An Initial Restoration Tool for Submersed Aquatic Vegetation

Healthy submersed aquatic vegetation beds provide food and habitat for wildlife, improve water quality, and protect our shores from erosion. Determining where underwater plantlife will thrive is therefore essential to any coastal restoration project. Below, the authors describe a tool for predicting potential growth.

By Hyun Jung Cho and Christopher A. May

Submersed or Submerged Aquatic Vegetation (SAV)—the group of flowering plants that have adapted to submerged life—plays several ecologically and commercially important roles in aquatic environments. Although fast growing SAV sometimes becomes a nuisance in inland freshwater bodies, SAV beds, particularly those lying in coastal environments, serve as essential food and habitat for waterfowl and aquatic animals. Healthy beds of SAV also help improve water quality and protect shores by assimilating excess plant nutrients and toxins, buffering wave energy, and stabilizing sediments. Therefore, SAV beds affect processes, evolution, and fates of coastal features such as estuaries (Carpenter 1981), and their distribution, abundance, and composition are widely accepted as good indicators of aquatic environmental quality (Dennison et al. 1993).

The federal Magnuson-Stevens Fishery Conservation Act of 1996 designates SAV as an essential fish habitat, meaning that fish depend on SAV for long-term survival and reproduction. Finfish and shellfish use this important resource to feed, raise young, and hide from predators. Some of the species that use SAV habitat for feeding or to raise young include blue crabs (Callinectes sapidus), brown and white shrimp (Farfantepenaeus spp.), dabbling ducks (Anas spp.), spotted seatrout (Cynoscion nebulosus), red drum (Sciaenops ocellatus), mullet (Mugil cephalus, M. curema), dolphins (Tursiops truncatus), and manatees (Trichechus manatus). Hundreds of millions of dollars are generated through commercial fishing, recreational fishing, and ecotourism activities focused on coastal environments. A 1995 estimate of the economic value of the commercial fisheries alone for the Gulf of Mexico was $823 million (NOAA 1997). Consequently, healthy SAV means a healthy economy for several communities. Sadly, SAV is on the decline.

Restoring SAV Habitat

The global trend of decline in coastal SAV is not news to most of us in the wetlands community. The causes for the decline vary extensively:

• geological events including coastal uplift and subsidence;
• tropical storms and hurricanes;
• biological disturbances including excessive local grazing by fauna;
• pathogenic microbes and diseases;
• increased levels of plant nutrients that cause phytoplankton blooms and excessive epiphytic algal growth;
• agricultural and urban runoff that increase turbidity;
• reduced dissolved oxygen and the introduction of toxic materials, which degrade the grazer community and control epiphytic algae on SAV;
• deforestation and channelization, which cause shoreline erosion, excessive sedimentation, and salinity alteration; and
• human recreational and commercial activities that directly disturb SAV and their habitat.

Despite the large number of causes of SAV decline, their cumulative impacts on SAV can be merged and reduced into manageable numbers of controlling factors responsible for the decline in SAV, such as reduced light, increased water column nutrients, or physical destruction. In addition, as rooted vegetation is lost, turbidity increases and nutrient absorption and wave buffering capacity decrease, making conditions ripe for additional SAV loss. Consequently, the negative impacts associated with excessive shore erosion and declining water clarity become even more significant, requiring habitat restoration in many cases.

Ecological restoration means returning an ecological system into a former or original state (Meffe and Carroll 1997). Thus, successful ecological restoration can be achieved when the previous less disturbed state of the ecosystem is known and the stressors that caused ecosystem alteration are identified and then eliminated or alleviated. Yet substantial historical information on SAV is usually not available for a given estuary or a coastal region, mainly due to the difficulty and

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high cost of conducting frequent surveys and monitoring.

For example, the Louisiana and Mississippi coasts are representative of the extensive loss of SAV habitat. Estimates of SAV loss in Lake Pontchartrain between 1953 and 1992 are as high as 75 percent (Turner et al. 1980; Burns et al. 1993). It has also been reported that more than one half of the SAV areaal coverage in Mississippi Sound declined between 1962 and 1992 (Moncreiff et al. 1998). Yet these calculations were largely based on a few one-time boat surveys that failed to depict the significant seasonal and annual variations in SAV abundance and species composition (Cho and Poirrier 2005b; Cho and May 2006b). In addition, the declines of more stable, climax community seagrasses such as turtle grass (*Thalassia testudinum* K.D. Koeing) and manatee grass (*Syringodium filiforme* Kützing) have resulted in the increased relative abundance of opportunistic, pioneer species such as widgeon grass (*Ruppia maritima* L.) and shoal grass (*Halodule wrightii* Aschers) in estuaries and along barrier islands of the northern Gulf of Mexico (Kahn and Durako, 2005). These changes accentuate the temporal and spatial fluctuations of SAV because areal coverage and distribution of both widgeon grass and shoal grass change substantially from season to season and year to year. Unpredictable SAV beds that shift in space and time will mean that the animals that depend on the resource will move more frequently. Animals that move frequently are more exposed to predators and their survival and reproduction is reduced. As a result, commercial and recreational fishermen will have to spend more time and effort to locate successful fishing grounds. Given these natural temporal and spatial variations in SAV abundance and species dominance, a more rational approach for habitat restoration would be the identification of the areas that can support SAV growth rather than the delineation of existing beds at certain times of the year.

The bottom dwelling SAV plants require light to photosynthesize, yet the lack of waxy cuticles on SAV blades make them vulnerable to constant air exposure. Healthy SAV habitat, therefore, depends on sufficient light reaching below the water’s surface. Along wave-stressed shores, the scoring effects of waves make the ground unstable. In addition, turbidity is higher, water-level fluctuation is greater, and the shoreface slope is steeper, thereby resulting in the gradual reduction of potential SAV habitat. As the extent of SAV growth is reduced in a wave-stressed shore, the wave buffering capacity and the sediment grip by the SAV shoots and roots decrease, which, in turn, returns as negative feedbacks to the remaining SAV (see Figure 1). Meanwhile, nutrients are usually not a primarily limiting factor for SAV in shallow estuaries because the rooted, vascular SAV can obtain nutrients from sediment as well as from the water column.

**A Model for Predicting SAV Restoration**

In 2001, W. Lee Long and R.M. Thom recommended constructing models that link SAV ecosystem function (or health) with ecological factors to help identify the key environmental factors that need improvement to prevent additional SAV decline and promote growth in areas of historical growth. An article published last year, *A Model to Estimate Potential SAV (Submersed Aquatic Vegetation) Habitat Based on Studies in Lake Pontchartrain, Louisiana* (Cho and Poirrier 2005a), features a model to identify potential SAV habitat by linking geospatial features, such as shoreface slope and profile, with a few key factors that control SAV distribution, such as water level fluctuation, water clarity, and minimum light requirements.

With these factors in mind, the potential SAV (PSAV) habitat model focuses on three main components: (1) annual mean water clarity and the minimum SAV light requirement to determine the maximum depth of SAV colonization; (2) annual mean water level fluctuation and wave mixing depth to determine the minimum depth of SAV growth; and (3) shoreface slope angle, based on the distance between the maximum and the minimum depths of potential SAV growth areas, to determine the total area of potential SAV habitat.

While the intricacies of the PSAV model established by Cho and Poirrier are beyond the scope of this article, in essence, the potential for SAV growth can be predicted by using the following equation: \[ \text{PSAV} = \frac{(Z_{\text{max}} - Z_{\text{min}} \times K_d)}{\sin \Theta \times K_N}, \] where \( Z_{\text{max}} \) represents the maximum depth of SAV growth, \( Z_{\text{min}} \) represents the minimum depth of SAV growth, \( \sin \Theta \) represents shoreface slope angle, and \( K_d \) represents the sunlight’s penetration in water.

The PSAV model serves as a useful tool in initial restoration planning. The model components first need to be measured at selected SAV habitat using transects that are perpendicular to the shoreline. Once the minimum light, water clarity, and shoreface slope parameters are determined, the model can be easily integrated into geographic information systems software to visualize the current potential habitat, to select feasible restoration sites, and to predict habitat increase with water clarity improvement (Cho and May 2006a). The identification and visualization of the direct benefits of water clarity improvement on SAV restoration would enhance management, funding, and community support, especially when it is linked to the consequential improvements in fisheries, shoreline protection, and water quality (Lee Long and Thom 2001).

The model was developed and verified using data accumulated during several years of extensive field surveys and scientific measurements conducted at fixed study sites in Lake Pontchartrain, Louisiana. Most recently, the model was applied in the Grand Bay National Estuarine Research Reserve, Mississippi, to estimate the reserve’s current potential SAV habitat and to predict habitat increase through water clarity improvements (Cho and May 2006a). The model estimated that a 20 percent improvement in water clarity from current conditions could increase potential SAV habitat at Grand Bay by 35 percent, from approximately 1,700 hectares of potential habitat.

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![Figure 1. A diagram indicating the negative feedbacks of SAV loss in a wave-stressed shore.](image)
to about 2,300 hectares. Because both Lake Pontchartrain and the open waters of Grand Bay were affected by the disastrous hurricanes of 2005, these areas offer opportunities to study the long-term effects of the hurricanes on estuarine resources, including SAV. The two estuaries are also characterized by high rates of naturally occurring shore erosion due to geologic subsidence and reduced amounts of sediment deposits. These areas are in need of plans and funding for habitat restoration that is readily executable and compatible with current environmental settings. The PSAV model will allow potential SAV habitat to be easily identified, thereby assisting in the initial planning and projection of restoration projects in these areas.

A landscape-level visualization of water level fluctuation and water clarity assists in identifying the main natural drivers or stressors of the estuarine ecosystem. In both Lake Pontchartrain and Grand Bay, the water depth is shallow (a mean depth of 3.7 meters and 1 meter, respectively). The south and east winds are the driving force that moves water from the Gulf of Mexico into the estuaries. These winds also cause waves to form, a major stress on shallow estuaries. The distribution of SAV indicates that the shores that are relatively protected from the predominant wind-driven wave energy or the resultant long-shore currents support substantial SAV beds. This explains the lack of SAV growth along wave stressed shores, as indicated by the PSAV model.

The model also helps demonstrate the impact of shoreline alteration on SAV habitat and restoration potential. Grand Bay is surrounded by undisturbed estuarine habitat and a small number of residential areas, whereas Lake Pontchartrain's natural shoreline has been extensively armored to prevent naturally occurring shoreline erosion. Especially on the south shore where the city of New Orleans is located, the natural wetland shorelines have been modified to bulkheads, riprap, and seawalls. Underwater structures at such rigid shores are subjected to the scoring effects of wave energy (List and Signell 2001). Wave action against the armored or hardened shores alters bottom sediment structure, decreasing sediment stability, and increasing sediment resuspension, which decreases water clarity. As a result, the maximum depth of SAV growth decreases, the minimum depth of SAV growth increases, and shoreline slope becomes greater over time. In combination, these changes reduce the area for potential SAV growth along the shorelines.

Previous records described the persistent nature of SAV along the south shore of Lake Pontchartrain (Suttkus et al. 1954). This growth has been lost over time (Törner et al. 1980; Burns et al. 1993). Now, at the south shore seawall in Lake Pontchartrain, SAV does not occur at all because the depths exceed the limits of potential SAV habitat under the current mean water clarity conditions. This provides a good example of how shoreline hardening results not only in SAV loss but also in permanent perturbation of SAV recolonization.

### A Balanced Approach

Successful SAV restoration calls for a holistic approach that incorporates restoration of shellfish beds, surrounding wetlands, tributary streams, invertebrate epiphyte grazers, and organisms that may disperse SAV seeds and other propagules. However, baseline data and general restoration principles can only serve as a foundation for future work. These data and principles include: (1) an understanding of the current status of SAV; (2) identification of the location, causes, and degree of habitat degradation; (3) habitat evaluation of areas for the feasibility of restoration as well as the potential for successful restoration; and (4) appropriate selection of site-specific restoration methods.

The restoration of SAV and its habitat is a complicated task with risks of failure, but this risk is an inevitable element in the protection of the vulnerable coastal resources and the wildlife and humans that are dependent on them. Two facts tend to be overlooked in coastal SAV restorations. First, restoration projects are driven, planned, and implemented by human beings. An SAV restoration project will be supported when it demonstrates the efforts will improve values important to humans such as fisheries management, protection of coastal communities from storm surge, and water quality. Second, submerged plants are living organisms. SAV restoration may not provide immediate results of wave dampening and shore protection in comparison to man-made structures, such as breakwaters and shore stabilizing constructions, that might be chosen as substitutes for SAV. Therefore, coastal environmental managers must demonstrate the long-term ecological and economic benefits of SAV restoration in comparison to construction of a hardened shoreline. SAV has an intrinsic resilience after disturbances, and restoration planners should focus on projects that would enhance the natural, internal resilience of biological systems.

Restoration planning should follow the general rules and consider all the elements that combine to improve the quality of life and ecosystem health for all coastal inhabitants. The PSAV modeling approach can improve restoration and management efforts by directing personnel and funding to project areas with a high likelihood of success.

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ignored SWD. Whether considering primary production and trophic web implications or storm surge abatement, the time to respond is now, before SWD casts more acreage into merely historical recollection.

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References


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modeling approach can improve restoration and management efforts by directing personnel and funding to project areas with a high likelihood of success. Successful restoration will in turn bring improved coastal management and socio-economic benefits to local communities and the environment.

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