The World's Most Troublesome Weed: Water Hyacinth and the Development of Wetland Science

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ABSTRACT

Water Hyacinth (*Eichhornia crassipes* (Mart.) Solms) is a large free-floating plant (up to 1 m tall) that can become established from seed and vegetative fragments. Vegetative growth is by stolons, creating floating mats of interconnected plants. Originally from South America, it reached the United States in the 1880s and, by the 1890s, had become a severe problem in Florida rivers. When large floating mats of Water Hyacinth began interfering with steamboat navigation on the St. Johns River and other rivers, various control measures were investigated to destroy or remove it, including mechanical harvesting, primitive herbicides, and physical barriers (booms). None proved completely effective. None of the numerous attempts to turn Water Hyacinth into salable commodities has been commercially viable. The lack of any permanent solution to Water Hyacinth infestations forced local governments in Florida to hire staff to deal with infestations in their jurisdictions. Eventually, the number of people working on Water Hyacinth control increased significantly, resulting in the establishment of the Hyacinth Control Society in 1961 to facilitate the exchange of information on how best to manage it. This Society was the first American professional society whose members were dedicated to protecting and managing wetlands.

INTRODUCTION

Scientists working in many disciplines (botany, zoology, wildlife biology, ecology, etc.) have contributed to the development of wetland science. At the same time, non-scientists also influenced its development, including businessmen and philanthropists, a newspaper editorial cartoonist, politicians, and a landscape architect (see numerous articles by van der Valk listed in References). Likewise, many organizations have also played an important role, including Ducks Unlimited, the Delta Waterfowl Research Station, and federal and state/provincial wildlife agencies. Besides individuals and institutions, another major factor, environmental disasters, shaped the development of wetland science. The most important were the rapid decline of waterfowl populations during the late 19th and early 20th centuries, wetland drainage, and the spread of invasive aquatic weeds.

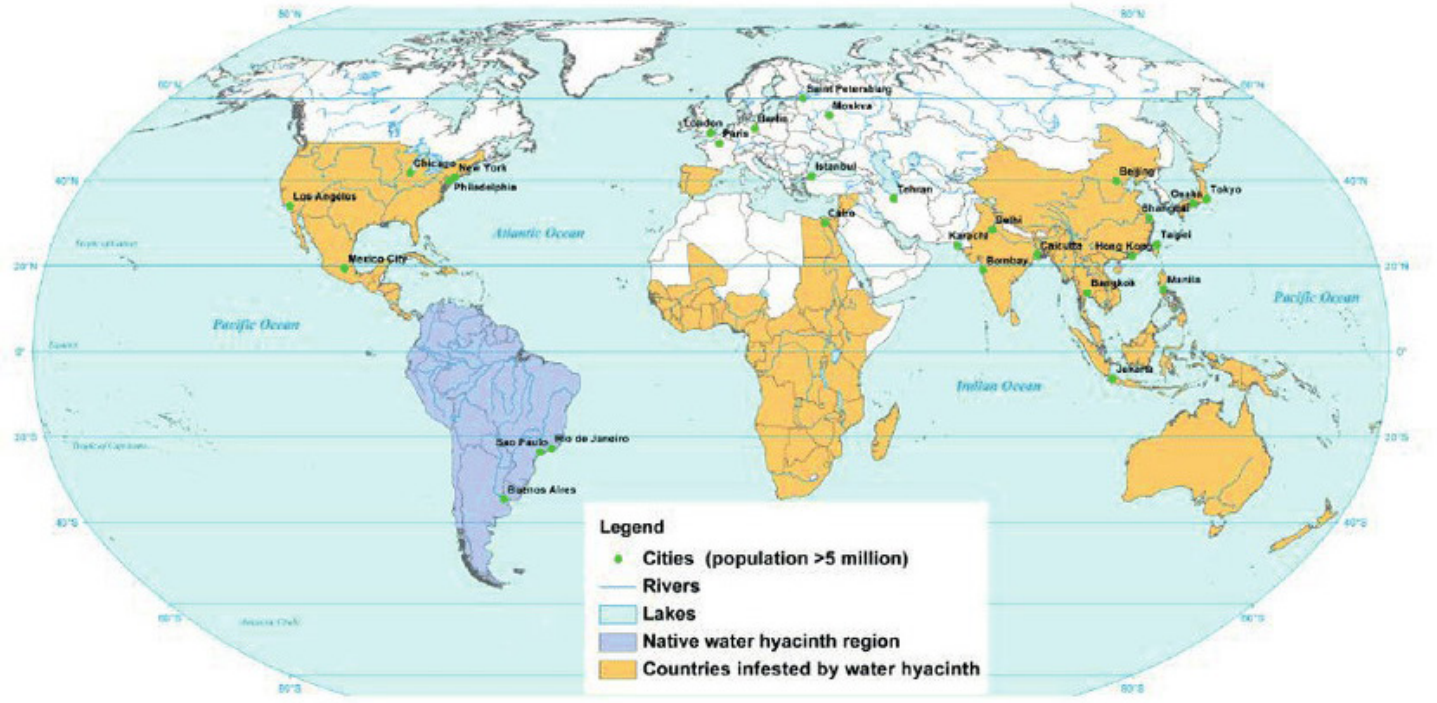

Figure 1. Global distribution of Water Hyacinth. Native distribution in purple. Introduced in beige. (Source: UNEP 2013)

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The spread of aquatic weeds worldwide (Holm et al. 1969; Murphy 1988) has caused massive problems in lakes and rivers by disrupting navigation, recreational uses, and water extraction for public water systems, industrial uses, and agriculture. Since the impacts of aquatic weed infestations were often local, this resulted in establishing local (county, municipal) government agencies dedicated to managing aquatic weeds. Eventually, this led to establishing a professional society in the United States to serve aquatic weed managers. It is the impact of one of these aquatic weeds, *Eichhornia crassipes* (Mart.) Solms, commonly called Water Hyacinth, on the development of wetland science that I examine in this paper.

Water Hyacinth was one of the earliest and most troublesome aquatic weeds to become established in the United States. Its native range was tropical South America (Figure 1). It eventually spread throughout the tropics and subtropics around the globe (Gopal 1987). Wherever it became established, Water Hyacinth negatively impacted navigation, irrigated agriculture, recreation, local hydrology, and public health. Thus, Water Hyacinth infestations called for significant efforts by local, state, and federal governments to eradicate or manage it. Consequently, Water Hyacinth had a major effect on the development of wetland science by creating numerous positions for people working on its management. In the United States, it also resulted in the establishment of a professional society of Water Hyacinth managers, the Hyacinth Control Society (now the Aquatic Plant Management Society), that eventually became an international organization.

In this paper, I focus on the establishment, spread, impact, and control of Water Hyacinth in the southeastern United States in the late 19th and early 20th centuries. Iqbal (2009) provides an interesting account of how the colonial government of Bengal, now mostly Bangladesh, attempted to deal with Water Hyacinth infestations in British India. For a more international perspective on the impact of Water Hyacinth, see Holm et al. (1969), Barrett (1989), and UNEP (2013).

THE BIOLOGY OF WATER HYACINTH

The most widely used scientific name of Water Hyacinth is *Eichhornia crassipes* (Mart.) Solms 1883. It had previously been called *Piaropus crassipes* (Mart.) Raf. 1837. However, because of precedence, many contemporary taxonomists prefer *Pontederia crassipes* Mart. 1823. There have also been numerous synonyms that are no longer considered valid. Water Hyacinth belongs to the Monocot family *Pontederiaceae* Kunth.

This species probably originated in the Amazon basin and, before 1800, was confined to tropical and subtropical South America. Even today, it is restricted to tropical, subtropical, and warm temperate climates because it cannot survive cold weather. Water Hyacinth had spread to Central America and the Caribbean by the end of the 19th Century. Today, it is found in South America, North America, Africa, Europe, Asia, and Oceania, including Australia (Figure 1).

Figure 2. *Eichhornia crassipes* (Water Hyacinth). (Source: Courtesy of the Center for Aquatic and Invasive Plants, Institute of Food and Agricultural Sciences, University of Florida)

Each plant is a floating rosette of vertical leaves arranged spirally and separated by short internodes (Figure 2). Each leaf consists of a petiole, often swollen at the base, and a round to oval blade up to 15 cm wide. The swollen petioles enable it to float. Plants are typically 50 to 70 cm tall but can reach 100 cm. At the base of each leaf, roots develop that can form long, dense masses. Horizontal stolons, from which daughter plants develop, arise from axillary buds. As a result of this vegetative reproduction, large floating mats or islands of inter-connected plants can rapidly develop.

Water Hyacinth's inflorescence is a spike up to 50 cm high (Figure 3). Each spike has 8-15 sessile flowers. The flowers have a perianth tube about 1.5 cm long terminated by six lilac or purple lobes up to 4 cm long. When the inflorescence has fully emerged, its flowers begin to open. After fertilization, the peduncle with its immature seed capsules starts to bend down and eventually becomes submerged. Each seed capsule matures underwater and can contain up to 450 tiny seeds.

Water Hyacinth flowers are tristylous and have six stamens and one style (Barret 1989). These are arranged in three possible configurations: a short style and medium and long stamens, a medium style with short and long stamens, or a long style with short and medium stamens. The medium-style form is common in most infested areas in North America. The different style-stamen forms are sexually compatible, and pollination, often by wind, results in an excellent seed set.

Seeds are released underwater from the mature capsules. The seeds can germinate immediately under suitable conditions but can remain dormant for years under unfavorable conditions. Seed germination requires aerobic conditions and alternating temperatures. Consequently, Water Hyacinth populations are established from seed mostly on exposed mud after falling water levels. These seedlings are rooted initially in the mud but become free-floating as water levels rise. Seedlings develop stolons; thus, large floating Water Hyacinth populations can become established rapidly.

More detailed information about the biology of Water Hyacinth can be found in Penfound and Earle (1948), Gopal and Sharma (1981), Gopal (1987), and Barrett (1989).

INFESTATION

By the late 19th and early 20th centuries, Water Hyacinth had become established in the southern United States, with the first infestations reported in Louisiana and Florida. At first, there was some confusion about what was causing the reported problems. "There has been a statement recently going the rounds of the daily press to the effect that the hyacinth has run wild on the rivers and other inland waters of Florida, covering the surface with a solid mass of vegetation and sending their roots eight feet through the water to the muddy bottom. It is expressly implied that this is the hyacinth *par excellence*, the bulbous plant so prized for its fragrant trusses [sic] of bloom on our lawns in early spring. As a matter of fact, this is far from the truth. The plant in question is the so-called Water Hyacinth (*Piaropus crassipes*), a member of the pickerel-weed family, and not even remotely related to the true hyacinth, which is, of course, a member of the lily family (Knowlton 1903)."

How did Water Hyacinth get to Florida? The culprit, according to Knowlton (1903), was Mr. Fuller. "It [Water Hyacinth] is a native of India and was introduced into Florida by a Mr. Fuller, who imported the plants about fifteen years ago and had them growing in a lake on his estate near Palatka. The plants increased so rapidly that to rid himself of the superabundance he threw the surplus into the St. Johns River. They increased with such astonishing rapidity that they finally covered the surface for miles, impeding navigation and otherwise causing alarm, but they disappeared as suddenly as they came." Knowlton was mistaken about Water Hyacinth being a native of India, although it was first reported in India in the 1890s (Iqbal 2009). "… the hyacinth was brought to Calcutta Botanic Garden from Brazil in the 1890s and at a later date some ladies, being attracted by its flower, collected and transplanted these weeds to their gardens in Dhaka (Iqbal 2009)." In reality, Water Hyacinths probably were brought to Florida from Louisiana.

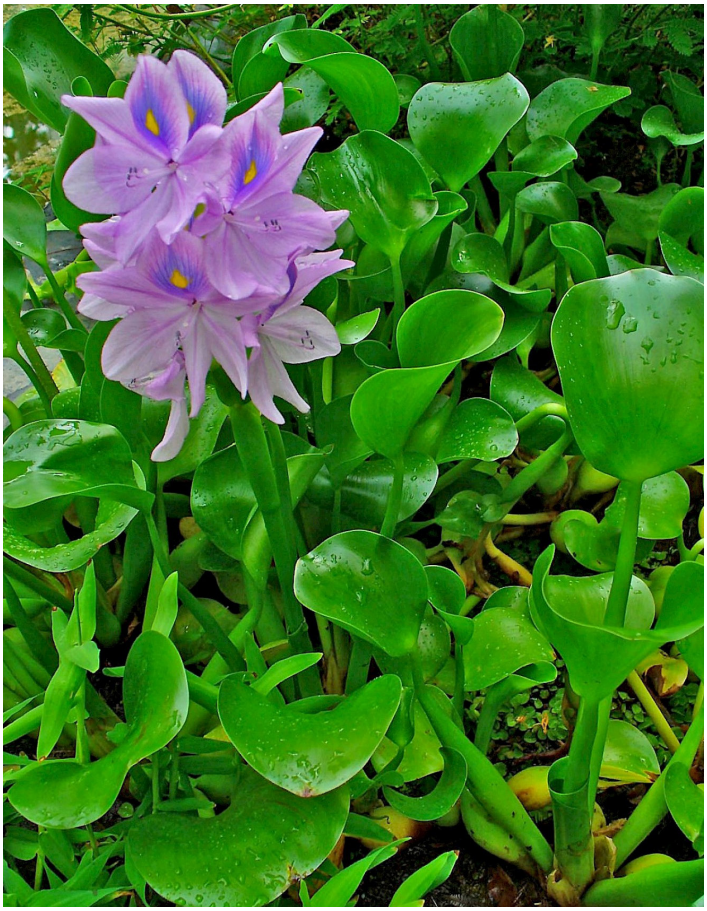

Figure 3. Flowering Water Hyacinth. (Photo by H. Zell; courtesy of Wikimedia Commons)

As an aside, the most incredible account of the introduction and spread of Water Hyacinth anywhere in the world comes from India. "The rapid spread of this weed in Bengal at the outset of the First World War has also been credited to the Germans, who wanted to weaken the British by killing their Indian subjects, hence it became known as the German pana or German weed (Iqbal 2009)." Biological warfare?

The earliest date that Water Hyacinth has been reported in the United States is 1884. This origin story is found in Klorer (1909): "It [Water Hyacinth] made its appearance here [Louisiana] at the time of the Cotton Centennial Exposition in 1884, being shown then as an exotic plant which readily made friends on account of its beautiful bloom and the little difficulty experienced in growing it. Some of the plants from New Orleans were taken to the surrounding parishes and cultivated in ponds and gardens as admirable aquatic specimens. It is supposed that they rapidly outgrew the limited water surface given to them and that they were cast out or probably dumped into some nearby stream and thus found conditions favorable to growing undisturbed." Klorer's account raises the question, how did Water Hyacinth get to Louisiana?

The most likely answer is that horticulturalists introduced it. Growing aquatic plants in aquaria (Hibberd 1856) and water gardens (Tricker 1897) was popular in the 19th Century. Exotic aquatic plants were imported and sold at local garden centers that stocked plants for water gardens. How easily Water Hyacinth could be obtained is described in a short article published in 1895 in *The Journal of Education*: "That the development of the aesthetic element in the child's nature is an essential part of his education is no longer questioned; and to this end, what simpler or more effectual means than the cultivation of a few flowers in the schoolroom? An admirable one for this purpose is the water hyacinth, which may be readily obtained of any leading florist for a trifling sum, providing no patron of the school has an extra root to give or throw away (Putnam 1895)." More sensible advice was published two years later in *The Water Garden*: "Advisable not to plant [Water Hyacinth] where it will not be winter-killed, as it will block navigable streams, and be a source of much trouble and expense to eradicate (Tricker 1897)."

Although the negative impacts of Water Hyacinth were first recorded in Louisiana and Florida in the 1890s, they were soon felt in Queensland, Australia in 1895, in South Africa in 1900, in Vietnam in 1908, and in Myanmar (Burma) in about 1913 (Gopal 1987, Iqbal 2009). Penfound and Earle (1948) summarized the damage caused by water hyacinth infestations: "… by (1) Obstructing navigation, (2) Impeding drainage, (3) Destroying wildlife resources, (4) Reducing out-of-doors recreation, and (5) Constituting a hazard to life (Penfound and Earle 1948)."

THE ST. JOHNS RIVER INFESTATION

The most dramatic and widely reported early water hyacinth infestation in the United States was in the St. Johns River in Florida (Lucas 1897, Webber 1897, Akroydd 1899, Curtiss 1900, Hope 1902). "Another case of obstruction by aquatic vegetation in America is found in Florida, U.S., North America, where — originally introduced from tropical South America for its beauty as a flowering plant — the so-called Water Hyacinth has become naturalized, and has increased to such an enormous extent in the St. Johns River as to cause serious apprehension that navigation may be altogether closed. …. small tributary creeks of the St. Johns River are entirely covered. The main channel of the river remains clear unless masses of the plants become so packed together as to produce a block. In most places the hyacinth grows to some extent on the muddy shores of the rivers and lakes, and the stolons become so entangled that the plants whose roots penetrate the soil serve to moor large floating masses to the shore. Masses get loose and are blown by the wind, even 25 miles up stream, and there form solid masses. Other large masses are carried by the current down to the sea.… Mr. Webber … gives a graphic account of the damage caused by obstruction to the rafts in which timber is brought down the river, and to fishing with nets, and an illustration … shows at once the great width of the St. Johns and the extent to which it is in places covered by Eichhornia, with large river steamers imbedded in it. Masses of the plant floating down stream get banked up against the long low bridge which carries a railway across the river or estuary and act as a dam to the water. Another illustration shows how the weed, floating down stream, is diverted by booms into docks similarly constructed, whence it is taken on shore and used as manure. (Hope 1902)." Similar infestations occurred worldwide with similar or worse impacts (Holms et al. 1969).

As soon as it was recognized as a significant impediment to navigation, a "war" on Water Hyacinth was declared (Dabney 1921). Ways to destroy Water Hyacinth began to be investigated, with the federal government often footing the bills (Ward 1914). Early solutions included crushing the plants, booms to prevent their spread (Figure 5), spraying them with a chemical solution previously developed to kill terrestrial weeds, and a "hyacinth elevator." Ward describes these pioneering efforts: "… a boat was equipped in New Orleans with rollers to crush the hyacinth and log booms to aid in gathering the plants. This apparatus worked very well in Louisiana. In 1900, spraying experiments were made with the Harvesta compound, made by the Harvesta Chemical Compounding Company of New Orleans. This gave satisfactory results at a much lower cost than the crushing method." However, the Harvesta chemical compound, which contained cyanide, proved to have unintended consequences. In Florida, Water Hyacinth was widely used as fodder for cattle. After Harvesta spraying, government authorities began to receive numerous complaints from farmers that sprayed Water Hyacinth was harmful to cattle. The River and Harbor Act of 1905 contained an appropriation for removing Water Hyacinth in the Florida waters, provided that no chemical be used that was harmful to cattle. "Accordingly, in Florida the method was adopted of breaking up the packs and pushing them into the current (Ward 1914)." Florida also experimented with

the "hyacinth elevator." A hyacinth elevator consisted of a catamaran scow, equipped with an inclined conveyor belt powered by a gasoline engine. It was the first aquatic weed harvester.

Ward (1914) summarized the various attempts to control Water Hyacinth: "There appears to be no method that will completely remove water hyacinth at a reasonable cost, although experiments have been made with every known chemical. Bodily removal is, of course, the most effective measure. This can be easily done with small areas. Spraying is the best method for large areas, but where the plant is eaten by cattle a mechanical device must be adopted like the hyacinth elevator that is used in the Florida waters. Good results can be obtained by closing creeks, bayous, and sloughs [with booms] (Figure 4) to prevent the movement of the plant to other waters." Until the advent of biological controls later in the 20th Century, the control methods described by Ward were the only ones for those charged with managing Water Hyacinth.

CURSE OR CROP

Not everyone considered Water Hyacinth infestations a problem to be solved by eradication. The glass-half-full optimists saw it as a resource to be exploited and quickly began exploring ways to turn this prolific plant into a money-making product (Bates and Hentges 1976; Pirie 1960). In many areas, feeding it to livestock (cattle, pigs) or using it as a soil supplement or mulch was successful (Sharma 1971; Wolverton and McDonald 1979; Gopal and Sharma 1981). See also Little's (1979) *Handbook of Utilization of Aquatic Plants. A Review of World Literature* for many more examples.

One of the primary problems facing would-be entrepreneurs is that Water Hyacinth is 90 to 95% water. Removing this water to produce a stable product is expensive. For example, Nolan and Kirmse (1974): "… [our] research study was part of an overall investigation of possible salable products from waterhyacinth plants harvested from the lakes and streams in Florida (Nolan and Kirmse 1974)." They did various studies to optimize the extraction of fibers suitable for paper-making from Water Hyacinth plants. Based on the whole plant, fiber yields were extremely low. Because fiber yields were so low, Water Hyacinth did not have salable value for the paper industry. Nolan and Kirmse tried to make the best out of their negative results. They ended their paper, "Even though this research has proved that commercially acceptable paper pulps cannot be made from waterhyacinths, publication of the procedures and the results obtained will, it is hoped, prevent others from undertaking an expensive research program to develop the use of waterhyacinth plants as a raw material for the paper industry."

Determining if Water Hyacinths can be used to make paper represents a sensible approach to finding a possible salable product. Not all proposals to exploit Water Hyacinth

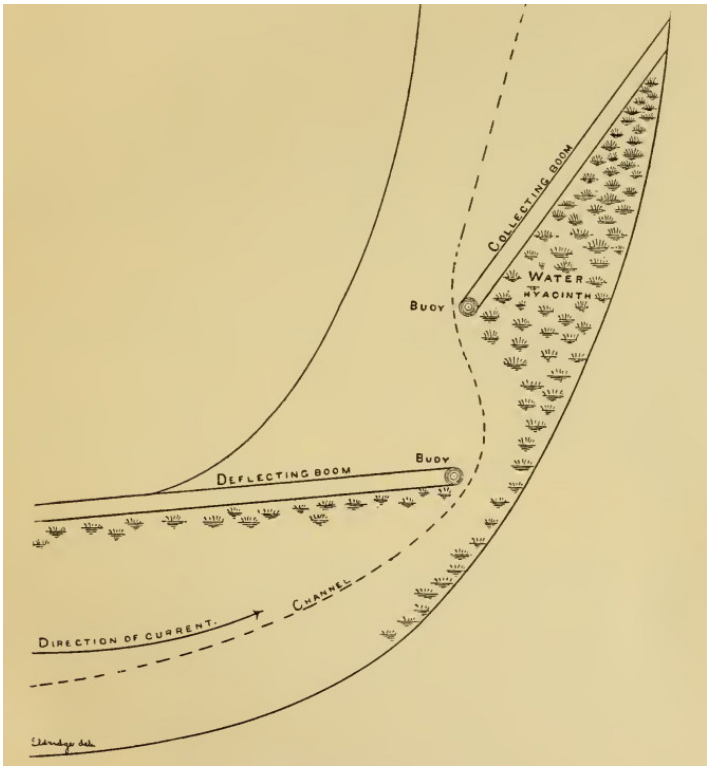

Figure 4. Deflection booms designed to remove Water Hyacinth from flowing water. (Source: Webber 1897)

Figure 5. A boom to prevent Water Hyacinth in tributary streams from entering the main river channel. (Source: *A Photo History of Florida Steamboats and Water Hyacinth Management*; courtesy of the Center for Aquatic and Invasive Plants, Institute of Food and Agricultural Sciences, University of Florida, and the Florida Fish and Wildlife Commission)

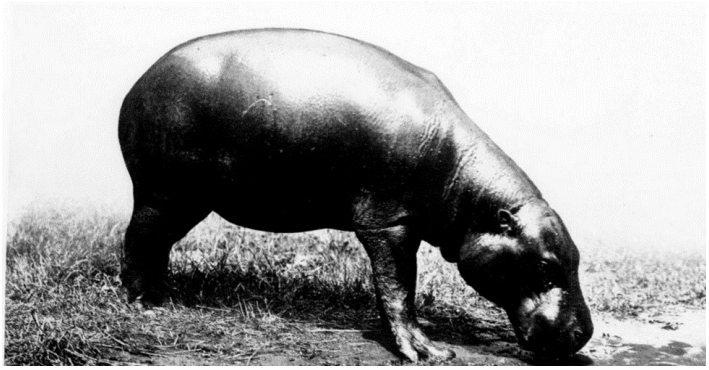

Figure 6. Pigmy hippo. (Source: *The Journal of Heredity* Volume 5, Number 21; 1914)

commercially were so rational. In 1914, *The Journal of Heredity* published arguably the most farfetched paper on turning aquatic weeds into cash. Its full title was "MEAT PRODUCTION IN SWAMPS: Introduction of Pigmy Hippopotamus Offers Opportunity for Utilization of Large Areas in Southern States to Produce Excellent Meat at Low Cost — Difficulties of Securing Breeding Stock at Last Overcome." The paper points out that the Southern states have over 10,000 square miles of wetlands. "… If properly seeded to water hyacinth and other aquatic plants, this vast region would be capable of producing a million tons of [pigmy hippo] meat per annum, worth $100,000,000 (P. B. P. 1914)." Its author, P. B. P., goes on to say that "the flesh … is highly esteemed, and when salted and cured, is known in the Cape of Good Hope [South Africa] as Zee-Koe Speck (lake-cow bacon)." The frontispiece for the issue containing this 1914 paper is a picture of a pigmy hippo (Figure 6). The paper ends more soberly: "At present the cost of breeding animals is prohibitive, the New York Zoological Society having paid $12,000 for three …."

Other attempts to find commercially viable uses for Water Hyacinth also have banked on its high productivity, e.g., for removing pollutants from water. Although Water Hyacinth has been shown repeatedly to be able to remove pollutants from contaminated water, what to do with the contaminated plants remains a problem. Biogas and biofuel production is possible, but this has never been done on more than a pilot scale. So far, no industrial-scale uses of Water Hyacinth have been developed.

THE HYACINTH CONTROL SOCIETY

"The introduction and rapid spread of the water-hyacinth (*Piaropus crassipes*) in some of the rivers of Florida, and the consequent injury to navigation, fishing, lumbering, and other industries, attracted considerable attention a few years ago, but since that time the plants are said to have so decreased in numbers as to be no longer troublesome (Harper 1903)." Although the scourge of Water Hyacinth in north Florida had diminished by the start of the 20th Century, its impacts further south in the state had just begun. During the

Figure 7. Hickey Creek, a tributary of the Caloosahatchee River in southwest Florida, was choked with Water Hyacinth in 1917. (Source: *A Photo History of Florida Steamboats and Water Hyacinth Management*; courtesy of the Center for Aquatic and Invasive Plants, Institute of Food and Agricultural Sciences, University of Florida, and the Florida Fish and Wildlife Commission)

first half of the 20th Century, Water Hyacinth was a serious aquatic weed problem in South Florida, and Water Hyacinth infestations (Figure 7) continued to interfere with recreational and commercial activities in rivers and lakes. This forced local governments to adopt measures to manage it. As more and more local government employees became involved in water hyacinth management, interest arose in establishing a professional organization to serve their needs. In 1961, the Hyacinth Control Society was incorporated precisely so that managers in Florida could share information on their efforts to control Water Hyacinth. The Society was one of the first formed to manage an invasive species in natural areas. Although it saw its mission allied more with weed science than wetland science, the Hyacinth Control Society was also one of the first organizations formed to protect and manage native wetlands in some sense.

According to the history of the Society on its website, its founding fathers, i.e., the subscribers to the Society's Incorporation papers, were all from Florida, mostly South Florida. T. W. Miller, the Society's first president, was the Director of the Lee County Hyacinth Control District. A. S. Chipley was a member of the Board of the Lee County Mosquito Control District, as was William Dryden. Thomas O. Fultz was the Mosquito Control Director of Polk County. Edward L. Seabrook was the Director of the Palm Beach County Mosquito Control District. Herbert J. Friedman was a businessman in Tampa, FL, who had served on several mosquito and hyacinth control programs. D. E. Seaman worked for the U.S. Department of Agriculture in Ft. Lauderdale on the biology and control of aquatic plants. Two things are evident from the affiliations of the "founding fathers": (1) the Society was initially established for and

governed by local government employees, and (2) Water Hyacinth control was closely linked to mosquito control. Because mosquitoes were vectors of human diseases like malaria, mosquito control was a significant public health problem in the southern United States (van der Valk 2022a). Thus, mosquito control was also an essential responsibility of Florida's local governments, as it is today.

At first, the Society's foci were (1) determining the extent of the Water Hyacinth problem and (2) developing the infrastructure needed to plan and fund control projects. Besides having an annual meeting, in 1962, the Society began to publish its *Hyacinth Control Journa*l. During the first decade of its publication, its papers dealt increasingly with controlling aquatic weeds with herbicides. With the establishment of other aquatic weeds, especially hydrilla (*Hydrilla verticillata* (L. f.) Royle), in Florida, the Society's mission was broadened to include their management.

After years of debate, the Hyacinth Control Society changed its name in 1976 to the Aquatic Plant Management Society. Accordingly, it re-named its journal the *Journal of Aquatic Plant Management*. By the early 1970s, the ever-lengthening list of aquatic weeds in Florida now included Eurasian watermilfoil (*Myriophyllum spicatum* L.), which was also a problem in wetlands outside of Florida. Gradually, the Society began attracting members from outside the state, and eventually, regional chapters were established. Since the 1980s, the Society has continued to expand in the United States and internationally. According to its website, the Society's objectives are "to promote the management of nuisance aquatic plants, provide for the scientific advancement of members of the society, encourage scientific research, promote university scholarship, and stir public interest in the aquatic plant science discipline."

The Hyacinth Control Society was the first professional organization established by and for people working on wetland management in the United States. Compared to the Society of Wetland Scientists' mission, its narrow focus is understandable. The Hyacinth Control Society was founded to serve government employees working on aquatic weed management. Nevertheless, the Hyacinth Control Society provided professional support and professional identity for a subset of managers and, eventually, scientists working to protect American wetlands. Their essential work allowed the public to use wetlands for recreation (boating, fishing, hunting, etc.), which helped to raise public awareness of the societal importance of wetlands and, thus, their preservation.

SUMMARY

Water Hyacinth, indigenous to tropical and subtropical South America, reached the United States in the 1880s and, by the 1890s, had become a significant problem in Florida rivers, most notably the St. Johns River. Because it was an attractive plant highly prized by water gardeners, it rapidly spread throughout the southeastern states. Water Hyacinth is a large free-floating plant (50 to 70 cm tall) that can become established from seed and vegetative fragments. Vegetative reproduction is by stolons, which can rapidly create large floating mats of interconnected plants.

When floating mats of Water Hyacinth began to interfere with steamboats transporting goods and people on the St. Johns River and other navigable rivers, the federal government started funding projects to control it. Various control measures were tried, including mechanical harvesting, primitive herbicides, and physical barriers (booms). None proved completely effective, and the primitive herbicides caused serious collateral damage. Many ways to turn Water Hyacinth into a salable commodity, from making paper to raising pigmy hippos for meat, were explored. Still, none proved to be viable on a commercial scale.

The lack of a permanent solution to Water Hyacinth infestations required local Florida governments to hire staff to deal with them in their jurisdictions. Over time, the number of people working on Water Hyacinth control increased rapidly, and this resulted in the establishment of the Hyacinth Control Society in 1961 to facilitate the exchange of information about the effectiveness of various control measures. In 1962, the Hyacinth Control Society began publishing a journal. The Hyacinth Control Society was among the first, if not the first, organization dedicated to protecting the integrity of America's natural wetlands.

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