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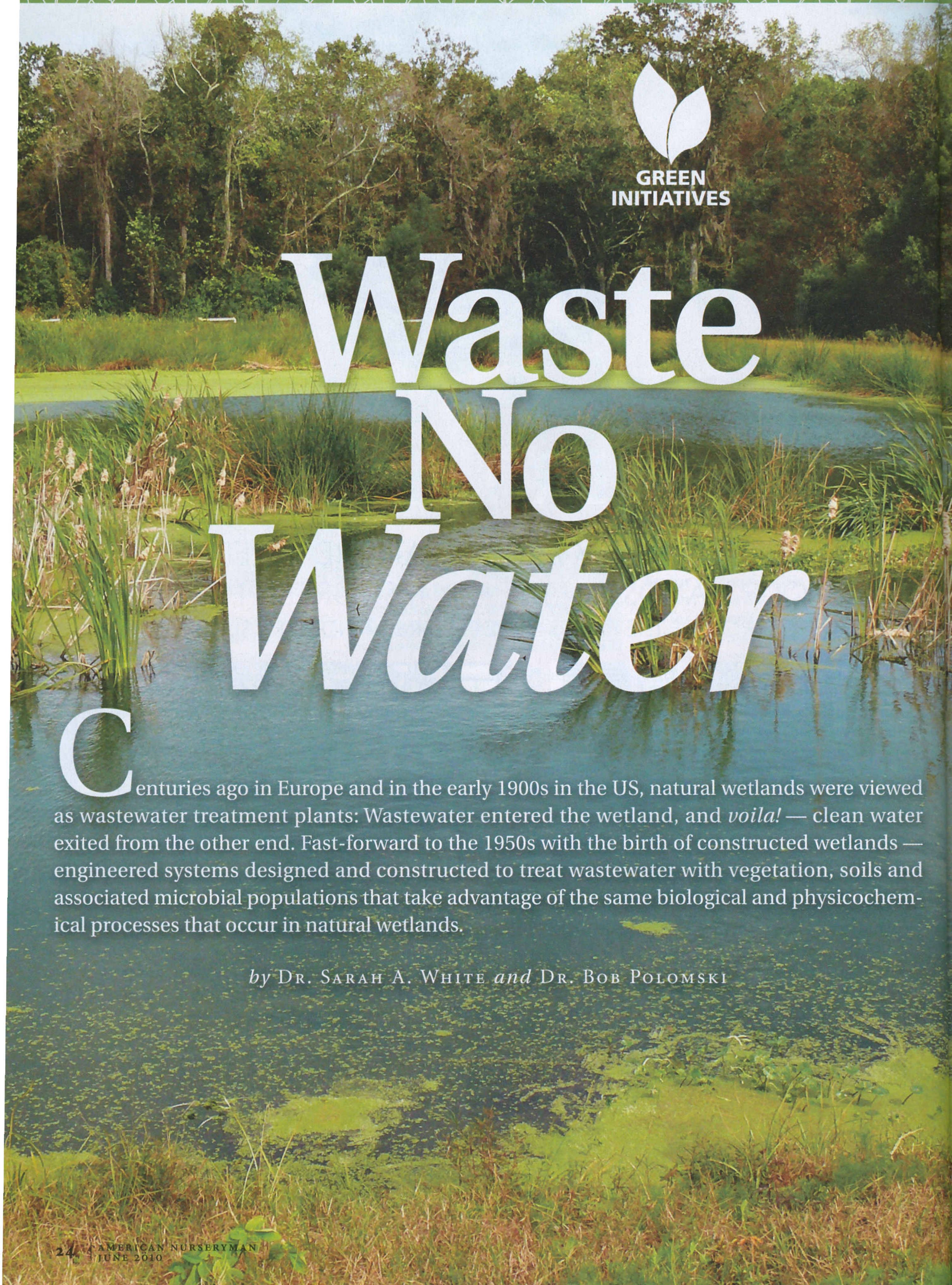
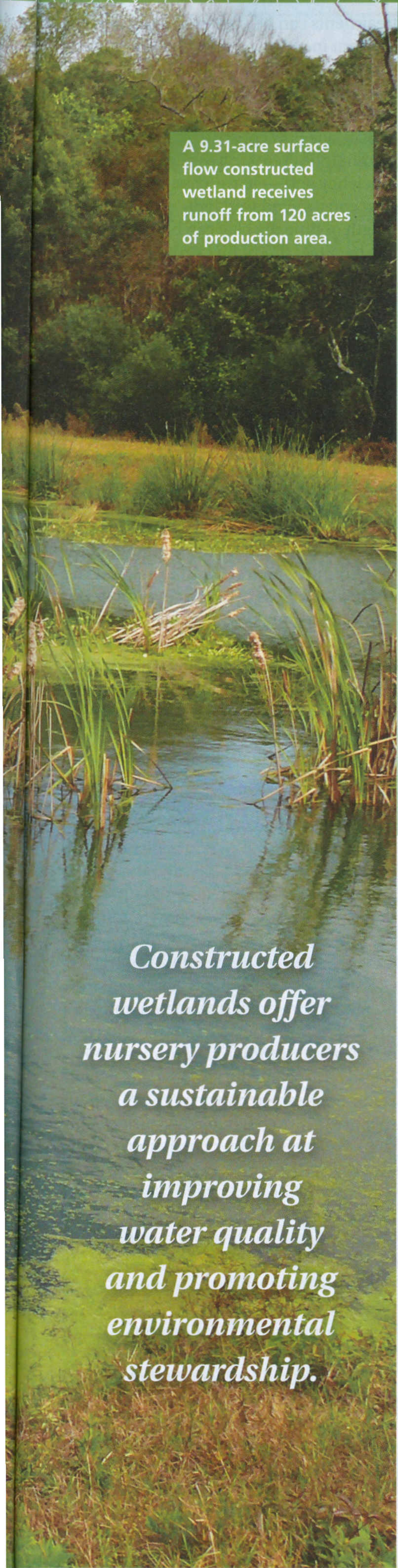


GREEN INITIATIVES

Waste No Water

Centuries ago in Europe and in the early 1900s in the US, natural wetlands were viewed as wastewater treatment plants: Wastewater entered the wetland, and *voila!* — clean water exited from the other end. Fast-forward to the 1950s with the birth of constructed wetlands — engineered systems designed and constructed to treat wastewater with vegetation, soils and associated microbial populations that take advantage of the same biological and physicochemical processes that occur in natural wetlands.

by Dr. Sarah A. White *and* Dr. Bob Polomski



A 9.31-acre surface flow constructed wetland receives runoff from 120 acres of production area.

PHOTO COURTESY OF DR. SARAH A. WHITE

Constructed wetlands offer nursery producers a sustainable approach at improving water quality and promoting environmental stewardship.

Diverse plants for surface flow constructed wetlands

The following is a list of wetland plants growing in a surface flow constructed wetland system at a commercial nursery in Cairo, GA.

Common name	Botanical name	Wetland occurrence
Cattail	*Typha latifolia*	Widespread; greater than 80%
Duckweed	*Lemna valdiviana*	Widespread; greater than 80%
Floating pennywort	*Hydrocotyle ranunculoides*	Widespread; greater than 80%
Water pennywort	*Hydrocotyle umbellata*	Widespread; greater than 80%
Pickerelweed	*Pontederia cordata*	Abundant; 50% to 80%
Alligatorweed	*Alternanthera philoxeroides*	Common; 20% to 50%
Broadleaf arrowhead	*Sagittaria latifolia*	Common; 20% to 50%
Giant bulrush	*Schoenoplectus californicus*	Common; 20% to 50%
Maidencane	*Panicum hemitomon*	Common; 20% to 50%
Watermeal	*Wolffia brasiliensis*	Common; 20% to 50%
Carolina mosquito fern	*Azolla caroliniana*	Uncommon; 5% to 20%
Climbing hemp-vine	*Mikania scandens*	Uncommon; 5% to 20%
Golden canna	*Canna flaccida*	Uncommon; 5% to 20%
Smooth beggartick	*Bidens laevis*	Uncommon; 5% to 20%
Water primrose	*Ludwigia leptocarpa*	Uncommon; 5% to 20%
American cupscale	*Sacciolepis striata*	Rare; less than 5%
Asian dayflower	*Murdannia keisak*	Rare; less than 5%
Bermudagrass	*Cynodon dactylon*	Rare; less than 5%
Black willow	*Salix nigra*	Rare; less than 5%
Bulltongue arrowhead	*Sagittaria lancifolia*	Rare; less than 5%
Common rush	*Juncus effusus*	Rare; less than 5%
Curly dock	*Rumex crispus*	Rare; less than 5%
Elderberry	*Sambucus canadensis*	Rare; less than 5%
Jointed spikesedge	*Eleocharis equisetoides*	Rare; less than 5%
Knotweed	*Polygonum punctatum*	Rare; less than 5%
Redroot flatsedge	*Cyperus erythrorhizos*	Rare; less than 5%
Soft rush	*Juncus effusus*	Rare; less than 5%
Swamp barnyardgrass	*Echinochloa walteri*	Rare; less than 5%
Wild ageratum	*Conoclinium coelestinum*	Rare; less than 5%

Since their origin in Germany, constructed wetlands have been studied and implemented around the world. They have been used for decades, mostly for the treatment of domestic or municipal sewage, which largely focused on reducing nutrients, suspended solids, heavy metals and pathogens. Success in cleansing municipal and industrial point-source discharges led to the widespread use of constructed wetlands to treat many other types of wastewater, including industrial and agricultural wastewaters, acid mine drainage, landfill leachate and stormwater runoff (suspended solids, organics, oil and grease, and heavy metals).

For the nursery and greenhouse industry, constructed wetlands offer producers an inexpensive approach for treating runoff containing nutrients, pesticides and other organic contaminants, allowing compliance with increasingly stringent environmental regulations regarding the discharge of nonpoint-source pollutants.

Three types of constructed wetland systems exist: surface flow (free water surface), subsurface flow (horizontal or vertical flow) and floating vegetated wetlands (floating vegetated mat systems). Surface flow and subsurface flow constructed wetlands are commonly used to treat agricultural wastewater.

Surface flow constructed wetlands. A surface flow constructed wetland resembles a shallow (0.5 to 2.5 feet) freshwater marsh and generally requires a large land area for wastewater treatment. To remediate nursery and greenhouse wastewater, surface area can be reduced with a concomitant increase in depth (approximately 3 to 4 feet), which promotes anaerobic conditions that facilitate denitrification.

A researcher at Clemson University, Clemson, SC, has been studying the nutrient-removal effectiveness of a surface flow constructed wetland at a large nursery in southern Georgia since 2002. The research, funded as part of the USDA-Agricultural Research Service Floriculture and Nursery Research Initiative, studies a 9.31-acre surface flow constructed wetland built in 1997 and populated by diverse obligate and facultative wetland plants (photo, opposite). Obligate

Subsurface flow constructed wetlands lined with fired-clay media and planted with phosphorus hyperaccumulators can consistently remove phosphorus from nutrient-rich runoff.

wetland plants are found in wetlands 99 percent of the time; facultative wetland plants are found in wetlands between 67 percent and 99 percent of the time (table, page 25).

In a five-year study (April 2002 to June 2007) that monitored nitrogen and phosphorus reduction from inflow to outflow, the surface flow constructed wetland was highly efficient at removing nitrogen from nursery runoff from a 120-acre catchment (large container production area), although it failed to consistently lower orthophosphate levels in runoff.

The researcher concluded that a surface flow constructed wetland is suitable for removing oxidized nitrogen forms (notably nitrate-nitrogen) from nursery runoff and — depending on size — is capable of handling the large volumes of runoff generated by medium to large nursery and greenhouse operations.

Surface flow constructed wetlands work best for high to moderate runoff volumes, where land is both available and affordable. Nitrogen (nitrate, nitrite and ammonia) removal in constructed wetland systems is highly efficient, with greater than 90 percent removal efficiency from midspring through late fall. Efficiency declines during winter months, but substantial nitrogen removal does continue. Constructed wetland systems should be large enough to retain water for three to three-and-a-half days.

Phosphorus removal is more variable, and simply passing water through a surface flow constructed wetland will not adequately reduce phosphorus levels. Additional action is necessary. A secondary subsurface flow cell receiving discharge from the primary free water surface cell, lined with fired-clay particles, is the most reliable and consistent phosphorus treatment option. The clay used should have sufficient particle size to prevent clogging and to allow infiltration and water movement; it should be examined for its capacity to bind phosphorus.

Water moves through this portable subsurface flow constructed wetland, which is established with bulrush, via a solar-powered pump.

The clay's phosphorus-removal efficiency declines as binding sites fill, so monitoring is necessary to determine when to replace the clay. These secondary treatments can be greater than 80 percent efficient in reducing phosphorus concentrations in discharge.

Planting nitrogen and phosphorus "hyperaccumulators" in surface flow and/or subsurface flow constructed wetlands can also help increase phosphorus-removal efficiency and — in the case of subsurface flow constructed wetlands — increase the length of time the clay can bind phosphorus because the plants provide an additional phosphorus sink.

Some species that show potential for removing excess phosphorus from runoff include *Canna* 'Yellow King Humbert' ('Yellow King Humbert' canna), *Iris* 'Full Eclipse' ('Full Eclipse' Louisiana iris), *Pontederia cordata* 'Singapore Pink' ('Singapore Pink' pickerel rush) and *Thalia geniculata* f. *rheumoides* (red-stemmed alligator flag).

Subsurface flow constructed wetlands. Surface flow constructed wetlands typically require a large land area, and the concomitant loss of production for remediation area makes them less attractive to greenhouse and nursery operations constrained by limited production space and expensive land. Subsurface flow constructed wetlands offer producers a viable alternative.

A subsurface flow constructed wetland consists of a lined or impermeable basin filled with a 2-foot-deep coarse medium having high hydraulic conductivity — typically pea gravel — and wetland plants (photo, above left). Wastewater flows horizontally or vertically below the surface of the media to prevent exposure to humans or wildlife; remediation is aided by plants and associated microbial populations.

Subsurface flow constructed wetlands are better for winter treatment compared to surface flow constructed wetlands and emit less total ammoniacal nitrogen (NH_3-N and NH_4^+-N) to the atmosphere; volatilization appears to play a more prominent role in the nitrogen budget of surface flow than subsurface flow constructed wetlands. However, the gravel substrate of subsurface flow constructed wetlands is costly, and treatment longevity is finite because substrate clogging may occur after several years of operation.

A portable subsurface flow constructed wetland system was developed by Mobile Environmental Solutions Inc., Tustin, CA (photo, below left). The "portable wetland" uses bulrush (*Schoenoplectus* sp.) planted in a lightweight medium of three-eighths-inch pumice. Inflow and outflow pipes manage the movement of water in this self-contained system, which can be transported by a midsized pickup truck.

Floating vegetated mat systems are established with liners of various aquatic species placed in aerator cups. Roots grow through the cups and into the water column, providing surface area for nutrient-processing microorganisms.

PHOTOS COURTESY OF DR. SARAH A. WHITE

At a glance

For more information about cleaning runoff with a constructed wetland system, visit http://tinyurl.com/sustainable-nursery.

Floating wetlands. Floating vegetated wetlands offer nursery producers another wetland remediation system option. Floating wetlands are potential alternatives to constructed wetland systems and could be established in drainage ditches or retention ponds. Once established, floating wetlands provide nutrient-processing functions similar to wetlands. They have been used in swine-wastewater lagoons, fishery wastewater and retention ponds.

These wetlands float on the surface of the ponds, placing large root-surface areas in contact with the water column. This surface area in the water column provides habitat for nutrient-metabolizing microbes, aids in direct filtration of particulate matter from the water and enhances nutrient uptake by plant species.

Instead of using free-floating plants, such as duckweed (*Lemna valdiviana*), water hyacinth (*Eichhornia crassipes*) or water lettuce (*Pistia stratiotes*), the floating mat treatment system accommodates emergent plants, which greatly expands the plant palette (table, below). Multiple types of floating wetlands are available.

One option uses a half-inch-thick mat made of a buoyant material that floats on the pond's surface. Plants growing in special containers are placed in the holes; their roots grow freely in the water to "mine" the water for nutrients and to provide a large surface area for colonizing microorganisms (photos, above).

At Clemson University, we assessed the potential of floating wetlands to remediate nutrient-rich runoff similar in composition to water flowing from the stormwater treatment areas into the Florida Everglades. The floating mats were established with bentgrass (*Agrostis* sp.), golden canna (*Canna flaccida*), mountain spikerush (*Eleocharis montana*) and soft rush (*Juncus effusus*). After five months of sampling, we found the floating wetlands reduced both nitrogen and phosphorus effluent concentrations. Nitrogen and phosphorus removal were consistent in both the pond and vegetated channel floating wetland treatments.

Floating wetlands may have great potential when used to "polish" nutrient-rich water. They are easy to install, maintain and harvest, and may prove to be an economically feasible treatment technology for polishing water quality to very low phosphorus effluent concentrations. The ease of floating wetland installation into retention ponds or drainage ditches makes this a less expensive approach than other remediation systems.

An additional benefit of floating wetlands is easier harvest of plant mass for additional nutrient removal; they can be adapted to various site-specific functions, facilitating quick installation, rapid establishment and simpler harvest. Any nutrients fixed in plant roots or shoots are easily removed from the aquatic system as plants are harvested. This harvested tissue may then be used as a media amendment or nutrient source if properly composted. It also permits use of plants other than the typically invasive free-floating plants.

Further work needs to be done to identify nutrient-specific hyperaccumulating species that offer functionality and aesthetics, allowing for customization. Also, we would like to evaluate their effectiveness in remediating nutrient and pesticide loads in irrigation ponds. Floating wetlands are easy to install and harvest, expanding their utility from simple nursery treatment systems to potential aquatic gardens for water features on golf courses and residential retention ponds.

Constructed wetland systems comprise a part of a whole-systems approach to nursery crop production that involves effective fertilizer, water and pesticide management, as well as the successful capture and cleansing of runoff. This approach can protect the environment and improve the economic viability of your operation.

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Emergent plants for floating vegetated wetlands

The following is a list of emergent plants evaluated in floating vegetated wetland studies.

Common name	Botanical name
Bentgrass	*Agrostis* sp.
Bermudagrass	*Cynodon dactylon* 'Tifton 85'
Canna	*Canna* 'Australia'
Carolina willow	*Salix caroliniana*
Cattail	*Typha latifolia*
Elephant ear	*Colocasia esculenta* 'Black Magic'
Giant reed	*Arundo donax*
Golden canna	*Canna flaccida*
Iris	*Iris ensata* 'Variegata'
Iris	*Iris laevigata*
Maidencane	*Panicum hemitomon*
Mountain spikerush	*Eleocharis montana*
Napier grass	*Pennisetum purpureum*
Soft rush	*Juncus effusus*
St. Augustine grass	*Stenotaphrum secundatum*
Wild millet	*Panicum miliaceum*