Soil Bioengineering

written by Rick Grillmayer,
Nottawasaga Valley Conservation Authority

WHAT IS SOIL BIOENGINEERING ?

Soil bioengineering is an established method of stabilizing or protecting eroded soils. It is unique in that plants and plant parts (roots, stems) are used as the main structural components to reinforce the soil and to provide protection. Soil bioengineered structures rely on living or dead plant materials and can act as drains and prevent earth movement. The techniques outlined in this manual use woody plants that root from dormant cuttings. There are effective methods of using wetland or herbacious plants, coir logs, and pre-grown plant mats in soil bioengineering for lake shores and river banks. These methods are not listed in this manual because they can be more complex and costly, making them unsuitable for the active volunteers.

HISTORY OF SOIL BIOENGINEERING

Soil bioengineering has been widely practiced in Europe, in various forms, since the 1500's. Today there is a professional association dedicated to the promotion and advancement of soil bioengineering, called the Gesellschaft fur Ingenenieurbiologie. In North America, soil bioengineering was also in widespread use from the late 1920's to the 1940's. But with the availability of cheap energy and the high cost of labour in the 1950's, steel and concrete structures became preferred over soil bioengineered structures.

Fortunately for rivers and streams in North America, soil bioengineering has been regaining popularity since the early 1980's, and is now once again in widespread and successful use. Many large scale projects have been completed, such as the Rehabilitation of the Markham Branch of Highland Creek, and the Mad River Cribwall in Glen Huron.

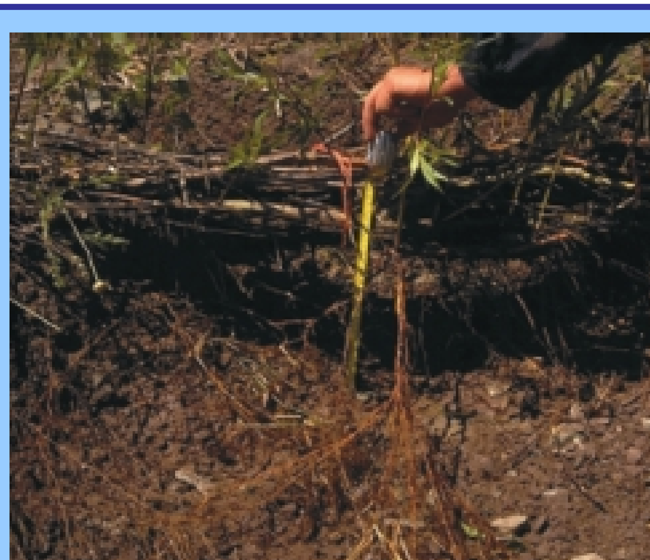

Figure 1: The root system of a 3 year old fascine placed on a clay/shale slope. (photo by Rick Grillmayer)

BENEFITS OF SOIL BIOENGINEERING

There are many benefits associated with using soil bioengineered structures. The roots, stems and associated foliage from the cuttings used to build the structures form a protective vegetative cover that reinforces the soil and protects it from erosion. Because these structures are created with living vegetation, they grow stronger and more effective with age. This is in direct contrast to inert structures (gabions, concrete and sheet piling) which weaken and crumble with age.

The root systems of the living structures penetrate the soil, providing substantial strength and resistance to movement. Figure 1 shows the root system of a 3 year old fascine placed on a clay/shale slope. The roots of Heartleaf and Slender willow, as well as Carolina poplar, have grown deeply into a very compact soil. These growing plants will provide protection and stability long after the stakes, twine, and original cuttings in the fascine have decomposed.

Perhaps the greatest benefit of living structures lies in the many functions that they perform. Not only do they provide stability, but they provide food and cover for wildlife, oxygen and moisture through transpiration, and they are a part of the ecosystem. Living structures are also attractive and can be very cost effective. It is the habitat benefits of soil bioengineering that make the method interesting to those working to create habitat be it aquatic or terrestrial. Most of the techniques in this manual are built by hand, which makes them compatible with environmentally sensitive sites or sites with limited access.

Figure 2: Bioengineered slope on the left and concrete block wall on the right. (photo by Rick Grillmayer)

The following figures illustrate the benefits of a soil bioengineered structure. On the left side of Figure 2 is a soil bioengineered cribwall constructed in the fall of 1993 by the Collingwood Harbour Remedial Action Plan on a tributary of Black Ash Creek. On the right side is a concrete block wall built by the Town of Collingwood Public Works Department during the summer of 1995. Figure 2 shows both walls during the spring floods. Both structures have performed their roles in terms of protecting the streambank, but only the cribwall has provided the extra benefits of habitat and natural aesthetics.

Soil bioengineered structures also lend themselves to the volunteer group. They are relatively easy to build and with a bit of scrounging, the materials can be acquired for little cost.

LIMITATIONS OF SOIL BIOENGINEERING

While soil bioengineering has many advantages, it does have limits. The use of soil bioengineered structures would be ineffective on a site that is densely shaded since the live materials used need sunlight in order to grow. Sites with toxic soils (or no soils !!) and extreme water velocities/level fluctuations should be avoided. The requirement of dormant materials also limits the use of soil bioengineering to seasons when access to certain sites may be limited. The most important thing to remember if you wish to use soil bioengineering is that you are building a LIVING structure, one that needs to grow.

The methods in this section of the Techniques chapter will provide most of the information you need to build the structures described. Those wishing to use soil bioengineering are also urged to refer to the authors listed in the bibliography.

MATERIALS

Selection of species

Willows (shrubs and trees), dogwoods, and poplars are the main species that are readily available in Ontario. The species listed in Appendix B are described as either native, or non-native. Where possible, projects should avoid the use of non-native species since they can outcompete and displace native plants.

It is recommended that tree form willows be avoided when working on small streams. As the trees mature, the root systems will eventually fill in the floodplain, congesting the channel. This is particularly evident with Salix fragilis, and S. fragilis/alba. Shrub willows and dogwoods can provide the stability/habitat sought, while still allowing the stream to use its floodplain.

Poplars should not be used in stream projects where beaver dams are perceived as a problem. Beavers will cut and utilize a wide range of trees and shrubs, but they prefer poplars. Poplars are shade intolerant (will not grow in the shade), so they should be used in the open. They are a good species to use if quick growth is required. Beavers have also been known to browse on the live cuttings used in the construction of the various techniques. This browsing can be serious if it occurs immediately after installation, before the structure has a chance to grow. We recommend inspecting the structures periodically and repairing any damage. If the browsing continues to be a problem, removal of the beavers may be required. Once the structure is growing, the browsing rarely destroys the structure.

All of the species listed in Appendix B possess a certain degree of environmental flexibility in terms of their ability to grow in a range of soil types and moisture regimes. To maximize your chances of success, you should try to select species whose growing conditions roughly match the environmental conditions of the project site. We also recommend mixing several species of cuttings in each structure. Each method lists some suggested species. Care should also be taken to select species with root systems that match the nature of the soil movement at the project site. Sites with deep earth movements may require plants with deep and widespread root systems.

Figure 3: A 2.5 year old Heartleaf willow live stake. (photo by Rick Grillmayer)

Willows, dogwoods, and poplars are pioneering species. This means that they are often the first species to grow in an area that has been cleared or disturbed. This trait gives these woody plants the ability to grow quickly, vigorously and in abundance. Figure 3 shows a 2.5 year old Heartleaf willow live stake. This live stake, planted in a streambank, has grown substantially in a relatively short period of time. This abundant fast growth is a result of full sun exposure and proper soil conditions. In shaded conditions, most plant material will grow poorly and be relatively short lived. Over time, the species originally planted may give way to other types of trees and shrubs. .

Locating material donor sites

All of the species listed in this chapter can, with a bit of effort, be found in areas were they can be collected free of charge. Many of the materials listed in Appendix B cannot be purchased or are prohibitively expensive if available.

The locating of donor sites is best done in advance of project construction. Most species are easiest to identify in the spring and summer, when catkins and leaves are present. Potential sites can be found by driving around, paying attention to roadside ditches, abandoned fields, hydro corridors (or other utility right of ways), drainage ditches, or riverbanks. For those that have access, airphotos can also be used to locate donor sites. In most cases donor sites will be privately owned so you will need to secure permission to harvest. Township or county road superintendents are constantly battling willows in their attempts to maintain drainage in roadside ditches. This is also true of Drainage Superintendents, who often welcome having "nuisance" willows removed from municipal drains.

In some cases there will be materials growing onsite. Ideally, donor sites should be close to the project site, as distant sites require more effort logistically to use.

WHEN TO HARVEST

All live materials should be harvested when they are dormant. While many species of willow will root from a cutting that is not dormant, the chances of success are slim, and only if specific site conditions are met. Dormant materials have the highest probability of growing with the broadest range of site conditions. One of the best indicators of dormancy is when the leaves have turned color, and fall from the twig. The time in which this happens can vary, but as a general rule one should not harvest materials until:

October 20 - Southern Ontario
October 15 - Central Ontario
October 10 - Northern Ontario

Materials can be cut and used through the winter till spring, until the buds have begun to flush (break open, usually in early April). Materials should NOT be used once the buds have broken.

Figure 4: The use of a set of sawhorses makes it easier to tie the bundles. (photo by Rick Grillmayer)

EXTENDING THE WORKING SEASON

Using dormant materials in the time that they are readily available restricts projects to a window of opportunity from Mid October to Mid April. One method of extending this season is to place dormant materials in cold storage. Willow and dogwood cuttings have been stored successfully for as long as 10 weeks after harvesting. Cuttings should be stored at temperatures between 3 - 5^{o}C, with moderate to high humidity. Some molding of the cut ends will occur, but the stems should be fine as long as they don't dry out. Commercial storage may be expensive, but options include ice rinks, vegetable barns (cabbage storage etc.) or refrigerated truck units.

HOW TO HARVEST

Materials can be cut with pruning shears, clearing saws, hand saws, or chain saws. Since many of the structures require substantial amounts of cuttings, a mechanical saw is the most efficient. For cuttings with diameters from 10 mm to 70 mm, a clearing saw is recommended. Since the cuts will be close to the ground, a clearing saw is far easier on the operator than a chainsaw. Chainsaws work best on materials over 70mm. Both chainsaws and clearing saws are potentially dangerous tools, those using them are urged to wear the appropriate safety equipment.

When tying together materials for transport - construct the bundles so that all of the growing tips are aligned in the **same** direction. This makes it much easier to use the materials onsite. Bundles should be constructed such that they are easy to transport and should be tied so that they do not fall apart when handled. Leave all of the side branches intact. The use of a set of sawhorses makes it easier to tie the bundles (Figure 4). For this manual, a bundle is typically 40 cm in diameter.

Figure 5: Successful coppice growth from the stem. (photo by Rick Grillmayer)

When cutting the material be sure to make the cuts 15 - 30 cm above ground. This will ensure successful coppice growth from the stem (Figure 5). Caution - for safety reasons leaving high stumps should be avoided in areas frequented by people. This coppice growth can be cut 2 - 3 years later and is often easier to handle than the original stems, grows faster as a cutting, and the number of stems sometimes increases tenfold over a given area.

A note of caution - for safety reasons, leaving high stumps should be avoided in areas frequented by people.

To help you in the construction of future projects, keep track of areas that have been mowed for clearing, or harvested by previous soil bioengineering projects. They can be re-cut in the future, usually providing better quality material than during the first harvest.

HOW TO TRANSPORT

Remember that the cuttings are ALIVE, and should be handled with care. When transporting them any distance, they should be covered (in an enclosed truck, or tarped over) to avoid drying out from the wind. Cuttings that are not used within 12 hours of harvesting should be stored with the cut ends in water. You should avoid storing cuttings (unless in a controlled environment like a cooler) for more than 72 hours after harvest. Every effort should be made to keep cuttings, cool, moist, and shaded.