Restoration and Reclamation Review
Student On-Line Journal
Vol.2, No.2, Spring 1997
Department of Horticultural Science
University of Minnesota, St.Paul, MN

Use of Manufactured Materials in Shoreline Restoration Projects

Leslie H. Knapp

INTRODUCTION

The restoration of wetland fringe vegetation along lakeshores is receiving increased attention in Minnesota. Demonstration projects are underway that can provide lakeshore landowners with ideas on how to revegetate their lakeshore to naturalize the shoreline, control erosion, reduce wave action, reduce the level of pollutants entering the lake, provide wildlife habitat, and reduce maintenance requirements. Partnerships between public agencies and landowners are being formed, in some cases providing funding assistance to landowners. Shoreline erosion, a particularly critical factor during vegetation establishment, is caused by a number or combination of components including wind, motorboat, and jet ski generated waves; ice heave; groundwater seepage; water level fluctuation; runoff from adjacent uplands; and human use of the waterfront (Cannon River Watershed Partnership, 1996; Craig, 1997; Dindorf, 1993; Goldsmith, 1991 and 1993; McFadden, 1996; Yost, 1996) . These components can make shoreline revegetation difficult. A wide range of materials, both natural and manufactured, can help control erosion and facilitate shoreline revegetation. In general, erosion control materials are used where vegetation has been removed from soil and erosion can occur. Once established, vegetation can stabilize an area by reducing the impact of raindrops and runoff velocity, helping to hold soil in place, and absorbing some wave impact. In many cases, vegetation cannot be established within the desired timeframe or cannot withstand the erosive forces present unless some form of erosion control is used during the establishment period (Craig, 1997; Goldsmith 1991, 1993 and 1994; Lancaster, ND).

ORIGINATION OF THE TECHNIQUE

Bioengineering techniques in general began to be applied about 100 years ago in Europe where plant material has been used to stabilize mine sites, slopes and other areas. Historically, various materials ranging from straw, hay, and paper to burlap were used as mulch to control erosion in newly seeded areas. In the United States, the Soil Conservation Service (now the Natural Resource Conservation Service) standardized the use of loose hay or straw mulch to control erosion in areas where vegetation was being reestablished. The technology of incorporating mulch in blanket form dates back to the 1930's and 1940's. According to one manufacturer (Neimeier, 1997), the oldest patent on record in the United States was for corn plant material in blanket form recorded in 1934. The use of erosion control blankets began in the United States about 30 to 35 years ago, in the form of a wood fiber blanket. Machine production of erosion control blankets in North America began in Toronto, Canada in the early to mid-1980s. About 14 manufacturers in the United States make erosion control blankets. A variety of biodegradable and other specilized materials, some with plant material incorporated in them, started to come on the market about 20 years ago (Neimeier, 1997).

BASIC EROSION CONTROL MATERIALS

In order to assess methods suitable for the lakeshore environment, several basic erosion control materials are reviewed in this section, including mulches, meshes, erosion control blankets, geosynthetic turf mats, and hard armored material. A wide variety of materials are available to address erosion problems encountered in revegetation projects ranging form golf courses to lakeshores. In the following section, some more specialized materials are reviewed. Factors to consider when selecting an erosion control method include site topography, slope steepness, the movement pattern and flow velocity of water, water level fluctuation, wave action, and cost. Once the type or types of erosion are defined, erosion control materials can be selected.

Mulches

Temporary erosion control techniques include the placement of loose mulch. Loose mulch can consist of straw, hay, other plant fibers, wood, or paper. Loose mulches commonly consist of straw or hay fibers that decompose within one growing season. These materials can be hand spread or machine-blown over a seeded surface at a rate of 3,000 to 4,000 pound per acre. Loose mulches don't resist wind or water flow well and are most suitable for areas undergoing mild erosive force, such as flat or slightly sloping terrain of 5:1 (horizontal:vertical) or less. Loose mulches applied to slopes approaching 5:1 or with significant wind exposure should be crimped into the soil with a coulter disk, oversprayed with a chemical bonding agent, or mechanically anchored with erosion-control mesh. If the area is going to be mowed, a mesh that will degrade rapidly should be selected. Anchored mulches can be used in low-flow swales (depressions or drainages) or wetland fringes where flow-induced shear stress does not exceed 1.45 pounds per square foot. Hydraulically applied mulches (hydromulches) typically consist of wood or paper fiber mixed with water, seed, and fertilizer. Hydromulches, sprayed onto the soil at a rate of 1,500 to 3,000 pounds per acre, demonstrate similar longevity and range of applications as loose mulches, but offer the convenience of one-step application. Both can be combined with chemical bonding agents to improve short-term stability and attachment to the soil (Lancaster, ND; North American Green, 1995). Mulch material costs about $0.25- $0.30 per square yard (RS Means, 1997).

Meshes

Erosion control meshes are open weave geotextiles consisting of jute, coconut, or polypropylene. Depending upon the material, these meshes may last from 1 to 5 years. A mesh that will break down rapidly should be selected if the area will be closely mowed. Some accelerated photodegradable netting options provide short term (30-60 days) erosion protection before complete deterioration. Close mowing soon after vegetation establishment is required to facilitate photodegradation (Lancaster, ND; North American Green, 1995). A rough material cost for meshes is $0.10 to 0.50 per square yard (Geosynthetics, 1997).

Erosion Control Blankets

Erosion control blankets can be used on sites where slopes range from gentle to steep, or where high flow channels or highly erodible areas are present. Blankets are constructed of a mulch fiber such as straw, excelsior, coconut, or blends of these materials sewn or glued to a biodegradable or synthetic netting. Single- netted blankets with photodegradable or biodegradable netting are generally used on moderate (2:1) slopes and swales with shear stresses of 1.55 pounds per square foot or less. Double-netted blankets provide a higher degree of protection for more severe terrain on slope gradients up to 1.5:1 and in channels where shear stresses approach 1.65 pounds per square foot. Straw-coconut and coconut blankets provide long-term erosion protection for slopes exceeding 1:1 and in channels where shear stresses reach 2.25 pounds per square foot. Blankets are applicable to most areas where expected long-term erosive conditions will not exceed the limits of established vegetation (Lancaster, ND; North American Green, 1995). Wildlife can get caught in the netting used in the manufacture of erosion control blankets. Some manufactures are now marketing a "wildlife friendly" net, designed for ecologically sensitive sites that can be filled with 1 of 4 matrix options. Net construction allows intersecting jute strands to move independently of one another to reduce the risk of wildlife entanglement. The netting in this temporary blanket is 100% biodegradable so that no synthetic netting residues are left after vegetation establishment (Nelson, 1997; North American Green, ND). A rough material cost for erosion control blankets is $0.35 to $1.70 per square yard (Geosynthetics, 1997).

Geosynthetic Turf Mats

Geosynthetic turf mats offer a higher degree of erosion control on sites where flow channels or steep slopes exposed to large volumes of runoff require permanent support. These heavy duty, nondegradable, three- dimensional mats provide permanent reinforcement for vegetation and are designed to work with vegetation to increase resistance to erosion. These mats typically contain a fiber matrix of polypropylene or coconut fiber sewn into netting to provide long-term or permanent erosion protection and allow vegetation to grow in areas that would otherwise require riprap or concrete placement. The mats can withstand shear stresses up to 8 pounds per square foot, similar to 24-inch rock riprap, while providing a more natural and appealing surface with less usage limitations (Lancaster, ND; Langford, 1996; North American Green, 1995). A rough material cost for geosynthetic turf mats is $3.00 to 4.00 per square yard (Geosynthetics, 1997).

Hard Armored Materials

Hard armored materials such as riprap, gabions, interlocking concrete block and poured concrete, are used in areas where dense, healthy vegetation cannot be maintained due to environmental conditions such as excessive shading, wetness, contamination, or intermittent drought. Hard armored materials are sometimes the only option available in very high discharge channels where flow-induced shear stresses exceed 8 pounds per square foot (Lancaster, ND; North American Green, 1995). There are negative aspects of hard armored materials. Concerns about the loss of green space and the trend for using softer materials because people are demanding a more natural look, has made the use of vegetation to soften and naturalize the appearance of areas increasingly important. Vegetation provides additional benefits such as wildlife habitat, trapping and filtering sediment and pollutants in runoff, and (in conjunction with microorganisms) metabolizing and breaking down many pollutants carried by silt and clay particles. Riprap can harbor snakes and rodents, which are typically not desirable. Vegetation pockets between riprap collect debris and litter. It is difficult to walk on or use areas covered with riprap, and the danger of tripping and injury from falling are concerns (North American Green, 1997). Armored material costs vary greatly depending on method and material hauling distance, but can be estimated at about $7.00 to $40.00 per square yard (RS Means, 1997; Latimore, 1997).

SPECIALIZED MATERIALS

Some specialized adaptations that may apply to lakeshore revegetation were also reviewed. These include pre-seeded blankets, pre-vegetated mats, rolled fiber modules and manufactured islands.

Pre-seeded Blankets

Seed mixtures can be incorporated in blankets with double-sided, synthetic netting. Seed is set in a cellulose fiber growth medium that adheres together when water is absorbed, and biodegrades. Pre-seeded blanket installation is easier than seeding on steep slopes or in the water along shorelines. Evenly spaced seed distribution is maintained under difficult site conditions (Nelson, 1997). Pre-seeded blankets may not be suitable for some soil conditions. In dry environments, irrigation is helpful since the cellulose layer does not dissolve if dry and can act as a barrier to seed germination and rooting (Hanrahan, 1997). Another major disadvantage is that seed is not in direct contact with soil. Manufacturers (Nelson, 1997; Hanrahan, 1997) and users (Dindorf, 1997; Stromen, 1997) agree that this results in lower success rates than seeding directly into site soils. Pre-seeded standard rate cool season and warm season grass mixes are available. Contract order, custom seeded blankets are available on request for a wider variety of plant communities. Since seeds are incorporated by the manufacturer, site-specific seed mixtures or local genotypes will not be available unless the manufacturer prepares the blanket using local seed on a contract basis. This requires significant lead time. The pre-seeding option currently applies to 4 kinds of blankets and, with the standard mixes, adds about $0.50 per square yard to the blanket cost (Hanrahan, 1997).

Pre-vegetated Mats

Pre-vegetated mats are similar to sod, containing mature plants. A mature stand of wetland vegetation can be established rapidly on shorelines, stream banks, tidal areas, swales, detention basins, or wetlands. Roots have grown through mat and are in direct contact with the soil when installed. Roots are kept moist by the water retaining capacity of the fiber as establishment occurs allowing for rapid incorporation and soil stabilization. Such rapid plant establishment is often needed to control moderate to high levels of erosion from waves and currents. Mats are grown in a nursery setting where maintenance and conditions are conducive to plant establishment. Mature stands of vegetation are easy to transport and can be installed over a wider planting season than seeded blankets. The mats do not float on water and have moisture and nutrient retention capabilities. Sediment accumulation around plant roots provides a medium for stable plant growth and expansion (Craig, 1997; Bestmann Green Systems, ND; Goldsmith 1993).

Pre-vegetated mats that are 2 inches thick, 16.5 feet long, and 3 feet wide, weigh about 2 pounds per square foot and are designed for use where flow velocities are 2 feet per second or less, or wave heights are less than 1 foot, and where slopes are less than or equal to 1:5. These mats are typically available in with plants for wet meadow, stream and lake, ditch and swale, saltmarsh and brush plantings. The wet meadow mat contains sedge (*Carex* spp.), soft rush (*Juncus effusus*), wool-grass (*Scirpus cuperinus*), and fowl manna-grass (*Glyceria striata*). The stream and lake mat contains sedge, blue flag iris (*Iris versicolor*) Canada manna-grass (*Glyceria canadensis*), and rice cutgrass (*Leersia orizoides*). The ditch and swale mat contains redtop (*Agrostis alba*), soft rush, twig rush (*Juncus nodosus*), and barberpole sedge (*Scirpus rubrotinctus*). The saltmarsh mat contains saltmeadow cordgrass (*Spartina patens*) and seashore spikegrass (*Distichlis spicata*). The brush mat contains mixed dogwoods (*Cornus* spp.) and mixed willows *(Salix* spp.) Additional species are available in smaller quantities, and contract orders can be prepared. Individual plants grown in coir fiber are available from the manufacturer for installation in the mats. Plants from other sources may also be added (Bestmann Green Systems, ND). The material cost for these mats are about $200 per 50 square foot module or about $3.80 per square foot. Unvegetated mats can be purchased for about $125 per module or $2.50 per square foot (Hartwell, 1997).

Pre-vegetated mats that are 3.5 inches thick, 50 inches long, and 30 inches wide, weigh about 6 pounds per square foot are designed to withstand velocities up to 5 feet per second or waves up to 20 inches, where slopes are less than or equal to 1:3. These mats commonly contain such species as sweet flag *(Acorus calamus*), blue-flag iris, baltic rush (*Juncus balticus*), common reed (*Phragmites australis*), soft-stem bulrush, burreed (*Sparganium* spp.), saltmarsh cordgrass, narrow-leaf cattail (*Typha angustifolia*), and broad-leaf cattail (*Typha latifolia*). Additional species are available in smaller quantities, and contract orders can be prepared. Individual plants grown in coir fiber are available from the manufacturer for installation in the mats. Plants from other sources may also be added (Bestmann Green Systems, ND). The material cost for these mats are about $60 per 10 square foot module or about $2.50 per square foot. Unvegetated mates can be purchased for about $35.00 per module or $3.50 per square foot (Hartwell, 1997).

Since pre-vegetated mats are mass produced in a nursery, site-specific species or local genotypes will not be available unless the manufacturer grows them from local seed on a contract basis. If considering this option, it takes about three months for the nursery to produce pre-vegetated mats from seed. For large contract orders, 18 months advanced notice is recommended to assure availability. Temperature regulation during shipping is sometimes required. Products must be installed immediately, or stored (unrolled) in a temporary constructed holding pond with appropriate levels of sunlight, moisture, and protection from herbivores. Manufacturers are considering developing regional growing areas so that more appropriate plant mixes and genotypes can be grown. The coir fiber in mat takes up to 5-7 years to break down, and by then plants are well established. Wildlife entanglement is less of an issue than with unvegetated mats since mature plants stand above the netting (Bestmann Green Systems, ND).

Rolled Fiber Modules

These devices, constructed of rolled fiber in flexible modules, help plant establishment along stream or river banks, lake or reservoir shorelines, and in tidal areas. The rolls help stabilize soils and facilitate revegetation where steepness or exposure to waves or currents cause instability. These flexible rolls are typically 12, 16 or 20 inches in diameter, 10 or 20 feet long, and composed of coir fiber with a density of at least 9 pounds per cubic foot and can be placed directly on the bank, often retaining fill material placed behind them for plant establishment. The rolls are tightly bound with either a natural fiber or braided synthetic mesh to provide physical stability (Bestman Green Systems, ND; Craig, 1997; Goldsmith, 1991 and 1993).

As wave stilling devices, the rolls are typically placed offshore to break waves and initiate sedimentation processes that facilitate the establishment of vegetation that can dissipate wave energy. They provide an alternative to wave stilling devices constructed of stones or bundles of branches that are difficult to vegetate. Stone wave stilling devices are costly. Branch bundles can be obtained at little or no cost. Neither support vegetation. Individual plants grown in coir fiber are available from the manufacturer for installation in the fiber rolls. Plants from other sources may also be added. Rolled fiber modules collect and hold mineral and organic particles, provide a physically stable substrate for root growth, and slowly biodegrade to leave a self-maintaining erosion-controlling plant community. If the area behind the roll is filled for vegetation establishment this area can be seeded or planted using methods most suitable for the situation (Bestman Green Systems, ND; Craig, 1997; Goldsmith, 1991 and 1993).

The biodegradable version consists of coir fiber in a coir fiber mesh and can withstand flow velocities below five feet per second, wave heights below 20 inches, and slopes less than or equal to 1:3. A permanent version with a polyethylene mesh is available that can withstand flow velocities of 12 feet per second, wave heights up to four feet, and variably steep slopes (Bestmann Green Systems, ND; Craig, 1997; Goldsmith, 1991 and 1993). Rolled fiber wave stilling devices were used on demonstration projects in Minnesota. Wooden stakes specified by the manufacturer broke off due to ice action, metal stakes proved to be more effective. However there can be safety issues related to metal stakes. A demonstration plot will be installed in Minnesota this year using duck anchors and cable (Dindorf, 1997). Rolled fiber modules cost from about $12.00 to $30.00 per linear foot. Pre-vegetated plant rolls cost an additional 4.50 to 5.00 per linear foot (Hartwell, 1997).

Manufactured Islands

Manufactured islands provide vegetation, nesting sites, and shoreline protection on lakes, reservoirs, and detention basins where other techniques are not practical. They move with fluctuating water levels, do not reduce storage volume, and offer habitats free from land predators. Vegetation can be planted on the islands to provide wildlife food and cover, and fish can use the underlying root zone. Manufactured islands are anchored offshore where they can slow wave movement and reduce shoreline erosion. The islands are constructed of polyethylene tubing, covered with rough nylon geotextile, which provides footing for waterfowl, and other buoyant materials. The islands can be topped with vegetation or gravel, and are designed to withstand exposure to ice, wind, and ultraviolet rays (Bestmann Green Systems, ND).

Multiple 100-foot equilateral triangular units can be fastened together to create a range of configuration and cover types. Each unit is 10 inches high, weighs 70 pounds, and can support up to 400 pounds. Manufactured islands may be used to establish vegetation regardless of shoreline instability and fluctuating water levels. They are not recommended for areas with poor water quality, that can affect vegetation establishment, or where there is not sufficient water to support islands. Anchoring systems needed for installation are selected based on site conditions.

Twenty-eight plants are included in vegetated modules. Orders should be placed about three months in advance of need to ensure availability. Plants accompanying vegetated modules are packaged separately and may require temperature control and special storage requirements until installed. Although the islands are designed to withstand ice, information from Minnesota lakes, where ice can be a major problem, is needed. Islands can be stored on-shore in the winter and placed back on the lake in the spring after the ice is out (Hartwell, 1997). Manufactured islands cost about $3000.00 each. Another option in development are floating marshes that are designed to meet specific site needs. The marshes cost about 4.50 per square foot (Hartwell, 1997).

SUMMARY

There is a wide range of manufactured materials available that can be considered for use on lakeshore restoration projects. This paper reviewed some of the basic and specialized erosion control materials available. Each material has a specific range of applications. These applications, cost, and the goals of the restoration design should be considered in the selection process.

REFERENCES

Bestmann Green Systems. ND. Manufacturer's Information.Cannon River Watershed Partnership. 1996. *"Living on the Edge"* pamphlet. Faribault, MN.

Craig, A. Restoration Ecologist, Bestmann Green Systems. April 1997. Personal communication.

Dindorf, C. 1993. Aquascaping, A Guide to Shoreline Landscaping. Hennepin Conservation District. Minnetonka, MN

Dindorf, C. April 1993. Hennepin Conservation District. Personal Communication.

Geosynthetics (GSI). May 1997. Personal Communication.

Goldsmith, W., C. Franklin, and J. Alminana. 1994. *"Healing Public Stream Banks"*, Erosion Control March/April

Goldsmith, W. 1993. *"Lakeside Bioengineering"*, Land and Water. March/April: 37

Goldsmith, W. 1991. *"Working with Nature to Stabilize Shorelines"*, Land and Water. Nov/Dec: 35

Hanrahan, P. May 1997. North American Green. Personal Communication.

Hartwell, S. May 1997. Bestmann Green Systems. Personal Communication.

Lancaster, T. ND. *"Mulches, Meshes and Mats Keep Soil in Place, A Guide to Effective Erosion Control on the Golf Course*", Golf Course Superintendents Association of America Reprint.

Langford, R. 1996. *"Geosynthetically Reinforced Vegetation: A Soft Armor Alternative to Riprap"*, Land and Water, July/Aug.

Latimore, L. May 1997. Rust Environment & Infrastructure. Personal Communication.

McFadden, K. 1996. *"Design at the Edge: Art and Science for Lakeshore Restoration"*, Restoration & Reclamation Review.

Nelson. R. April 1997. Technical Services. North American Green. Personal Communication

Niemeier, J. April 1997. President, North American Green. Personal Communication.

North American Green. ND. Manufacturer's Information.

North American Green. 1995. Erosion-control Materials Design Software, Version III. North American Green Inc., Evansville, IN.

North American Green. 1997. *"Benefits of Geosynthetically Reinforced Vegetative Channel Liners Versus Riprap (Part II)"*, Erosion Discussion: Vol. 2, Issue 1

RS Means Company. 1997. Site Work and Landscaping Cost Data. 16th Edition.

Stromen, D. April 1997. Minnehaha Creek Watershed. Personal Communication.

Yost, D.G. 1996. *"Vegetative Cover for Erosion Control"*, Land and Water 40.