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GigaUnit Transplant System: A New Mechanical Tool for Transplanting Submerged Aquatic Vegetation

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BACKGROUND: Submerged aquatic vegetation (SAV) performs many important ecosystem functions, including wave attenuation and sediment stabilization, water quality improvement, primary production, food web support for secondary consumers, and provision of critical nursery and refuge habitat for fisheries species (Orth et al. 2006a). Over the last few decades, there have been global declines in SAV abundance, which could have widespread deleterious effects on coastal and estuarine ecosystems (Orth et al. 2006a).

U.S. Army Corps of Engineers staff have a need to understand the most effective tools available for restoring or mitigating damage to SAV. Regulatory personnel are responsible for issuing permits for activities that may impact sensitive nearshore coastal resources, including SAV. Other Corps activities, such as dredging, have the potential to negatively impact SAV, and mitigation may be required to restore damaged SAV resources. Planting SAV may also be a component of other types of Corps projects, such as beneficial uses of dredged material (Section 204) and ecosystem restoration (Section 206) projects.

Restoration of SAV habitats has been a major focus of many resource managers and scientists, particularly in coastal areas such as Florida and the Chesapeake Bay, where efforts to restore seagrasses and other submerged aquatic plants have been underway for more than two decades (Orth et al. 2006b). Traditional planting methods involve manually digging and replanting individual shoots or groups of shoots, known as 'planting units,' either bare-root or with associated sediments (e.g. plugs) (Fonseca et al. 1998). While this approach can be successful, it is also extremely labor-intensive and costly, leading to the restoration of relatively small areas (i.e. tens or hundreds of square meters) (Fishman et al. 2004).

Figure 1. GigaUnit Transplant System. Photo courtesy of Florida Wildlife Conservation Commission, Florida Wildlife Research Institute (FWC).

Mechanical planters, analogous to those used in terrestrial agricultural systems, offer the potential to plant and restore SAV much more rapidly, and at much larger scales, than would ever be possible with manual planting. However, the development and testing of this type of equipment has been initiated only recently. A submarine mechanical planter

(ECOSUB), operated by divers, has been used to plant and restore seagrasses in Australia (Paling et al. 2001a, 2001b). In the United States, Seagrass Recovery, Inc. (Ruskin, Florida) has developed and patented several types of mechanical equipment for use in seagrass restoration projects. One of these, the GigaUnit Transplant System® (GUTS) (Figure 1), was designed for the removal, transport, and subsequent replanting of large (1.8-m^2) planting units (e.g. "sods") of intact submerged aquatic vegetation (SAV), complete with roots, rhizomes, and associated sediments. Previous studies in Australia demonstrated that the planting success of large sods of seagrass was greater than that of individual planting units, especially in high wave-energy environments (Paling et al. 2001a, 2001b).

PURPOSE: This technical note describes two case studies in which GUTS was used to transplant seagrasses that were to be unavoidably damaged by proposed construction and dredging activities. The first, located near the Isle of Wight, in the Chesapeake Bay, Maryland, involved transplanting the seagrass *Zostera marina* (eelgrass) (BayLand Consultants & Designers, Inc. 2005). The second involved transplanting the seagrasses *Halodule wrightii* and *Thalassia testudinum* in Sarasota Bay, Florida (Uhrin et al. 2008). Information on operational capabilities and limitations of GUTS is presented, as well as recommendations for further use.

CASE STUDY: ISLE OF WIGHT, MARYLAND

Site Description. The Isle of Wight is located in Assawoman Bay near Ocean City, Maryland. The island is part of the Maryland Dept. of Natural Resources public land system managed by the Wildlife and Heritage Service. Extensive erosion along the southeastern shoreline resulted in development of a shore erosion control project by the USACE Baltimore District. The project employed non-structural protection methods including a near-shore low sill with tidal marsh and a larger protected area with more extensive tidal marsh with a public access pier. Construction of the shore protection project began in spring 2003 and was completed in fall 2004. A small bed of *Z. marina* (eelgrass) was present within the proposed project footprint, and would likely have been damaged during construction. This provided an opportunity to evaluate the capability of GUTS to transplant the temperate seagrass *Z. marina*.

Planting Operations. A demonstration project using GUTS was developed to relocate a portion of the eelgrass from the construction area to a transplant site located along the southwest shore of the island where SAV was not present. In September and October 2002, 165 planting units (approximately 1.2 m by 1.5 m and 20 cm thick) were transplanted. Monitoring was conducted immediately after transplanting and annually for 2 years following transplanting by BayLand Consultants & Designers, Inc.

Results. Thirty planting units were selected for monitoring immediately after transplanting and annually for 2 years following transplanting. Shortly after planting, the planting units were examined to verify the presence of visible eelgrass. Leafy above-ground tissues were present in all except two (93 percent). Exposed roots and rhizomes were observed in the remaining two planting units. In October 2003, 25 planting units (83 percent) contained eelgrass. By the end of the second growing season, all 30 (100 percent) planting units contained eelgrass. Qualitative estimates of shoot density indicate that shoot density within the transplanted sods declined over time relative to the original shoot density, probably due to a combination of transplant shock and other environmental factors. In contrast, shoot density in a nearby control area of denser eelgrass remained relatively constant over the monitoring period (BayLand Consultants & Designers, Inc. 2005).

These results indicate that the overall survival rate of transplanted *Z. marina* can be quite high. Furthermore, many planting units had expanded outside the original 1.2-m by 1.5-m boundaries. Natural recolonization processes also resulted in the creation of numerous small patches of eelgrass throughout the transplant area and in shallower water shoreward of the transplant site, suggesting that site conditions were favorable for continued growth and expansion of the transplanted seagrasses (BayLand Consultants & Designers, Inc. 2005).

CASE STUDY: LONGBOAT KEY, FLORIDA

Site Description. Residential canals in Sarasota Bay, Florida, were scheduled for maintenance dredging by the Town of Longboat Key. Although these canals were exempt from mitigation requirements due to grandfather provisions by State of Florida statutes, this dredging project provided an opportunity to conduct the first rigorous scientific study of the effectiveness of the GUTS. Donor sites were selected to meet the following criteria: a) depth of the site was within the operational limits of the GUTS, and b) a minimum of 50-percent cover by the seagrass *Halodule wrightii* or *Thalassia testudinum* was present. Three transplant sites were selected according to the following criteria: a) sites contained some existing seagrass interspersed with bare areas large enough to insert multiple sods, b) sites were within the operational depth and transport distance limits of the GUTS.

Planting sites were located within 2 km of individual donor sites and were spaced at distances ranging from 2 to 12 km from one another. Allocation of planting units among planting sites was based on logistical constraints and the availability of unvegetated substrate. For more details, see Uhrin et al. (2008).

Planting Operations. Specific locations for collection and replanting were identified by scientific staff, who provided guidance to Seagrass Recovery, Inc. personnel operating the GUTS. In April 2003, 18 *H. wrightii* planting units and 9 *T. testudinum* planting units (Figure 2) were transplanted, for a total of 27. The average distance between each of the planted sods was 8 m; the average distance from the edge of each planted sod and the adjacent existing seagrass bed was 2 m.

The perimeter of each planted sod was mapped using a surveyor-grade differential Global Positioning System (DGPS) at <0.5 m resolution. Metal stakes were inserted in the center of each sod (Figure 3), and shoot density was recorded in three replicate quadrats (0.125 m x 0.125m) per planting unit. Monitoring was conducted at intervals of 6, 12, 18, 24 and 36 months following transplanting. During this period, measures of survival, shoot density, perimeter expansion, and species composition were recorded.

Figure 2. Excavated *Thalassia testudinum* prior to transplant. (Photo courtesy of FWC.)

Figure 3. A survey post marks the center of a *H. wrightii* planting unit (Photo courtesy of FWC).

Results. Of the 18 *H. wrightii* planting units, a total of 12 (67 percent) survived after a period of 3 years. *H. wrightii* survival rates at each of the three transplant sites ranged from 40 to 89 percent. Shoot density generally declined during the first 6-12 months, then began to increase steadily after 18 months, a trend that continued until monitoring ceased at 36 months. Expansion of the sods beyond the original perimeter boundaries resulted in a net increase of more than 3,500 m^2 of *H. wrightii* (Uhrin et al. 2008). The total areal expansion of five surviving *H. wrightii* planting units is shown in Table 1.

Table 1. Change in total area of five surviving *H. wrightii* planting units from the original time of planting (Time 0) to the end of the monitoring period (36 months) (data from Uhrin et al. 2008).

Planting Unit	Change in Total Area (m^2) Over Time		
	Time 0	24 Months	36 Months
1	1.5	54.9	119.0
2	2.6	174.9	1028.9
3	1.2	198.1	793.4
4	2.2	164.4	288.7
5	1.5	26.8	898.0

The overall survival of planted *T. testudinum* planting units (89 percent) was higher than that of *H. wrightii*. However, in contrast to *H. wrightii*, shoot density in *T. testudinum* planting units did not increase over time, and was lower at 24 and 36 months than at the time of the original planting. Five of the *T. testudinum* planting units increased in size, resulting in a modest net gain of 11.8 m^2; however, the remaining three sods decreased in size.

IMPORTANT CONSIDERATIONS IN PLANNING: The following items should be considered when planning GUTS applications:

1. Since GUTS removes large areas of SAV, it is best suited to 'salvage' situations where damage to SAV resources is unavoidable. For example, SAV growing in or immediately adjacent to a navigation channel may be physically removed and relocated to reduce damage by dredging operations (Figure 4).

Figure 4. GUTS salvages seagrass near dredging operations in Florida. (Photo by Seagrass Recovery, Inc.)

2. Since the planting units are removed and replanted by the same vessel, transportation logistics are an important consideration. If the donor site and transplant site are separated by long distances (> 2 km), much time may be spent in transit between sites. In addition, high wind and wave conditions may limit the operational capacity of the vessel.

3. The water depths at which this equipment can effectively operate ranges from approximately 0.6 to 1.5 m (Uhrin et al. 2008). These operational limitations must be considered prior to selection of donor and transplant sites. In areas with relatively clear waters, the maximum desired planting depth could exceed the current depth range of the equipment. Conversely, in turbid waters, the desired planting depths may be too shallow to allow vessel access. Design and testing of GUTS for use in waters up to 12 m in depth is currently underway.[1]

[1] Personal communication, May 2008, J. Anderson, Seagrass Recovery, Inc., Ruskin, FL.

4. To date, transplantation of only three seagrass species (*Z. marina*, *T. testudinum*, and *H. wrightii*) has been attempted using this equipment. Survival and expansion of planting units varied among species. In some cases, transplanted *H. wrightii* can exhibit rapid growth, expanding beyond the original boundaries within 1-2 growing seasons, whereas expansion of transplanted *T. testudinum* was very slow, and may require 3-5 years or more to fully establish (Uhrin et al. 2008). Therefore, transplanted *T. testudinum* may require monitoring for at least 5 years or more in order to evaluate planting success.

5. In some cases, the planting units may be re-inserted into the bottom in a position slightly above the surrounding sediments. In areas with moderate to high wave and current action, erosion at the edges can result in exposure of the roots and some loss of SAV.

SUMMARY: GUTS is suitable for use in transplanting large areas of SAV in relatively shallow (< 1.5 m) waters where the donor sites are in relatively close proximity to the planting sites. Because large areas of SAV are removed, GUTS is best used in salvage situations where damage to existing SAV resources is unavoidable, such as areas in or immediately adjacent to dredged channels and harbors.

Transplants of *H. wrightii* have been most successful, exhibiting high survival (Table 2) and rapid expansion within 1-2 growing seasons (Uhrin et al. 2008). However, *H. wrightii* is also readily transplanted by traditional hand-planting methods, and a cost comparison of mechanical versus hand planting has not been done (Uhrin et al. 2008). Survival of the temperate seagrass *Z. marina* also appears to be quite high (Table 2), although additional demonstrations employing a more rigorous monitoring protocol are needed. Although the survival of transplanted *T. testudinum* was high (Table 2), Uhrin et al. (2008) do not currently recommend GUTS for transplanting *T. testudinum*, due to decreased density and lack of significant expansion after three years. Further testing is needed to evaluate the use of this equipment for use in transplanting other SAV species.

Table 2. Summary of transplant success for three seagrass species transplanted using the GUTS.

Species	Location	Planting Unit Survival		
		Post-Planting	2 Years	3 Years
Z. marina	Chesapeake Bay	93%	83%	100%
H. wrightii	Sarasota, FL	NA	NA	67%
T. testudinum	Sarasota, FL	NA	NA	89%

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