairie marshes and 5,365 acres of lake marshes remained in the early 1980s. Despite the extensive destruction of this habitat type, quality sites still can be found in Iowa in areas such as the Spring Run wetland complex in Dickinson County and the Dewey's Pasture wetland complex in Clay and Palo Alto Counties. While many of the site specific species inhabiting these wetlands were initially abundant, habitat loss dramatically reduced their numbers. Roosa and Eilers (1978) listed 34 of these species as threatened, endangered, or extirpated in Iowa. Because these wetlands were directly associated with Iowa's prairie habitats, they were typically surveyed as part of floristic studies of prairie vegetation. For this reason, the status of the hydrophytic plants inhabiting these wetlands has been well documented. The future of these habitats and the hydrophytic plants associated with them depends on the protection, management, and prevention of loss of remaining sites. There is, however, a moderate to high potential for restoration. As a result of federal and state wetland restoration programs initiated in the 1980s, the number of restored wetland acres in this category has already shown significant gains (Iowa Department of Natural Resources 1988). Restored wetlands typically lack the richness and diversity of natural marsh and prairie pothole wetlands. However, with concerted seeding and transplanting activities, the potential exists for more complete recovery.

Iowa's lake and pond wetland habitats had limited distribution in presettlement Iowa but were not uncommon, especially in the northwestern and north-central portions of the state. Furthermore, lake and riverine habitats were frequent along both the Mississippi and Missouri Rivers that border the state. Anderson (1996) showed

Table 1. Aquatic vascular plants associated with lake habitats listed as endangered, threatened, or extirpated in Iowa by Roosa and Eilers (1978).

FAMILY	SPECIES	COMMON NAME	STATUS
Acanthaceae	*Justicia americana*	Water-willow	Endangered
Asteraceae	*Megalodonta beckii*	Water marigold	Endangered
Brassicaceae	*Armoracia aquatica*	Lake cress	Extirpated
Callitrichaceae	*Callitriche heterophylla*	Water starwort	Threatened
Haloragaceae	*Myriophyllum heterophyllum*	Water milfoil	Extirpated
Hydrocharitaceae	*Vallisneria americana*	Tape-grass	Endangered
Nymphaeaceae	*Brasenia schreberi*	Water shield	Endangered
Poaceae	*Zizania aquatica*	Wild rice	Threatened
Pontederiaceae	*Heteranthera limosa*	Mud plantain	Endangered
Potamogetonaceae	*Potamogeton amplifolius*	Large-leaved pondweed	Threatened
	Potamogeton praelongus	White-stemmed pondweed	Threatened
	Potamogeton vaseyi	Vasey's pondweed	Threatened

64,041 acres of lake habitat, 18,726 acres of pond habitat, and 3,990 acres of riverine habitat. Based on these estimates, Iowa had approximately 87,000 acres of lake, pond, and riverine type habitat at the time settlement began. Today, 32,058 acres of lake habitat remain (Bachmann et al. 1980). These figures indicated a postsettlement habitat loss of over 50%. Because of extensive alteration of the remaining habitats, few, if any, quality sites remain. The future of these remaining sites depends on the prevention of further degradation. However, because of economic and recreational concerns, reversal of this decline is unlikely.

At the time of settlement, most habitat specific species were initially abundant (Iowa State Highway Commission 1917). However, the status of hydrophytic plants in Iowa's lakes has never been adequately documented and remains poorly understood today. Probably the best source of information available was prepared by Pammel as part of a statewide study of lakes and lake beds (Iowa State Highway Commission 1917). Roosa and Eilers (1978) listed only 12 species of hydrophytic plants associated with lakes as threatened, endangered, or extirpated in Iowa (Table 1), but further study of the hydrophytic plants inhabiting Iowa's lakes would undoubtedly result in an increase in the number of state listed species.

In Iowa, there are over 400 of species of hydrophytic species of plants (Lammers and van der Valk 1977, 1978). For this reason, consideration of this entire category of plants is beyond the scope of this paper. The hydrophytic species considered by this study are the aquatic vascular plants that grow in standing water associated with lake and lake marshes in Iowa. This includes submergent, floating-leaf, and shallow water emergents and follows the definition of Muenscher (1944). This definition states that aquatic vascular plants are those species that normally start their growth in water and must grow for at least a part of their life cycle in water, either completely submersed or emersed.

Historical research dealing with aquatic vascular plants inhabiting Iowa's natural lakes is limited and tends to concentrate on lakes in the Iowa Great Lakes region. A listing of papers critical to the evaluation of the current status of this group can be found in Lammers and van der Valk (1977, 1978), and Eilers and Roosa (1994). Many of the papers listed by these authors are annotated checklists that provide verification of the presence of various species in Iowa. However, few quantitative data exist that provide information on the relative abundance of these species in lakes.

The purpose of this study was to document the current status of aquatic vascular plants in selected natural lakes in western, northwestern, and north-central Iowa and compare the resulting data with existing historic data. Comparisons of species abundance and species diversity were made where possible. The results of these comparisons were used to determine if significant changes have occurred in the aquatic vascular plant populations in these lakes.

METHODS

In 1917, Pammel authored a paper that not only provided a list of the species present in the lakes surveyed, but also indicated the relative abundance of these species (Iowa State Highway Commission 1917) As part of this study, 15 natural lakes in northwestern Iowa were intensively surveyed during the summer of 1915. While a detailed description of survey methods were not presented by the author, it appears that both shoreline observations and boat surveys were utilized. An additional eight lakes in north-central Iowa were visited in 1916 and partial species lists were prepared.

In 1996, the Iowa Department of Natural Resources established the Iowa Eurasian Watermilfoil Program as mandated by state law (Iowa Department of Natural Resources 1997a). Eurasian watermilfoil (*Myriophyllum spicatum*) is a nonindigenous aquatic nuisance species which can create serious ecological problems in lakes following unintentional introduction. As part of the Iowa Eurasian Watermilfoil Program, 86 natural lakes located in northwestern and north-central Iowa and along the Missouri River were surveyed during the summer of 1996 for aquatic vascular vegetation. All of the lakes studied by Pammel in 1915 and 1916 were included in this survey.

Lakes were surveyed by establishing transects perpendicular to the shoreline. Transects were begun at the high water mark and were extended outward into open water to the outer edge of the submerged vegetation zone. Samples were collected by hand in shallow water and using a grapple in deep water. Species identification was made in the field whenever possible. If a positive identification could not be made in the field, specimens were collected and returned to the laboratory for examination. The distance between transects was determined by the abundance of aquatic vegetation present and the size of the lake being surveyed. Distances between transects varied from 100 meters for small, heavily vegetated lakes to 300 meters for large, sparsely vegetated lakes.

When conducting field observations on the 15 lakes surveyed by Pammel in 1915, care was taken to develop a complete species list for each of these lakes. All natural shorelines were walked by either the author or Iowa Department of Natural Resources field technicians. Boat surveys of the entire lake shoreline were also made in addition to taking transect samples. Records of the location of species not observed in 1996 were obtained from herbarium specimens located at Iowa Lakeside Laboratory and additional trips were made to those sites to determine if populations of those species still existed.

To further evaluate the status of aquatic vascular vegetation in Iowa's lakes, a survey of the littoral zone vegetation of 240 lakes in Iowa was conducted during the summer of 1996. The lakes included in this survey were 10 acres in size or larger and capable of supporting harvestable fish populations. Determination of the area of littoral zone vegetation was made by state fisheries biologists using existing maps and limnological data. State fisheries biologists, using existing limnological data and personal knowledge of each lake in the study, estimated the percentage of the littoral zone that was vegetated. The categories utilized were: <25%, 25% to 50%, and >50%.

Also, as part of the Iowa Eurasian Watermilfoil Program, these 240 lakes were ranked to determine their susceptibility to infestation by Eurasian watermilfoil. This ranking system was based on eight criteria: average summer Secchi disk depth, nutrient loading, sediment loading, fisheries potential, boating/recreational potential, residential/commercial potential, percent of littoral zone in lake, and percent of littoral zone currently vegetated. A complete description of the methods used to rank the 240 lakes in this study can be found in the *Comprehensive Plan for the Management of Eurasian Watermilfoil in Iowa* (Iowa Department of Natural Resources 1997a).

RESULTS

During Pammel's 1915 survey, 66 species of aquatic vascular plants were recorded. Pammel noted that five of these species were common in water over seven feet deep, 16 were common in water five to seven feet deep, 25 were common in water three to five feet deep, and 43 were common in water one to three feet deep. Pammel also observed that most of the lakes studied exhibited distinct littoral zonation. The zones that he noted included a wet meadow vegetation zone of sedges, grasses, and annuals that blended into the surrounding tallgrass prairie, an emergent vegetation zone predominated by cattails, bulrushes, and common reeds, a floating-leafed vegetation zone that included pondweeds (*Potamogeton* sp.), yellow water lilies (*Nuphar luteum*), and white water lilies (*Nymphaea tuberosa*), and a submergent vegetation zone where pondweeds (*Potamogeton* sp.) predominated.

Because of the lack of quantitative references, analysis was confined to the comparison of data obtained during this study with the data provided by the study conducted by Pammel in 1915. East Hottes, West Hottes, and Marble lakes showed small increases in species, while all of the other lakes showed marked declines in the species richness of the aquatic plant community (Table 2). The greatest decline occurred for East Okoboji Lake, with a loss of 40 species.

The largest decline of aquatic vascular plant species for all 15 lakes was noted for the wet meadow vegetation zone. Many of the wet meadow species that appear to have been lost were listed by Pammel as common in 1915. This includes the water marigold (*Megalodonta beckii*) that was listed by Roosa and Eilers (1978) as a state endangered species. Other noticeable changes observed were among the floating-leaf species, with the apparent loss of two species of water lilies (*N. luteum* and *N. tuberosa*) and several species of pondweeds (*Potamogeton diversifolius, Potamogeton epihydrus,* and *Potamogeton gramineus*).

Changes in the relative abundance of species in East Okoboji Lake, Rush Lake, and West Okoboji Lake were also noted. Rush Lake in Palo Alto County remains densely vegetated today, but the once abundant river bulrush (*Scirpus fluviatilis*) and other normally common species have been almost entirely displaced by hybrid cattails (*Typha x glauca*). In both East Okoboji Lake and West Okoboji Lake, northern milfoil (*Myriophyllum exalbescens*) and coontail (*Ceratophyllum demersum*) have become dominant species.

Other activities conducted as part of the Iowa Eurasian Watermilfoil Program provided data that can be utilized in the evaluation of the status of aquatic vascular vegetation in Iowa's lakes. Analysis of the percentage of littoral zone vegetated in 240 Iowa lakes showed that 75% of these lakes had less than one-fourth of the existing littoral zone occupied by vegetation (Table 3). The priority ranking system developed for Iowa lakes as part of the Iowa Eurasian Watermilfoil Program yielded similar results (Table 4).

Table 2. Species composition for lakes surveyed, 1915 and 1996.

LAKE	SPECIES PRESENT 1915	SPECIES PRESENT 1996	PERCENT CHANGE
Center Lake—Dickinson County	19	3	−84
Diamond Lake—Dickinson County	11	1	−91
East Okoboji Lake—Dickinson County	55	15	−73
Gar (Lower Gar) Lake—Dickinson County	29	14	−51
Hottes (East Hottes) Lake—Dickinson County	12	14	+17
Little Spirit Lake—Dickinson County	12	8	−33
Marble Lake—Dickinson County	7	11	+57
Pickerel Lake—Buena Vista County	17	3	−82
Robinson's (West Hottes) Lake—Dickinson County	11	14	+27
Rush Lake—Palo Alto County	26	7	−73
Spirit Lake—Dickinson County	29	25	−13
Storm Lake—Buena Vista County	13	3	−77
Swan Lake—Emmet County	27	6	−78
Tuttle Lake—Emmet County	15	4	−73
West Okoboji Lake—Dickinson County	50	19	−62

Table 3. Percent littoral zone vegetated for Iowa lakes.

PERCENT VEGETATED	NORTH-WEST DIS-TRICT	SOUTH-WEST DIS-TRICT	NORTH-EAST DIS-TRICT	SOUTH-WEST DIS-TRICT	STATE TOTAL
<25%	49	55	26	51	181
25% to 50%	15	16	4	8	43
>50%	10	2	4	0	16
Total	74	73	34	59	240

DISCUSSION

While the results from this recent study are preliminary in nature and will need to be followed with additional field work, they suggest that some rather dramatic changes have occurred with regard to the aquatic vascular plant communities in Iowa's lakes. The most startling changes observed during the 1996 survey were the reduction of species diversity, the loss of many wet meadow and floating-leafed

Table 4. Eurasian watermilfoil priority ranking system for Iowa lakes.

CATEGORY	NORTHWEST DISTRICT	SOUTHWEST DISTRICT	NORTHEAST DISTRICT	SOUTHWEST DISTRICT	STATE TOTAL
I	5	0	1	2	8
II	35	20	12	18	85
III	34	53	21	39	147
Total	74	73	34	59	240

Category I High Risk
Category II Moderate Risk
Category III Low Risk

species, and the elimination of littoral zonation. Over half of the lakes surveyed during 1996 were either devoid of aquatic vascular vegetation or vegetated by a very small number of species. The following examples of observations made during the 1996 field season are presented to illustrate the plight of aquatic vascular plants in Iowa's lakes.

At Lost Island Lake, once a favorite study site of Ada Hayden, a single cattail (*Typha* sp.) plant was observed. In the Iowa Great Lakes area, yellow water lily *(N. luteum)* was reported as common in 1915. During the 1996 survey, a single small population was observed while sampling Marble Lake. The most commonly observed species at Storm Lake during the 1996 survey was purple loosestrife (*Lythrum salicaria*), a nonindigenous aquatic nuisance species. Curlyleaf pondweed (*Potamogeton crispus*), another nonindigenous aquatic nuisance species, is now common in many of Iowa's natural lakes, including both East Okoboji Lake and West Okoboji Lake. Since 1993, Eurasian watermilfoil (*M. spicatum*), also a nonindigenous aquatic nuisance species, has been reported in six Iowa lakes, including Crystal Lake in Hancock County and Snyder Bend in Woodbury County (Iowa Department of Natural Resources 1997b). These observations suggest that the status of aquatic vascular plants in Iowa's lakes has undergone significant change from presettlement conditions.

Furthermore, the results of the littoral zone vegetation and priority ranking system surveys indicate that many of Iowa's lakes are currently failing to support viable aquatic vascular plant populations. Lakes listed as Category III (Low Risk) are unlikely to become infested with Eurasian watermilfoil because they currently do not support viable populations of aquatic vascular plants. In some of Iowa's lakes, the lack of aquatic vascular plants is intentional as the result of fisheries management practices. For other lakes, no specific reason can be cited as explanation for the nearly total loss of aquatic vascular plants.

Undoubtedly, the changes in aquatic vascular plant communities inhabiting lake, pond, and riverine wetlands are linked to a number of causes. Because of a lack of research data dealing specifically with these declines in Iowa, the following list is knowingly speculative and probably incomplete. Nevertheless, this list provides a basis for future study and consideration. No attempt to prioritize this list has been made, as each lake represents a unique situation and has been impacted by different combinations of factors.

1. ***Maintenance of stable water levels.***

Since presettlement times, most remaining natural lakes have had water control structures installed in an effort to maintain stable water levels. Examples of natural lakes with water control structures include Spirit Lake in Dickinson County, Clear Lake in Cerro Gordo County, Storm Lake in Buena Vista County, and Tuttle Lake in Emmet County. These structures were constructed to improve the recreational value of these lakes and, in many cases, to intentionally reduce aquatic vascular plant populations (Iowa State Highway Commission 1917). The most dramatic impact of water control structures is the prevention of the natural summer drawdown of these lakes except during periods of extended drought. Presence of these structures eliminates low shoreline habitats critical to many emergent species, prevents the re-establishment of emergent species that cannot germinate when the seeds are submerged, and causes the physical disruption of shoreline structure due to ice movement during the winter.

2. ***Increased sediment loading.***

With settlement came the conversion of Iowa's rich prairies to agricultural uses and as perennial cover was replaced with annual row crops, soil erosion rates increased dramatically. This erosion has significantly altered many of Iowa's natural lakes by increasing the amount of sediments entering these waterbodies. The effects of increased sediment loading include the direct filling of lake basins, conversion of rock, gravel, and sand bottom substrates to mud, and increased turbidity that limits the penetration of sunlight, thereby reducing the depth at which submergent vegetation can effectively grow (Bachmann et al. 1980).

3. ***Increased nutrient loading.***

Since the settlement of Iowa, wetlands have served as convenient sites for the disposal of nutrient-rich wastes. These wastes have included sewage from municipalities and manure from livestock feedlots. Since the 1940s, Iowa farmers have substantially increased their use of inorganic fertilizers and in doing so, added to the overall nutrient loading of lakes within the state. Nutrient loading alters normal nutrient cycles in aquatic ecosystems and promotes the growth of algae at the expense of aquatic vascular vegetation (Bachmann et al. 1980).

4. ***Dredging.***

As a result of increased sediment loading, many natural lakes in Iowa have been dredged in an effort to improve recreational opportunities. Dredging alters the bottom substrate, physically destroys existing aquatic vascular plants, and removes the seed and root reservoir critical for the redevelopment of aquatic plant communities (Bachmann et al. 1980).

5. ***Draining.***

As settlers spread out across Iowa, many small lakes were drained and the lake beds were converted to agricultural usage. In the early 1900s, the State of Iowa conducted an evaluation of Iowa's remaining natural lakes. At that time, many shallow lakes were determined to be of limited recreational value and were slated for drainage (Iowa State Highway Commission 1917). Many of these lakes were extensively vegetated and their destruction represents an irreplaceable loss of aquatic vascular plants. Draining and subsequent agricultural usage converted viable aquatic habitats to human altered terrestrial systems. As lakes were drained, the existing aquatic plant community were physically destroyed. While the root and seed reservoir may initially remain viable, continued tillage eventually destroyed the system's capacity to be restored.

6. ***Intensive residential shoreline development.***

Because of the limited number of lakes in Iowa, those with recreational value have experienced extensive commercial and residential development. With this development has come the destruction of shoreline habitat critical to the existence of many species of aquatic vascular plants. Even if the shoreline habitat is not destroyed, the adjacent littoral zone is subjected to increased human impact that adversely affects the aquatic vascular plant community (Davis and Brinson 1980).

7. ***Increased boating activity.***

Iowa has one of the highest per capita ownership rates of boats in the United States with over 182,000 boats registered in the state (Iowa Department of Natural Resources 1997b). With a limited number of lakes available in the state for boating activity, Iowa's lakes experience intensive boating pressure. Boating activities impact aquatic vascular plant communities by fragmenting and uprooting submergent and floating-leafed species and increasing turbidity (Davis and Brinson 1980).

8. ***Aquatic vegetation control programs.***

Because aquatic vascular plants are often considered detrimental to aquatic recreation, many lakes have been chemically treated to conrol or eliminate aquatic plant populations (Scalet et al. 1996). These programs destroy the existing plant populations, decrease species diversity, and increase the susceptibility of these lakes to the invasion of nonindigenous aquatic nuisance plant species.

9. ***Introduction or invasion of nonindigenous aquatic nuisance animal species.***

In the late 1800s and early 1900s, carp *(Cyprinus carpio)* were stocked in many of Iowa's lakes and streams. Since their introduction, they have had a negative impact on the aquatic vascular plant communities in these habitats They are responsible for the uprooting of vascular plants and disruption of aquatic plant communities. Their foraging activities also stir up bottom sediments, increasing turbidity that reduces the effective depth of light penetration. More recently, additional nonindigenous aquatic nuisance animal species such as rusty crayfish (*Orconectes rusticus*) and zebra mussels (*Dreissena polymorpha*) have begun to invade lakes and represent new threats to aquatic vascular plants. In some instances, nonindigenous aquatic animal species such as grass carp (*Ctenopharyngodon idella*) have been intentionally introduced into lakes to control aquatic vegetation (Scalet et al. 1996).

10. ***Introduction or invasion of nonindigenous aquatic nuisance plant species.***

In recent years, a number of nonindigenous aquatic nuisance plant species have begun to invade wetland habitats in the United States. Species that have already begun to impact aquatic vascular plant communities in Iowa include purple loosestrife *(L. salicaria)*, Eurasian watermilfoil (*M. spicatum*), and curlyleaf pondweed (*P. crispus*). These species replace native species, disrupt the natural ecology of plant communities, and stimulate public interest in aquatic plant control programs that affect both nonindigenous and native species of aquatic vascular plants (Smith and Barko 1990).

11. ***Shoreline succession resulting in establishment of woody vegetation.***

At the time of settlement, most lake and marsh shorelines blended into the surrounding tallgrass prairie. Only areas protected from prairie fires supported permanent stands of trees. However, with the tillage of the prairie, the fires that controlled woody vegetation along lakeshores were eliminated. Since the turn of the century, most lakeshores have undergone succession to woodland habitats (Bernstein et al. 1990). This successional change displaces the natural low shoreline plant community with woody vegetation. As these woody species mature, they shade the adjacent aquatic habitat, creating a zone between the lake shore and the inner edge of the established emergent vegetation beds that is devoid of aquatic plant life.

12. ***Restructuring of aquatic plant communities.***

As aquatic habitats become altered, there is often a restructuring of the aquatic vascular plant communities. While aquatic vascular plants may remain abundant in aquatic ecosystems, the once diverse community may become dominated by only several species. This ecosystem restructuring typically eliminates the rare or uncommon species (Davis and Brinson 1980). Rush Lake in Palo Alto County is an excellent example of an aquatic ecosystem which has undergone aquatic plant community restructuring. While still abundantly vegetated, the once diverse aquatic plant community has bee replaced by a community dominated by hybrid cattails (*Typha x glauca*).

13. ***Environmental pollution.***

The input of environmental pollutants, especially herbicides, has increased significantly since the late 1940s. These herbicides enter aquatic ecosystems along with surface runoff from agricultural and residential sites within the watershed. Once in a lake, these herbicides weaken or directly kill aquatic vascular plants (Bachmann et al. 1980). As plant communities are destroyed, there is a general disruption of the entire community structure. In the aftermath of community disruption, aquatic ecosystems become increasingly susceptible to community restructuring and invasion of nonindigenous aquatic nuisance plant species.

14. ***Construction of locks and dams on the Mississippi River.***

In an effort to maintain navigation on the Mississippi River, a system of locks and dams has been constructed by the Army Corps of Engineers. These locks and dams have impacted the river system by disrupting the normal cycle of spring flooding and summer low water flows. Their presence has completely inundated some previously existing lakes, converted standing water habitats into river channels, and created standing water habitats where they did not previously exist (Center for Global Environmental Education 1997). The presence of locks and dams has resulted in a large-scale transformation of the Mississippi River ecosystem accompanied by community restructuring and according to Pitlo (1998), invasion of nonindigenous aquatic nuisance plant species such as curly-leaf pondweed (*P. crispus*), purple loosestrife *(L. salicaria)*, and Eurasian watermilfoil *(M. spicatum)*.

15. ***Construction of upstream flood control dams and channelization of the Missouri River.***

Following years of extensive flooding along the Missouri River bottoms, a series of upstream flood control dams were built that have disrupted the normal cycle of spring flooding and summer low water flow. After construction of the flood control dams, the Missouri River was extensively channelized to enhance navigation as far upstream as Sioux City, Iowa. As a result of this channelization and the subsequent deepening of the river bed, many of the previously existing oxbow lakes have been partially or completely drained (Fruhling 1989). This alteration of these aquatic habitats has severely affected the existing aquatic vascular plant communities.

CONCLUSION

The status of aquatic vascular plants in Iowa is ultimately tied to the management and utilization of wetland habitats. Acquisition and protective management of fen, bog, and seepage wetland habitats appears to have stabilized the status of the unique hydrophytic plants that inhabit those sites. While the destruction of marsh and prairie pothole wetland habitats in Iowa has been extensive, recent federal and state programs have reversed the trend to drain and farm these wetlands. With intensive management, many of these restored wetlands have the potential once again to become vegetated with the rich and diverse hydrophytic plant communities that once inhabited them.

The status of hydrophytic plant communities associated with lake, pond, and riverine wetland habitats is not encouraging. The fact that aquatic vascular plants have drastically declined in many natural lakes is no revelation to the careful observer., but for most people, gradual change can be deceptive. Changes that occur in small increments over long periods of time are eventually perceived as almost no change at all. Without the scientific documentation of these long-term trends, there is danger that the degraded condition will eventually be seen as normal and a lower state of environmental quality will become acceptable. For many of Iowa's natural lakes, this point has already been reached.

The intent of this paper has not been to provide definitive answers. Rather, it has been an attempt to stimulate interest and raise questions concerning the plight of aquatic vascular plants and the lakes that they inhabit in Iowa. Healthy lakes support rich and diverse communities of aquatic vascular plants. In a very real sense, aquatic macrophytes are like the canary in a mine. As their numbers decline and disappear from our lakes for no readily apparent reason, it should alert us to the fact that changes are occurring that need to be studied, evaluated, and if feasible corrected before these important resources are irrevocably impacted.

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