Riparian/Wetland Project Information Series No. 15
July, 2000

COSTS AND CONSIDERATIONS OF STREAMBANK BIOENGINEERING TREATMENTS

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Introduction

One of the most frequently asked questions involving streambank bioengineering work is how much does it cost. Figures for traditional treatments like rock riprap are readily available. However, because bioengineering treatments are relatively new in the United States, little accurate data has been published on installation costs. This paper does not put actual dollars to the treatments because those dollar cost will change from area to area based on labor costs, material costs, and equipment costs. By using the staff-hour estimates, a person can put the actual dollar costs that are reasonable for their area in the equation and come up with a fairly good cost estimate for their project. Fischenich and Allen (1999) have put together a preliminary estimate based on their experiences, research, and experiences of other bioengineering practitioners. Their work is the basis for this Riparian/Wetland Information Series paper.

Equipment considerations

When developing a restoration plan, consideration should be given to the equipment and materials required for vegetation handling and planting. The tools and the planting techniques required will depend on the type of vegetation, i.e., woody or herbaceous, the size of plants, soils, the size of the project and site conditions. Freshwater herbaceous plantings with low wave or current energy environments may call for hand tools such as spades, shovels, and buckets. In contrast, high energy wave and currents environments may require specialized equipment. Tools, such as, chain saws, loppers, and hand pruners will be needed for the preparation of woody materials. Heavy hammers and sledges will be needed for driving stakes in wattles and brush

mattresses. Power augers, water jets, and planting bars can be used to install willow cuttings. In some cases, backhoes and excavators may be necessary to dig trenches or shape slopes. Small front-end loaders and walking excavators are sometimes required to minimize disturbance of existing vegetation and soil. Other equipment and materials may include fertilizers, soil amendments, (e.g. lime), fencing for plant protection, and irrigation equipment to provide supplemental water during dry conditions. Additional equipment and materials that might be necessary for keeping plants alive before they are planted may include shading materials such as tarps, buckets with water for holding plants, and water pumps, hoses and water trucks for watering the plant materials.

Bioengineering treatment vs. traditional method cost

Bioengineering treatments are normally less expensive than traditional methods of streambank erosion control, such as, riprap revetment and bulkheads, but not always depending on the environmental setting and the project objectives. Costs can vary tremendously based on availability of materials, hauling distances, prevailing labor rates for the geographic area, and a host of other factors. When comparing bioengineering methods with traditional engineering applications, each must be considered on its merits. This includes comparing life-cycle costs, design and construction costs, and future management and replacement costs.

Bioengineering treatments require a longer term investment early in the project life to ensure that the living system is established. Then, maintenance drops off and the vegetation in the bioengineering treatment continues to grow, spread, and strengthen the newly protected streambank.

Treatment	Relative Cost	Relative Complexity
Live stake	**Low**	**Simple**
Joint planting	**Low**	**Simple**
Live fascine	**Moderate**	**Moderate**
Brush mattress	**Moderate**	**Moderate to Complex**
Live cribwall	**High**	**Complex**
Branchpacking	**Moderate**	**Moderate to Complex**
Conventional vegetation	**Low**	**Simple to Moderate**
Conventional bank armoring (riprap)	**Moderate**	**Moderate**

Table 1: Streambank Erosion Protection Treatment Relative Costs And Complexity (Fischenich and Allen 1999)

Some maintenance costs may be associated with the bioengineering treatment later in the project life, but these costs will normally be small. In contrast, the traditional treatment using inert structures, such as riprap revetment, will have a high construction cost and a substantial replacement or refurbishment cost. Costs for bioengineering treatments versus hard structures are difficult to compare when strictly looking at dollars per unit of measure. The most common denominator for arriving at costs seems to be labor, in terms of the person hours it takes to build

and install a particular treatment. In addition, material costs and equipment rental, etc. should be considered. Table 1 describes the relative costs and complexity of bioengineering treatments in relationship to two conventional treatments.

Staff-hour Costs of Bioengineering Treatments

Table 2 gives labor estimates for various kinds of vegetative and bioengineering treatments depending on available information. Please note that these vary considerably and depend largely on proximity to site, prevailing labor rates, etc. The physical condition and experience of the planting crews directly influence these figures. As the planting crews become better conditioned, especially in hot and humid areas, they will be able to complete more feet or acres of treatment. In addition, as the crews build more bioengineering treatments, they will become more proficient and efficient in the techniques and procedures.

Plant materials can significantly increase the cost of any bioengineering project. Woody and herbaceous plant materials are an inherent part of any streambank bioengineering project. The location of a harvestable stand can increase project costs if it is a long distance away from the project area. The size and vigor of the stand will also dictate plant establishment. As more projects are designed and funded, ownership of the plant materials will become a more pressing problem. Presently, most landowners are quite willing to allow renewable harvesting of the plant materials without much, if any, cost. However, additional demands will change this attitude and the cost for plant materials will increase. Harvest permits similar to Christmas Tree permits sold by the USDA Forest Service may eventually be required.

ACTIVITY	PER PERSON LABOR REQUIRED
Wattling	**6-17 ft/hr**
Brush Layering	**6-17 ft/hr**
Brush Mattress	**0.2-1.2 yd^2/hr**
Dormant Posts	**10 - 20 posts/hr**
Willow Cuttings	**45 - 50 cuttings/hr**
Plant Roll	**20 ft/hr**
Coir Fascine	**5 ft/hr**
Sprig Planting	**5-24 yd^2 /hr**
Seedling Planting	**30-120 plants/hr**
Ball & Burlap Shrubs	**1-15 plants/hr**
Containerized Plants	**20-100 plants/hr**
Vegetative Geogrids	**0.7-1.3 ft/hr**
Seeding	**0.05-0.5 ac/hr**
Hydroseeding	**0.12-0.37 ac/hr**

Table 2. Labor estimates for a variety of vegetative and bioengineering treatments (Fischenich and Allen 1999).

Brush Mattress or Matting

The cost of a brush mattress is moderate according to Schiechtl and Stern (1984), requiring 0.2 to 1.2 staff-hours/yd^2 (2 to 5 staff-hours/m^2). In a training session conducted as part of a shoreline erosion control workshop, a crew of 20 students using hand tools installed about 21.5 yd^2 (18 m^2) of brush mattress at a rate of about 1 staff-hour/yd^2. This rate included harvesting the brush, cutting branches into appropriate lengths, and constructing the mattress. This rate of production compares favorably to an average rate of 1.1 yd^2 (0.92 m^2) of brush mattress/staff-hour by a leading bioengineering firm in the United States.

Brush Layering

There are few references on the cost of brush layering. Schiechtl and Stern (1984) reported the cost to be low, presumably in comparison to techniques using riprap or other similar materials. In the training session mentioned earlier, a crew of 20 students using hand tools installed about 66 ft (20 m) of brush layering along one contour-slope in about 30 min. This equates to 6.6 ft (2 m)/staff-hour. Often, costs can be reduced if machinery such as bulldozers or graders can gain access to the site and reduce the hand labor required in digging the trenches. Workers would then fill the trenches with brush, which in turn could be covered using the same machinery.

Fascines or Wattles (Willow Bundles)

Grey and Leiser (1982) reported staff-hour costs for installing wattling and willow cuttings at Lake Tahoe, California. These staff-hour costs run about 6 linear ft of wattling per staff-hour and 46 small willow cuttings per staff-hour. Grey and Sotir (1996) quoted average installations rate of 5 linear ft of fascine production per staff-hour. Obviously, if one were to place a coir fabric between contours of fascines, production rates would decrease substantially. According to Ms. Sotir, who has done this extensively, it would probably cut the time in half for the amount of linear ft per staff-hour.

Dormant Willow Post Method

Roseboom (1995) reported that bioengineering work on a 600-ft reach at Court Creek, Illinois, took 5 men, two 8-hr days to install 675 willow (12- ft tall) posts on 4-ft centers. This included installation of a rock toe (20 tons of 10 in riprap) with a coir geotextile roll along 300 ft. Also, 60 cedar trees were laid and cabled along the toe of the slope to trap sediment. Included in the estimate were an excavator operator along with the 4 other men previously mentioned. This equates to about 17 posts/staff-hour that includes harvesting and installing the willow posts plus the other operations mentioned above, e.g., shaping site, cedar tree installation.

Vegetative Geogrid

Staff-hour costs for 123 ft of a 6-ft high vegetative geogrid installed on the UpperTruckee River included 3 days time of:

1 - foreman/equipment operator
1 - equipment operator
2 - laborers
1 - supervisor/project manager

Thus, 120 staff-hours were expended on the above project assuming an 8-hr day. This equates to about 1 staff-hour/linear foot of treated bank. About 66 % of the costs of this treatment can be attributed to labor.

Standard Seeding

The cost for broadcast seeding/ ft^2 can vary considerably according to some literature sources. Reported costs in staff-hours/ ft^2 vary from 0.005 (Kay 1978) to 0.084 (Schiechtl and Stern 1984) depending on the hydrology, degree of slope, and, most importantly, the price of seeds used.

Hydroseeding

Depending on the material used and the distance to adequate water, 4,784 to 23,920 ft^2 (4,000 to 20,000 m^2) can be hydroseeded by one machine/day (Schiechtl and Stern 1984). A hydroseeder normally uses a two-man crew.

Hydromulching

Mulching is often applied over seeds by a hydromulcher (similar to a hydroseeding machine). For hydromulching or mechanical mulching without seeds, about 0.14 to 0.60 staff-hours/yd^2 (0.12 to 0.50 staff-hours/m^2) is estimated (Schiechtl and Stern 1984). Mulching after seeding increases the cost/m^2 considerably. Hydromulching with a slurry of wood fiber, seed, and fertilizer can result in a cost of only 0.010 staff-hours/ft^2 (0.008 staff-hour/m^2), according to calculation's derived from Kay (1978), who reviewed contractor costs in California. The above staff-hour calculations assumed: use of a four-man mulching- machine, seed and fertilizer applied at a rate of 0.75 tons/acre (0.15 metric tons/ha), and an application rate of 2 tons/hour.

Sprigs, Rootstocks or Plugs, Rhizomes, and Tubers

Costs for digging grasses and other herbaceous plants in their native habitat and transplanting the propagules will vary depending on the harvesting system used, the placement of the plants, the site, the propagule size, and distance to the planting site. For digging, storing, handling, and planting sprigged wetland grasses and sedges, it has been reported that a rate of about 1,000 plants/10 staff-hours is possible (Knutson and Inskeep 1982). Sprigs of this type were placed on 1.5 ft (0.5 m) centers, which would cover 300 ft^2 (250 m^2**).** Allen, et al. (1984) reported a rate equivalent to 400 plants/10 staff-hours for digging, handling, and planting single sprigs. According to Knutson and Inskeep (1982), using plugs of any species (grass or forb) is at least three times more time-consuming than using sprigs (1,000 plugs/30 staff-hours). However, Mandel (personal communication) advocates that plugs are as fast to use as sprigs because of the uniform size, ease of shipment and staging, reduced processing time, and easier placement of the plugs.

Bare-root Tree or Shrub Seedlings

Depending on type of plant and local conditions, the reported costs of planting vary considerably. On good sites with deep soils and gentle slopes, experienced crews can plant between 100 and 125 plants/staff-hour. Logan et al. (1979), however, estimated that only 200 to 400 plants/day/person could be achieved on sites like the banks of the upper Missouri River.

Balled and Burlapped Trees or Shrubs

Planting costs for this type of transplant will be much higher than bare-root plants because of the size. Large balled and burlapped plants generally must be moved with equipment. In some of the West Coast areas, landowners are planting much larger stock including ball and burlap plants to get shade on the streams faster (Hoag and Landis 1999). Planting costs for balled and burlap plants typically range from 10 to 25 plants/staff-hour (Schiechtl and Stern 1984). Mandel (personal communication) argues that 5 to 15 balled and burlapped plants is a more reasonable figure. These figures will depend upon access to the planting site by transportation equipment.

Containerized Plantings

The cost of plantings varies depending on plant species, pot type, and site conditions. Using containers other than paper pots, 20 to 100 plants/staff-hour can be planted. With paper pots, up to 60 plants/staff-hour can be planted (Schiechtl and Stern 1984). Logan et al. (1979) stated that the cost for hand-planting containerized stock ranges from one-half the cost for bare-root seedlings to a cost equal to or exceeding container seedlings.

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