

Nonindigenous Aquatic Plants

A Garden of Earthly Delight

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Who knows what evil lurks in the hearts of . . . water gardens?

Aquatic plants have been important as a source of food, commodity and religious inspiration to people since the early days of humanity. The aquatic grass known as rice (*Oryza sativa*) was cultivated in Asia more than 3,000 years ago and continues to be a leading



staple of the world's food supply. Other edible and medicinal aquatics like sweet flag (*Acorus*), water chestnut (*Trapa*), and cattail (*Typha*) were in wide use by 300 B.C.

It is understandable that movements of useful, edible, and ornamental water plants have closely followed patterns of human migration throughout history. The Egyptians were already known to cultivate water plants by 2500 B.C., and they had introduced the water lotus (*Nelumbo*) to Egypt by 500 B.C.

Europeans began to cultivate water plants in the 18th century, but it was not until the discovery of *Victoria*, the magnificent giant water lily, that interest in water gardening burgeoned in both the Old and New Worlds.

Yet, despite their many beneficial uses and aesthetic appeal, some aquatic plants have gained reputations as inimical aggressors that threaten to destroy the ecological integrity of natural plant communities.

Adaptation to life in water has conferred most aquatic plants with



*Ancient Egyptians introduced the aquatic papyrus (*Cyperus papyrus*) for use in boatmaking and as a writing material. It is a major component of the impenetrable "sudd" formations that now plague the Nile and other rivers.*

highly efficient vegetative reproduction and dispersal mechanisms. Even disallowing for human introductions, aquatics represent the most widely distributed plants on earth. The same biological characteristics responsible for their success also have enabled certain species to become some of the world's most notorious weeds.

Definitions

"Nonindigenous" species (also referred to as "alien", "exotic", "foreign"), are those that did not occur within a particular region prior to human habitation. Such species are not part of the original ("native") flora of a

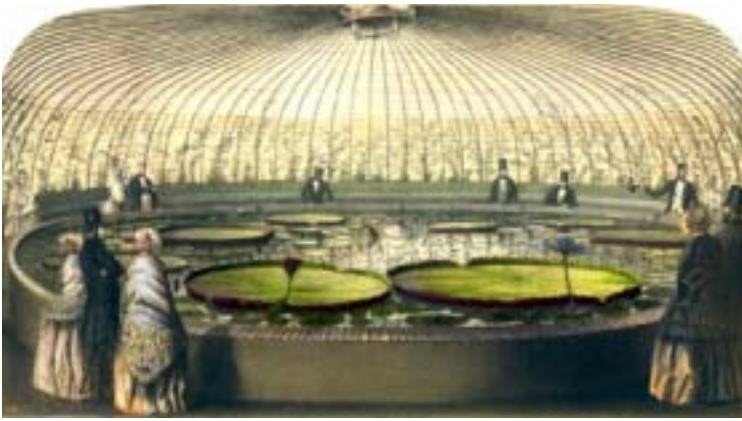
region and typically their existence is in some way the result of human intervention.

"Naturalized" species are those nonindigenous species capable of establishing and persisting in a new region without cultivation. A "cultivated" plant is one grown intentionally in intensively managed environments. Naturalized species capable of spreading considerably within native communities are referred to as "invasive". Although defined variously, a "weed" is any plant that interferes with management or appreciation of natural resources. Simply put, weeds are plants that grow where they are viewed as undesirable. Because this concept is quite subjective, one person's weed may be another person's wheat. Indeed, such differences of opinion are at the very heart of the invasive aquatic species problem.

What is the Problem?

The essential problem with nonindigenous species is that human-mediated dispersal vastly accelerates events that influence ecological processes. No natural community is devoid of change, including immigration and emigration, which are salient features of nearly all populations. However, the methodical pace of most natural migrations enables communities to respond and adjust ecologically to occurrences of new species, usually without perturbation or severe repercussions.

When species migrate naturally, they do so along with their predators, pathogens, and other associated species, thus maintaining an ecological balance in newly colonized areas. However, when humans introduce species to localities far-removed from their native



Delighted visitors gather around the incredible Victoria, a plant whose discovery in the early 19th century stimulated interest in water gardening worldwide.

lands, they immediately establish a biological arena for competition under circumstances that probably never would have occurred as a result of natural processes. Freedom from predation, exploitation of new niches, and hybridization with native species all can result in explosive outbursts of nonindigenous species and concomitant losses of natural biodiversity.

The ecological consequences of invasive species introductions are devastating, leading to a total disruption of biotic communities that ultimately can result in the replacement or even extinction of native species. Invasive aquatic plants also impact people directly by interfering with waterway navigation, irrigation, agriculture, and countless commercial and recreational activities.

Financial costs associated with the control of invasive plants and animals can be staggering, and are estimated to exceed 138 billion dollars annually in the United States alone. Each year, Americans spend more than 100 million dollars just to manage hydrilla and water hyacinth, two of our many invasive aquatic plants.

Even with such a high financial outlay, control of most invasive aquatic plant species is usually only temporary and does not result in their eradication. The introduction of hydrilla in Connecticut provides a good example. This invasive species was first found in the state within a small private pond where it had been established for at least a decade before its discovery. The pond was drained and dredged and herbicides were applied as an “overkill”

approach to ensure its eradication. Now several years later, the hydrilla is back, at a density as high as before the treatments began. In addition, two new populations of hydrilla have since been found in

Connecticut (one quite close to the original), and neighboring Massachusetts reported its first incidence of hydrilla only months ago.

The inability to eradicate this highly invasive species within even a tiny pond, and to prevent its spread to nearby areas, underscores the gravity of the situation. Once established, aquatic plants are virtually impossible to eradicate.

The Cause of the Problem

Although many water plants have widespread geographical distributions naturally, nearly all nonindigenous hydrophyte invasions can be traced initially to the activities of people. Notably, more than 75% of all nonindigenous aquatic plants in the northeastern United States originated as escapes from cultivation.

Once aquatic plants are released into nonindigenous habitats, most species can easily spread over greater

distances due to their efficient dispersal mechanisms. Dispersal of invasive aquatic plants is unwittingly facilitated by people, who carelessly transport viable stem fragments from lake to lake on contaminated boats and trailers.

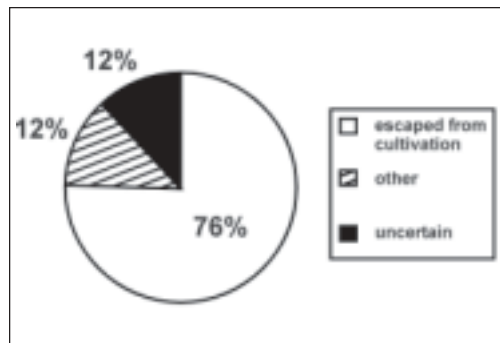
The growing popularity of water gardening and “natural” aquariums has exacerbated the problem by increasing the commercial availability of many invasive nonindigenous aquatic plants either directly or indirectly.

Some invasive species such as egeria (*Egeria densa*), fanwort (*Cabomba caroliniana*), Miramer weed (*Hygrophila polysperma*), parrot’s feather (*Myriophyllum aquaticum*), and water hyacinth (*Eichhornia crassipes*) are readily available from various water garden and aquarium suppliers in the United States.

These species are popular in aquariums and water gardens because of their durability and “vigor”, which ironically, also indicates their high potential for invasiveness. Even some tropical species such as water hyacinth, which normally cannot withstand cold winters, can reach nuisance levels in temperate localities within a single growing season.

Many submersed species (typically sold as “oxygenating plants”) look similar and it is sometimes difficult for experts to identify certain species correctly. The frequent use of incorrect nomenclature by retailers makes it difficult for even educated consumers to determine whether they are purchasing harmless or dangerously invasive species. A good example is “Anacharis”, a name formerly applied to *Elodea*, a native submersed plant genus, but one that is no longer valid scientifically. However, retailers frequently use “Anacharis” as a common name and apply it to several similar genera in the frog-bit family (Hydrocharitaceae) including the native *Elodea* as well as the highly invasive *Egeria* and *Hydrilla*. Without adequate training, most people would find it difficult to separate these three genera. Consequently, it is wise to avoid purchasing any aquatic plant sold simply as “Anacharis.” *Myriophyllum*, the water milfoil genus, is also very difficult taxonomically and contains

Over three-quarters of all aquatic plant introductions in the northeastern United States have resulted from careless cultivation practices.



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several invasive species. Here again, it is best to avoid purchasing plants sold simply as “water milfoil” or “*Myriophyllum* sp.”

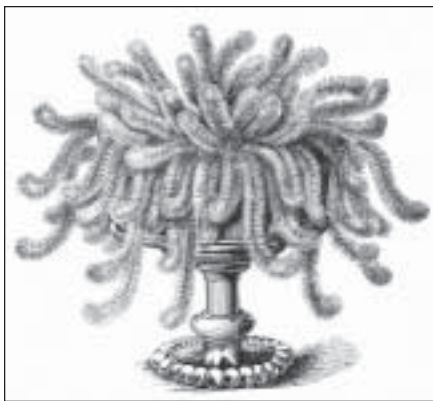
Invasive aquatic plants have also been distributed indirectly. Some aquatics like water lilies (*Nymphaea* spp.) are relatively safe for water gardens and contain no seriously invasive species or cultivars. However, suppliers sometimes raise stocks of water lilies in ponds that contain invasive submersed species. In such instances, viable fragments of invasive submersed plants have become attached to water lily rootstocks resulting in their inadvertent shipment to customers. If the “hitchhikers” are not discovered and removed by the customer, then potentially they can establish wherever the water lily is planted (and also disperse from there).

Aquatic plants should always be purchased from reputable suppliers who are knowledgeable about and concerned with invasive species, rather than from anonymous or unfamiliar sources such as Internet auctions. If more people insisted on purchasing only truly native species, then, the availability of nonindigenous species, hence their dissemination, would predictably decline.

Legislation: Impact or Impasse?

Several important pieces of legislation have been enacted to deal

Parrot feather (Myriophyllum aquaticum) from South America has been a horticultural favorite for more than a century. It is seriously invasive in many parts of the United States.

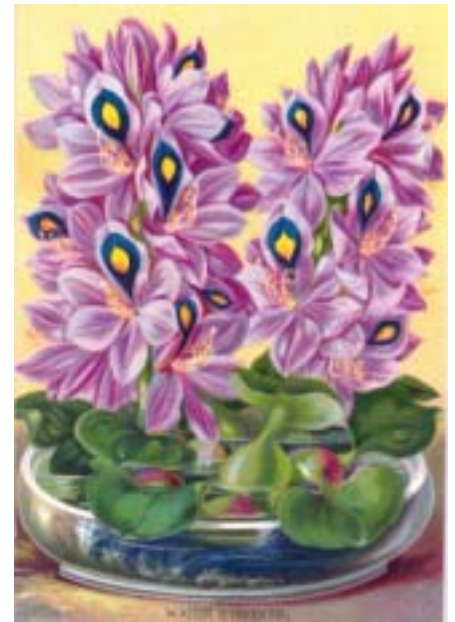


with invasive species. The Federal Noxious Weed Act (now incorporated into the Plant Protection Act) was issued on January 3, 1975, to curb the spread of invasive plants. Currently, 19 aquatic and wetland plants are on the Federal list of noxious weeds including water velvet (*Azolla pinnata*), hydrilla (*Hydrilla verticillata*), Miramer weed (*Hygrophila polysperma*), oxygen weed (*Lagarosiphon major*), ambulia (*Limnophila sessiliflora*), and four species of giant water fern (*Salvinia*) which are very difficult to distinguish taxonomically. All of these species are popular in water gardens and aquariums. Despite the fact that this law prohibits the dissemination of noxious weeds into or within the United States, several of these species remain available commercially.

In 1977, Executive Order 11987 was issued to: “. . . restrict the introduction of exotic species into any natural ecosystem of the United States . . .” The “*Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990*” specifically targeted the control of invasive aquatic organisms. Designed primarily to deal with zebra mussels, this act directed Federal agencies to assess invasions of all aquatic organisms including freshwater plants.

Another significant legislative step was taken on February 3, 1999, when Executive Order 13112 was implemented: “. . . to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause . . .” This Executive Order further focused attention and resources on the problem of invasive species, and together, these laws have stimulated progress toward the formulation and implementation of an effective management plan to control the spread and impact of noxious plants and animals.

Yet, even with these federal statutes on the books and a host of additional state laws directed at resolving the invasive species problem, the frustrating fact remains that all of the invasive aquatic plants introduced to the United States are still here. Although laws may be helpful in many respects, they simply



This 19th century advertisement for water hyacinth (Eichhornia crassipes), assured that “the rapidity of growth will delight you.” Efforts spent combating invasive populations of this plant for more than 100 years have been far from enjoyable.

do not make invasive species go away. Generally lacking vigilant enforcement, our laws remain largely ineffective for preventing new incidences of invasive species.

What Happens to Nonindigenous Species?

The obstinate persistence of invasive aquatic plants is documented by historical plant distribution records collected throughout the country. Recent studies in the northeastern United States confirm that all 17 nonindigenous aquatic plants introduced to the region since the mid-nineteenth century are still found within North America and at least 16 of them continue to occur in the northeast. The same trend is apparent for invasive aquatic plants introduced to other parts of the country. These figures accentuate a sobering fact: *once invasive aquatic plants are introduced to the United States, they will not go away.*

All efforts thus far, including legislation, education, and management, have done little to quell the incessant invasions of aquatic plants. This observation not only stresses the



Kenilworth Gardens, an early distributor of aquatic plants, lies on the outskirts of Washington, D.C. where laws are now fervently passed to combat invasive species. Helen Fowler, the founder's daughter, is shown in a truck advertising "Aquarium Plants." A serious infestation of hydrilla was discovered at Kenilworth in the 1980s.

What Can Be Done?

It is patently obvious that the sale and distribution of cultivated specimens is and has been the foremost cause of nonindigenous aquatic plant introductions in the United States. Given that invasive aquatic plants are nearly impossible to eradicate once they become established, it appears that the only effective recourse for curtailing these incessant outbreaks may be to impose a complete moratorium on the sale and distribution of nonindigenous aquatic

plants throughout the United States. Such an action would require aquatic plant dealers to distribute only benign, native species.

Although this alternative would provide an effective solution, there are a number of arguments that could be raised against its implementation. Aquatic plant dealers would likely object to such restrictions as excessively prohibitive, reducing their ability to provide customers with desired merchandise. Certainly, some exceptions would be necessary—e.g., allowing the sale of cultivated water lilies (the "bread and butter" of the water garden industry) that are not known to constitute threats to natural communities.

A formidable logistic obstacle to instituting a complete ban of nonindigenous aquatic plants would be the implementation of an effective means of enforcement. Admittedly, in a society where drugs, rape and murder have become mundane topics of the daily news, it is difficult to envision politicians rallying

for an all-out "crackdown" on the illegal sales of aquatic pond plants.

Perhaps the sale of aquatic plants, like dangerous drugs and chemicals, should involve a carefully monitored permit system. Ideally, such a system should involve some degree of education and training in invasive species. Enforcement could proceed by permit revocation and levies of severe fines for businesses in non-compliance with federal and state invasive species laws.

However, such a system would also require a substantial number of inspectors in order to assure compliance by aquatic plant retailers throughout the United States. Where would the funding come from?

One way to think of the funding level necessary to achieve effective enforcement of invasive species restrictions is as an investment, given that additional expenditures in the billions of dollars will inevitably accrue if the importation of nonindigenous aquatic plants is not somehow stopped.

Moreover, costs to curtail invasive aquatic plant species essentially represent stewardship dues, given the inestimable value of our natural aquatic resources. As taxpayers who would ultimately shoulder the burden of such programs, we can either decide to accept the expenses necessary for ending invasive species introductions, or rather be content to idly do nothing and watch as our precious aquatic habitats deteriorate to ruination.

Happily, there has been an increasing level of awareness among many gardeners regarding the threats of invasive species, and a number of

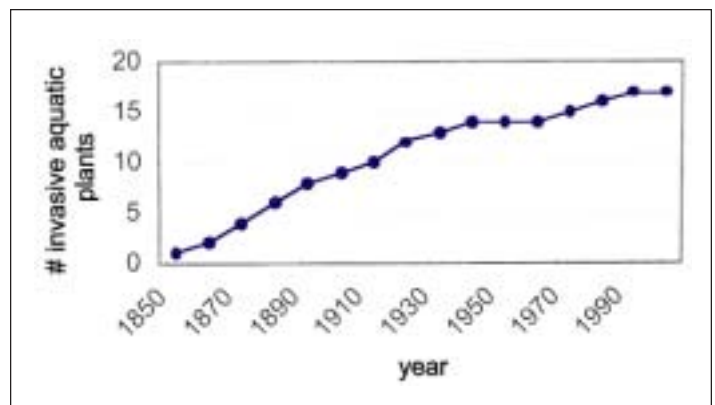
severity of the problem but indicates that a different approach must be taken if we are to solve it.

For more than a century, the United States has experienced a steady accumulation of new invasive aquatic plants with no end in sight. One new invasive aquatic plant species has been added to the flora of the northeastern United States approximately every ten years since 1850. New introductions of invasive aquatics like giant water fern (*Salvinia molesta* in 1998) and mosquito fern (*Azolla pinnata* in 2000), continue to materialize elsewhere in the country as well. It comes as no surprise that both of these recent introductions are due to escapes of cultivated plants.

To make matters worse, the nonindigenous aquatic plants that were introduced previously have relentlessly continued their stifling expansion into new territories. Water chestnut (*Trapa natans*) was new to Connecticut in 1999, European frog-bit (*Hydrocharis morsus-ranae*) new to Michigan in 2000, Eurasian water milfoil (*Myriophyllum spicatum*) new to South Dakota in 2000, and hydrilla (*Hydrilla verticillata*) new to Massachusetts in 2001, just to name a few of many examples.

If these disturbing trends are allowed to continue, it is predictable that a complete demise of our native aquatic plant communities is inevitable.

The number of invasive aquatic plant species in the northeastern United States has progressively increased during the past 150 years.



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organizations now promote educational programs that instruct members to “plant native” species whenever possible.

Furthermore, any move to prohibit nonindigenous aquatic plants from the retail trade would be easier to accept and implement if viable, native alternatives were readily made available as “safe” substitutes. There are many native aquatic plants that are equally effective as “oxygenators” and that have underwater foliage similar to many of the imported nonindigenous species. In fact, the North American flora possesses some of the highest diversity of aquatic plant species anywhere in the world, thus constituting a more-than-adequate assortment of species to select from.

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Although the suggestion of prohibiting nonindigenous aquatic plants from retail trade may seem radical to some, this concept is not the same as suggesting a ban on tulips or roses. For one thing, aquatic plants may be quite fascinating, but there aren't many submersed species that are particularly attractive as far as ornamental plants are concerned. Oftentimes, aquatics (especially submersed species) are grown in gardens for their functional rather than aesthetic attributes. It is difficult to imagine that water gardeners looking for “oxygenating plants” would be overly concerned whether they would have to grow a native species of *Elodea* rather than an invasive *Egeria*. Neither plant is showy, and such oxygenating plants usually are not visible from the surface of a water garden anyway.

Consumers typically purchase the plants that are readily available from retailers, which in the case of aquatic



Elodea canadensis, a North American native, was introduced to Europe where it is invasive.

plants, often tend to be nonindigenous invasive species. Yet most consumers would probably accept suitable native substitutes if they were easily obtainable.

However, there will always be those who absolutely insist on owning novel, rare or unusual species to beautify their pond or aquarium, and who do not think that nonindigenous plants constitute a serious environmental problem. Demanding aquarists encourage aquatic plant dealers to continually seek out novelty species from different parts of the world. Ultimately a decision must be reached whether it is worthwhile to satisfy the fancies of a few while incurring hundreds of millions of dollars in losses each year and the irreparable damage to natural ecosystems that accompanies the status quo.

The Bottom Line

Half a millennium ago, Hieronymus Bosch painted his infamous *The Garden of Earthly Delight*, which depicts a world indulging in various nefarious pleasures—and the extreme punishments awaiting the revelers. Admittedly, it is a stretch to associate aquatic plant cultivation with Bosch, but

perhaps his basic message is pertinent here even after 500 years. As far as aquatic plant invasions are concerned, we have clearly identified the major source of the problem and also an effective solution. It is now a matter of choosing whether or not to proceed with an appropriate course of action, regardless of repercussions to the cultivated aquatic plant trade. Otherwise, we as Bosch's subjects, must be willing to pay the consequences of our actions, if not spiritually, then at least financially and ecologically.

Indeed, the escapes of invasive aquatic plants from cultivation and ensuing infestations that have severely degraded our natural habitats, fittingly represent a nonindigenous “garden” of our earthly delights. Sadly, however, it is a garden choked with weeds.

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