California Bulrush Improves Wetland Water Quality

By Herry S. Utomo and Ida Wenefrida

As the social demand for a cleaner and better environment grows, more ecological engineering that incorporates phytoremediating plants will be integrated in the architecture and design of better quality human settlements and other social and sport facilities. Blended into the designed landscape, these plants will add aesthetic values of the design while providing a natural way to remove various pollutants and waste.

California bulrush (*Schoenoplectus californicus*), also known as giant bulrush, can facilitate removal of some toxic metals from both municipal and industrial pollutants. In wetland construction and reconversion of degraded marshes, this plant helps improve water quality.

California bulrush is a perennial graminoid plant commonly found in marshes, swamps, seeps, lake, washes, floodplains, along lake and stream margins and in wet meadows. It spreads primarily by vegetative propagation, producing new stems from an extensive system of underground rhizomes and, to a limited extent, through seed dispersal. It can grow in relatively deep water of 36 inches or more to produce extensive colonies. When established in conjunction with shorelines, California bulrush provides an effective buffer that dissipates wave energy, reduces shoreline scouring, and traps suspended sediments and other solids. Dense stands of California bulrush are efficient users of available nutrients, producing significant amounts of organic matter. The cumulative effects of organic matter production, sediment trapping and erosion control not only provide shoreline protection, but also accelerate sediment accumulation and near-shore building.

In addition, this plant has been known to provide a favorable habitat for wildlife, including some endangered species.

Removing pollutants from water

In recent years, ecological engineering has been increasingly used to address a broad range of issues, including to better design and architecture of human settlements, to treat pollutants and hazardous waste, to conduct ecological restoration and remediation, and to protect fundamental food production. Constructed wetlands, common around golf courses, are a part of ecological engineering to address a variety of purposes, from restoring degrading wetlands to serving specific functions: buffering valuable aquatic

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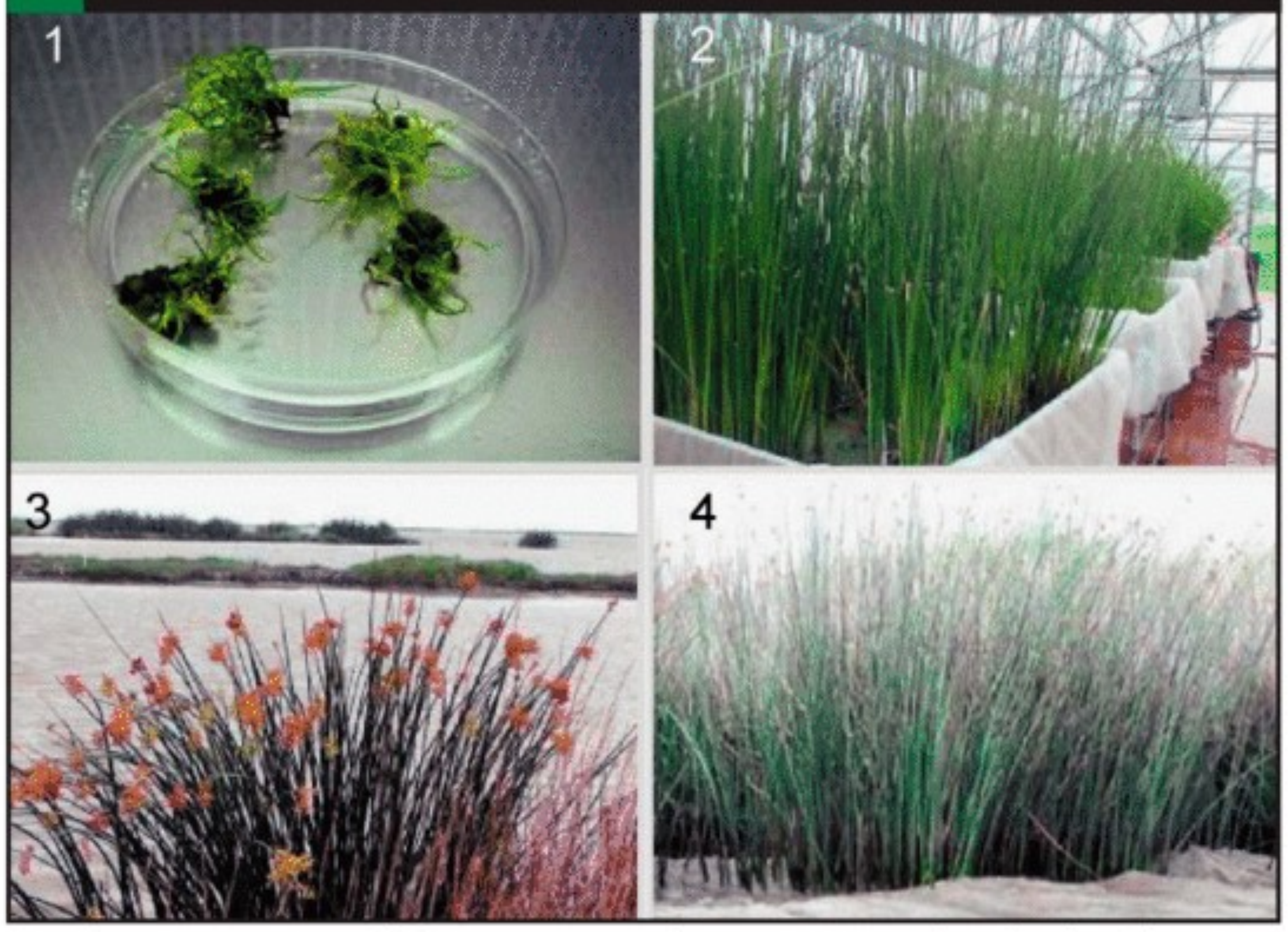
TABLE 1

Performance of California bulrush breeding line LA268 and Restorer in multi-year trials

Trait	Mean[1]	
	LA268	Restorer
Rate of spread (m^2/yr)[†]	7.52[a]	5.17[b]
Plant height (cm)[†]	182.8[a]	164.7[b]
Stem diameter (mm)[†]	13.14[a]	12.40[a]
Stem count[††]	81.7[a]	43.3[b]
Stem count[†]	1538[a]	1332[b]
Number of panicles[†]	738[a]	712[a]
Panicle weight[†]	636.5[a]	467[b]
Salinity tolerance	Moderate	Moderate

[1]Values in the same row followed by the same letters are not significantly different ($P<0.05$)
[†]Freshwater plots (3 blocks, 4 replications; 2 year data)
[††]Brackish marsh (3 blocks, 4 replications; 2 year data)

PHOTO A



Under appropriate laboratory conditions (1), individual cells are capable of self-regeneration into whole plants (2). A promising line, LA309, has been identified for potential release based on trials at a Great Lakes site (3 and 4).

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systems from point and non-point sources of pollutants, and as a treatment area to remove toxic metals from wastewater, storm water runoff and chemical runoff. California bulrush, together with other plants such as cattail (*Typa angustifolia*), has the ability to phytoremediate contaminants from the water and soil (Hawkins et al., 1997; Murray-Gulde et al., 2005).

These plants can take up the hazardous level contaminants, including mercury (Hg), selenium (Se), lead (Pb), zinc (Zn), methyl (Me) and arsenic (As), from the water and soil and translocate them into various organs, such as roots, shoots and leaves. Colonies of California bulrush provide strong interwoven root masses that stabilize sediment surface and soil matrix and prevent erosion and re-suspension of the precipitated contaminants. Vigorous biomass of California bulrush can provide significant binding sites for these harmful elements, allowing these metals to be sequestered in wetland sediments in non-bioavailable forms.

When California bulrush was used in a wastewater treatment, bio-concentration factors (ratio between concentration of metal in the plant and in the water) of 1,911 for Hg, 9,593 for Se and 4,927 for As have been reported (Sundberg-Jones and Hassan, 2007). The ability to tolerate toxic metals varies among plants. In cases where natural vegetation cannot grow due to high levels of metal toxicity, California bulrush can be used as a cover plant to mitigate the problem until favorable conditions are achieved to allow re-establishment of natural vegetation.

Use for erosion control

California bulrush can be used for erosion control along golf course pond and stream shorelines, canal banks, levees and other areas of soil-water interface. Its colonies tend to grow parallel to and continuous along shorelines, or in unobstructed habitats in solid, somewhat circular, stands that may exceed an acre or more. Its stems effectively trap sediment and serve as a buffer to dissipate wave energy, thus enhancing the establishment of other vegetation along the shorelines.

When used as open-water barriers, California bulrush significantly dissipate wave energy, reduces suspended sediments, improves water quality and promotes diverse communities of submerged underwater aquatics. In highly impacted areas, such as Louisiana coastal wetlands where an unprecedented magnitude of coastal marsh loss occurs, better adapted and superior cultivars of California bulrush are needed. It can provide both short- and long-term vegetation.

When properly established and in the appropriate habitat, California bulrush will persist and potentially remain effective indefinitely. California bulrush has a relatively low tolerance to salinity and therefore is generally restricted to fresh and intermediate marsh habitats. Greater salt tolerance in California bulrush will increase its role in reducing coastal erosion control and restoring salt marshes.

Genetically improved bulrush

Since natural variation found in California bulrush does not provide preferable levels of salt tolerance, novel plants need to be developed. In an attempt to improve salt tolerance, parts of actively growing flowers from one of the most tolerant lines were used to produce callus cultures on media containing growth regulators. This produced millions of break-free

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individual cells. Under appropriate laboratory conditions, these individual cells will be capable of self-regeneration into whole plants (Photo A — 1 and 2). Using this approach, what would require thousands of acres to grow millions of plants in a typical farm setting can substantially be reduced into laboratory-size petri dishes. Our cellular selection using millions of cells has yielded 384 lines generally regarded as salt tolerant. These lines are being grown in the greenhouse for further evaluation in coming years. These salt-tolerant mutants are not considered genetically modified organisms and, therefore, will not be subjected to a strict regulation associated with the use of genetically modified organisms. If these plants retain their salt tolerance as they did at the cell level, they will be readily available for use in coastal marsh restoration.

Promising line

A promising line, LA309, has been identified for potential release. These lines were selected based on replicated preliminary field tests at the Rice Research Station in 2004 and 2005, followed by multi-location trials in 2006 to 2008 at the Great Lake site (Photo A — 3 and 4). An additional testing site at Sweet Lake, Cameron, La., was added in mid-2008. In the preliminary field tests, a total of 48 bulrush ecotypes collected from marshes across Louisiana was evaluated in replicated field trials at the Rice Research Station.

Nine promising lines that have good spreadability, stem density, biomass accumulation and seed production were selected for multi-location trials in 2006 at the Great Lake site, and in 2008 at Sweet Lake.

In parallel to the field tests, greenhouse screening to determine the salt-tolerance level among these ecotypes was also carried out in the same years. After exposure in a salt concentration of 12 parts per thousand in continuous flooding for six months, eight survivors were recovered, increased in the greenhouse and included in the replicated multi-location trials together with the original nine lines.

Experimental line LA268 spreads fastest among the 48 tested accessions. Under a freshwater environment, LA268 spreads vegetatively with an average rate of 7.5 m^2 (square meters) annually (Table 1). With an average height of 182.8 cm (18 cm taller than Restorer), LA268 has dark green hard stems with an average diameter of 1.3 cm. Mature seed has an average germination rate of 4 percent, shows dormancy and a portion of the seed remains viable for several years if the seed is left in the ground. Development of improved California bulrush lines will help in erosion control efforts, remediate metal toxicity and pollutant problems and increase the effectiveness of wastewater treatments.

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