E3198 • New • December 2013

Rebuilding an Eroding Bank on an Inland Lake

A Comparison of Traditional and Prefabricated Encapsulated Soil Lifts

Background

Every year, more people buy or build homes, cabins or recreation spaces on one of Michigan's many inland lakes. In years past, if their shorelines showed signs of erosion from wind, wave and ice action, many shoreline property owners would "harden" them with rock riprap or vertical seawalls. Unfortunately, this practice has resulted in the cumulative loss of shoreline and shallow water habitat on Michigan inland lakes (O'Neal & Soulliere, 2006).

Using a more natural erosion control measure, such as a encapsulated soil lift (ESL), will create a vegetated, more gently sloped, lake-friendly shoreline.

ESLs (sometimes referred to as "vegetated geogrids") are vegetative bioengineered structures that are usually built on a rock base. They are useful in rebuilding eroded, vertically faced banks. Soil layers are "encapsulated" inside of biodegradable fabric to form the lift. Each new course, or layer, of lift is placed on the preceding course but stepped back to create the desired slope. Lifts may be continued up to a height of 8 feet. They are planted or seeded to long-rooted native plants that help to stabilize the soil layers.

ESLs on a rock base are especially useful on lakefronts that experience moderate to high wind, wave and ice action, and where significant soil loss has occurred (Herbert, Schutzki, Skubinna, Lounds, Majka, Bohling, & Tripp, 2010). They may also be used to replace failing seawalls. Once established, these vegetated systems create a new slope with root structures that can withstand the erosive forces of wind, waves and ice (Eubank & Meadows, 2002). ESLs have traditionally been built on-site, but in recent years, prefabricated (factory-built) versions called coir fiber block systems have become available.

In 2011, a 3-year study began at the Shoreline Management Demonstration Area (*www.shoreline.msu.edu*) on Gull Lake at the W. K. Kellogg Biological Station (KBS). The study was designed to compare the effectiveness of two types of ESLs that are used to stabilize shorelines:

Abbreviations

CNSP	Certified Natural Shoreline Professional
ECB	erosion control blanket
ESL	encapsulated soil lift
KBS	Kellogg Biological Station
MNSP	Michigan Natural Shoreline Partnership
MSU	Michigan State University
OHWM	ordinary high water mark

- **Traditional soil lifts** – These lifts are built on-site using coir fiber (shredded coconut husk fiber) blanket-lined forms into which soil is tamped to create a formed soil layer, or lift.
- **Prefabricated lifts** – These factory-built "systems" have coir fiber blocks sewn into the nose (lakeward) edge. There's no need to build a form to hold soil because the block serves as a form. Each 10-foot-long section has interconnecting ends that create a solid lakeward face to protect the inner soil layer. These prefabricated systems require less time and labor to install, but increase the cost of materials.

Similar plant species and planting plans can be used with both lift types.

We predicted that traditional and prefabricated soil lifts would perform similarly – allowing contractors to choose either technique based on project-specific time and budget constraints.

Study Design

We compared the performance of traditional and prefabricated ESL structures over a 3-year period. To accomplish this, 40 linear feet of a traditional lift (T-lift) and 40 linear feet of a prefabricated coir-block lift system (P-lift) were constructed side-by-side on an 18-inch-high rock base on a moderate- to high-energy shoreline. The Ordinary High Water Mark (OHWM) at this site was determined to be 18 inches. The rock base was built to that height to avoid continual inundation of the lower lifts, and lined with nonwoven geotextile fabric to avoid slumpage.

The Certified Natural Shoreline Professional Program

The flagship educational program of the Michigan Natural Shoreline Partnership (MNSP) is the Certified Natural Shoreline Professional (CNSP) program. CNSP is a certification training for shoreline contractors who want to expand their business services to include natural shoreline landscape design and bioengineered erosion control. To maintain their certification, CNSPs must successfully complete MNSP-approved continuing education activities. More technically challenging than the basic bioengineering techniques taught during the certification training, building encapsulated soil lifts (see fig. 1) is an appropriate activity for CNSP continuing education.

Figure 1. Workshop participants install a prefabricated soil lift at Kellogg Biological Station near Hickory Corners, Michigan, in July 2011. The participants were Certified Natural Shoreline Professionals (CNSPs) who earned continuing education units by installing traditional and prefabricated ESLs for this comparison study during a one-day workshop. You can watch a brief video about the installation at *www.shoreline.msu.edu/shorelinemgt/natural-shoreline-constructing-encapsulated-soil-lifts/*.

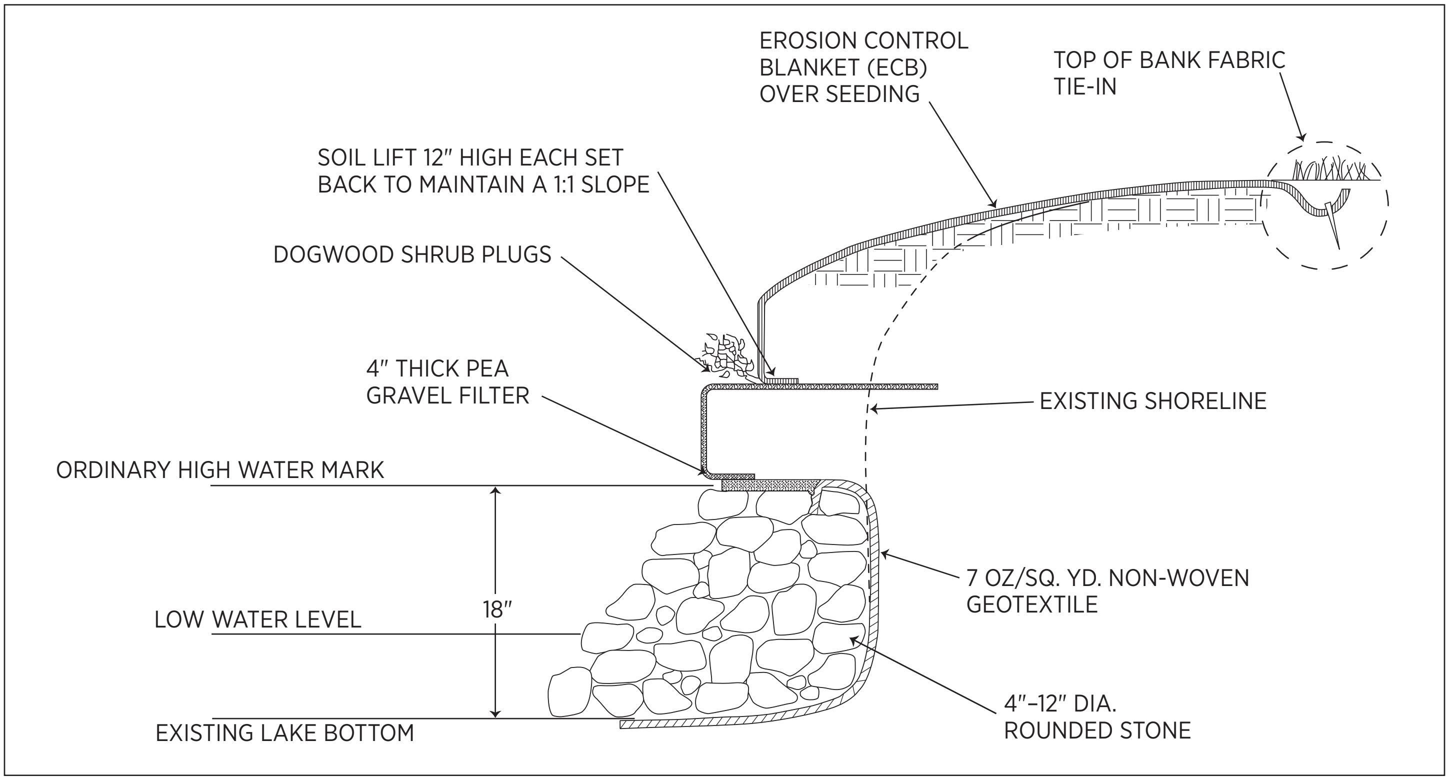

Figure 2. Cross-section of encapsulated soil lift project at KBS.

One upper and one lower course of both lift types were installed (see fig. 2). The tamped soil in the lower T-lift was wrapped in a layer of woven coir mat lined with a light-grade, totally biodegradable coir fiber erosion control blanket (ECB). The upper T-lift was wrapped in just one layer of ECB.

The prefabricated coir fiber block system came with a coir fiber block sewn into a coarsely woven coir mat. The coir block served as a form in which to build the lift. Due to the coarser weave of the block system mat, both courses of prefabricated lifts were lined with ECB to secure soil particles.

Both structures were planted following identical planting plans, which included:

- Two species of native dogwood plugs (*Cornus sericea* and *Cornus racemosa*) placed at 18-inch intervals between the two courses of lifts on both structures.
- A seeding of native grasses, sedges and wildflowers (see Table 1) that was put down before blanketing the top of each lift.
- A cover crop seeding of annual rye and oats to suppress weed growth during the first growing season. (**Note:** To avoid possible reseeding and competition with native species in ensuing years, cover crop seed heads were removed in August 2011.)

The side-by-side lift structures (see fig. 3) were exposed to similar site conditions, such as sunlight, precipitation, and wind, wave and ice action. We monitored both structures to compare:

1. Plant establishment.
2. Invasion by native and nonnative weed species.
3. Ability to withstand wind, wave and ice action.

Table 1. Seeded and volunteer plant species on KBS soil lift project, August 2011 to August 2013.

Plant Category	Scientific Name	Common Name	Date First Recorded/ Not Observed*
Cover Crop Species	*Avena sativa***	Seed oats	7/28/2011
	*Lolium multiflorum***	Annual rye	7/28/2011
Seeded Species	*Aster novae-angliae*	New England aster	7/11/2012
	Calamagrostis canadensis	Blue joint grass	Not observed
	Carex crinita	Fringed sedge	Not observed
	Carex vulpinoidea	Brown fox sedge	Not observed
	Elymus riparius	Riverbank wild rye	Not observed
	Elymus virginicus	Virginia wild rye	8/08/2013
	Eupatorium maculatum	Spotted joe-pye weed	Not observed
	Eupatorium purpureum	Purple joe-pye weed	9/15/2012
	Glyceria striata	Fowl manna grass	Not observed
	Iris virginica shrevei	Blue flag iris	Not observed
	Juncus effusus	Common rush	Not observed
	Liatris spicata	Marsh blazing star	Not observed
	*Lobelia cardinalis***	Cardinal flower	9/15/2012
	Lobelia siphilitica	Great blue lobelia	9/15/2012
	Monarda fistulosa	Wild bergamot	5/17/2012
	Penstemon digitalis	Foxglove beard tongue	6/19/2013
	Physotegia virginiana	Obedient plant	8/08/2013
	Rudbeckia laciniata	Wild golden glow	6/19/2013
	Scirpus atrovirens	Dark green rush	Not observed
	Solidago patula	Swamp goldenrod	Not observed
	Verbena hastata	Blue vervain	9/15/2012
	Zizia aurea	Golden Alexanders	7/11/2012
Volunteer Species (Not included in seed mix)	*Asclepias syriaca*	Common milkweed	5/17/2012
	Eupatorium perfoliatum	Boneset	7/11/2012
	Impatiens capensis	Spotted touch-me-not (jewelweed)	9/15/2012

* "Not observed" means the species was not observed on the site during the study period.

** Species did not return in Year 3.

Note: All plant identifications were made when the plants were in bloom.

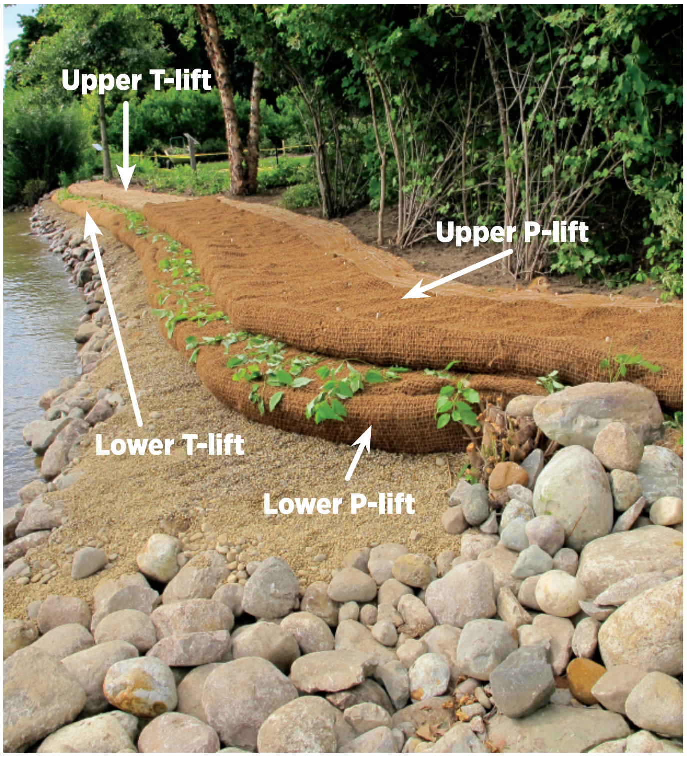

Figure 3. Newly constructed upper and lower traditional and prefabricated lifts (T-lift and P-lift, respectively).

Plants were monitored using percent vegetative cover estimates at ground level inside 20 half-meter quadrats (small plots used to study plant or animal populations). Five quadrats were located along established transects in each of the four lifts. Woody shrub (*Cornus* spp.) establishment was monitored by direct stem count. Lift performance was monitored through observation and characterization on a three-point scale where:

1 = total failure

2 = partial failure

3 = no failure

Both lift structures were constructed and planted on July 14, 2011. Data were collected twice in 2011 (in August and September), three times in 2012 (in May, July and September) and twice in 2013 (in June and August).

Results and Discussion

The traditional lift structure was consistently more densely vegetated (higher percent vegetative cover) than the prefabricated lift structure (see fig. 4). Vegetative cover was primarily composed of the annual cover crop species in 2011. The abundances of these two species were greatly reduced in 2012 and 2013, and vegetative cover was composed primarily of native wildflowers, including a few volunteer species not included in the seed mix (see Table 1).

The greater vegetation densities observed on the traditional lift may be explained by the availability of irrigation. A period of low precipitation soon after construction (in August 2011), and then a significant drought in 2012, created the unanticipated need to irrigate the lifts. Unfortunately the irrigation didn't reach most of the P-lift structure, which may have contributed to its lower percent cover.

With or without irrigation, both lift structures followed the same growth pattern – reduced percent cover in Year 2 and then a rebound in Year 3. This pattern may reflect the combined Year 2 effect of no more annual cover crop and severe drought. The rebound in Year 3 may be because it typically takes longer to establish native plants from seed than it does turf grass and forage crops.

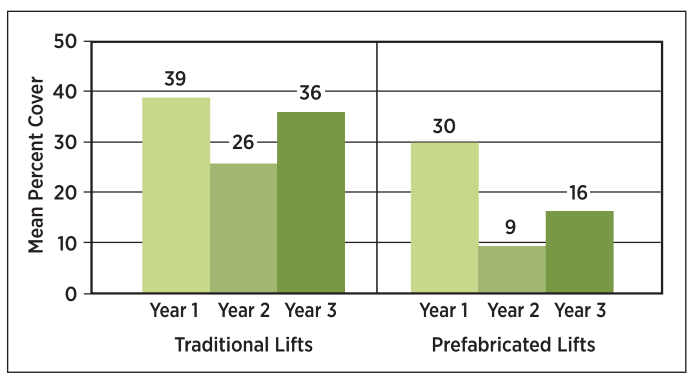

Figure 4. A comparison of the mean percent vegetative cover over the 3-year study period on the traditional (T-lift) and prefabricated (P-lift) lift structures.

Although the T-lift structure initially had more native and nonnative weed species than the P-lift structure, by Year 3 there was no significant difference in the number of different weed species observed (see fig. 5). However, by August 2013, the vegetative cover on the P-lift was made up almost entirely of weeds. (**Note:** Weeds, both native and nonnative, were recorded and then removed from the study area.) Again, drought and lack of irrigation may have played a role in the poor establishment of any type of vegetation on the P-lifts.

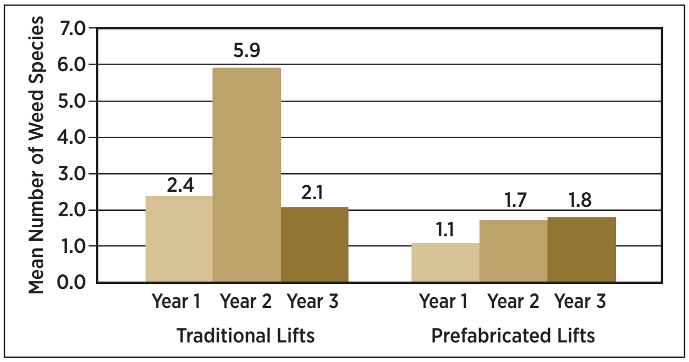

Figure 5. A comparison of the number of native and nonnative weed species present on traditional and prefabricated lifts over the 3-year study period.

Shrub (*Cornus* spp.) survival decreased over the study period (see fig. 6). The low moisture conditions created by the coir block in the nose of the P-lifts initially created concern about adventitious rooting (roots growing from along the stem) and shrub survival. However, there was no significant difference in survival of shrubs in the two structures. Surviving shrubs in the T-lift did appear to be more vigorous in 2013.

The root masses created by the surviving shrubs will eventually colonize the soil layers in both structures, creating a stable, rebuilt bank. Planting more shrub plugs directly into the lifts is an option for the future.

Total lift failure is defined as a complete collapse of soil layers and loss of soil into the lake. None of the lifts failed during the study period.

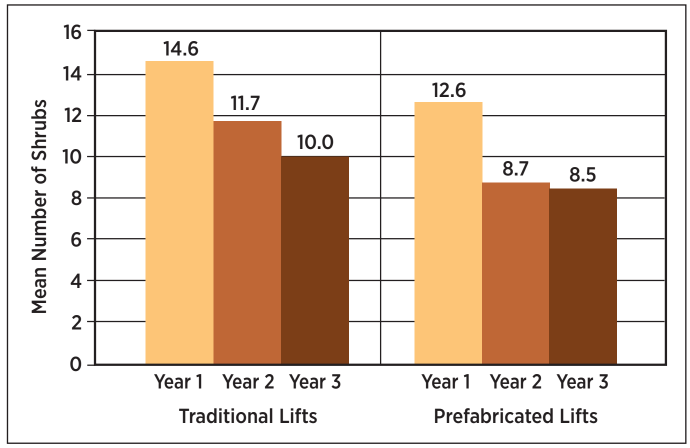

Figure 6. A comparison of *Cornus* spp. shrub survival over the 3-year study period.

Grazing of all plants and shrubs by deer or other animals was evident on both structures. The upper T-lift, with just the ECB to encapsulate the soil layer, experienced damage from deer traffic almost immediately. The damage did not result in total lift failure and the lift was eventually stabilized by the roots of growing plants. The upper P-lift, equipped with the ECB, the coir-block system and the built-in protective coir-block nose, appeared to be more resistant to damage from deer traffic than the T-lift.

Most of the species in the seed mix used on the lifts are adapted to wetland conditions (Herman, Masters, Penskar, Reznicek, Wilhelm, Brodovich, & Gardiner, 2001). The placement of the lifts above the OHWM appears to have impeded the movement of lake water (through capillary action) to the soil layers during normal water levels.

Waves provided some water to the lower T-lifts, but plants in the lower P-lifts were denied that benefit because the coir block soaked up the water before it could reach the inner soil layer. This design relegated the seeding and shrub plantings to mostly dry, upland soils. While the soils were irrigated periodically, they mostly depended on precipitation for moisture. Lack of water was most likely a major limitation to the germination and survival of a number of wetland species in the seed mix.

Conclusions

We conclude that, in terms of the following factors, there were no significant performance differences between the traditional and prefabricated ESLs at the study site over the 3-year study period:

- Plant establishment
- Resistance to invasion by native and nonnative weed species
- Ability to withstand wind, waves and ice action

Based on lessons learned from this project, we advise contractors to consider the following suggestions when designing and constructing encapsulated soil lifts:

- Closely match seed mix to anticipated soil moisture levels related to the OHWM.
- Plan for potential irrigation needs when lifts are placed at or above the OHWM.
- Experiment with positioning prefabricated lifts (with protective coir block) at or slightly below the OHWM to increase soil moisture.
- Minimize foot traffic, both deer and human, to maintain lift integrity.
- Encapsulate lifts in light-grade, totally biodegradable ECB (to hold soil particles) plus light-grade woven coir mat (to minimize deer damage). (**Note:** Heavy blanketing may impede seed germination.)
- Plant lifts to long-rooted native plant plugs to speed the development of vegetative cover. Consider under-seeding with a low-growing, moisture-appropriate sedge species to establish a permanent weed barrier.

References and Resources

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Resources

KBS Shoreline Management Demonstration Area (*www.shoreline.msu.edu*) – This website provides information on shoreline management to protect lake water quality, along with in-depth descriptions, histories and photo journals on the four demonstration shoreline landscapes at Kellogg Biological Station.

Michigan Natural Shoreline Partnership (*https://sites.google.com/site/mishorelinepartnership/home*) – This organization was formed in 2008 to promote the use of natural landscaping and erosion control to protect Michigan's inland lakes. The partnership brings together technical expertise and organizational support to address informational, educational and policy needs related to natural shoreline development. MNSP is a public/private partnership consisting of 15 governmental agencies, industry representatives, academic institutions, environmental organizations and nonprofit organizations actively engaged in promoting natural shoreline management.

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