Trials of Erosion Control Netting for Improved Stability of Forest Roadside Slopes
Trials of Erosion Control Netting for Improved Stability of Forest Roadside Slopes

Stephen G. J. Homoky
ABSTRACT

The application of soil netting with established agronomic herbaceous vegetation cover is a useful technique to control surface erosion. However, the practice is confined to carefully engineered structures on highways, waterways, and municipal construction sites with uniform slopes and largely homogeneous soil materials.

The erosion control net should allow emergence of germinants and should be flexible enough to maintain full contact with the soil surface. Achieving the latter requirement is sometimes difficult on forest roads due to the roughness of cut and fillslope surfaces. Therefore, the choice of netting is limited to its flexibility.

Three types of netting were selected for this study and their performances were evaluated. It must be emphasized here that the results should be viewed in terms of significance of these nettings on forest roads only.

Quantitative results support earlier empirical qualitative statements as regards timing of vegetation establishment in the British Columbia interior, length of time required to control surface erosion, and the decline of natural erosion with the passage of years on exposed, untreated surfaces. The study also revealed that erosion control on forest roadsides is possible without the use of netting, but that certain types of netting can contribute significantly to increased and accelerated sediment trapping and biomass build-up. Therefore, erosion control objectives on forest roadsides should be viewed in these two terms.

This report is intended for researchers involved with forest soil conservation research, and for engineering personnel engaged in forest road construction and maintenance.
ACKNOWLEDGEMENTS

The author acknowledges with thanks the co-operation of individuals who made this working paper possible.

The following people helped with their valuable constructive comments: Paul R. Commandeur, Research Scientist of Forestry Canada, Pacific Forestry Centre, Victoria, B.C., William W. Carr, Consultant, of Terrasol Environmental Industries, Abbotsford, B.C.

The dedicated staff of Production Resources of the Forestry Division Services Branch co-ordinated the production of this publication, with the editing services of Susan Bannerman, Kaatza Publishing Services, and the type formatting and layout skills of Dave G. Butcher, Dynamic Typesetting.
## CONTENTS

Abstract iii  
Acknowledgements iv  

1. Introduction 1  
2. Objectives 2  
3. Study area 3  

4. Materials and Methods  
   4.1 Materials 3  
      4.1.1 Erosion Control Netting 3  
      4.1.2 Components of the Hydroseeding Slurry 4  
   4.2 Methods 4  
      4.2.1 Design, Layout, and Establishment 4  
      4.2.2 Assessments 6  

5. Results 9  
   5.1 Live Vegetation Cover 9  
   5.2 Vegetation Composition 10  
   5.3 Soil Loss and Gain 10  

6. Discussion 14  

7. Conclusions and Recommendations 18  

Appendices 20  
Literature Cited 28  

\textbf{figures}  
1 Randomized design 4  
2 View of the layout 5  
3 Staking out the measurement line on jute net 6  
4 Recording with the rill meter 7  
5 Enlarged photo showing the soil surface profile recorded with the rill meter 8  
6 (a) Vegetation cover, Replicate II, 1984 10  
6 (b) Vegetation cover, Replicate II, 1985 10  
6 (c) Vegetation cover, Replicate II, 1986 10  
7 Erosion rates by treatment, year, and cumulative effects 12  
A (1) Schematic illustration of the rill meter with parameters used for the computation of erosion 20
tables
1 Percent live vegetation cover by year, treatment and replicate 9
2 Species frequency by replicate, treatment, and year 11
3 Computed erosion depths in centimetres 11
4 Cumulative erosion in centimetres from 1984 to 1986 13
A (2.1) Analysis of variance for percent live vegetation cover 26
A (2.2) Analysis of variance for cumulative erosion 26
A (2.3) Analysis of variance with contrast tests for cumulative erosion 27

appendices
1 Method of Computation of Erosion Depth, and Compensation for Measurement Errors 20
2 Statistical Analysis of the Results 26
1 INTRODUCTION

This is the final report of Experimental Project 818.01. The control of surface erosion on cut and fillslopes of forest roads has been practiced for many years and results have been documented. Evaluation of results are mostly qualitative but actual soil loss and gain have also been reported quantitatively. The most common technique of surface erosion control is vegetation establishment on exposed mineral soil surfaces with appropriate grass-legume mixes and/or shrub and tree species (Dyrness, 1967; Carr, 1977, 1980; Carr and Ballard, 1980; Homoky, 1984, 1987).

Control is successful on well-constructed road slopes when a plant-litter cover of about 70–75% is achieved in wet and moist biogeoclimatic zones, or somewhat less in zones with lower precipitation.

On certain slope configurations with weak segments, and on fine-textured soils, sands, or soils with loose coarse fragments, however, additional steps may be required to stabilize the surface. The slopes around major drainage structures, and bridge abutments would commonly fall into this category. Therefore, in order to enhance the knowledge and success of erosion control, testing soil amendments in association with vegetation cover establishment becomes desirable.

One well-known and widely used type of soil amendment is mulch. Another type of material suitable for treating slope surfaces in simultaneous application with vegetation is erosion control netting. This latter technique has been recognized in municipal, highway, and waterway construction projects as a means of keeping seed, fertilizer, and mulch on the slope, and providing protection for the germinating seeds. A wide variety of erosion control materials is available on the market, but their applicability is limited in the forest environment. Not all commercial products are suitable to treat uneven forest road slopes. The determining criterion is flexibility of the net in order to maintain contact with the slope soil surface.

Evaluation of performance of netting and vegetation must be done quantitatively to show as accurately as possible the change of slope conditions at the end of a given period. The parameter of interest is the decrease or increase of the soil surface elevation, which can be converted to the rate of soil volume increase or decrease per unit area per given time. This requires some form of measurement technique.

Works of earlier investigations (Dyrness, 1970; Carr, 1977; Carr and Ballard 1980) reported soil losses on untreated road slopes, and decreases or increases of soil profiles of vegetated slope surfaces. Dyrness (1970) in Oregon reported 1.14 cm soil loss over the first winter after road construction, resulting from water erosion. Additional soil loss due to dry ravelling was 1.2 cm during summer months. Total soil loss amounted to 2.34 cm, which translates to 234 m$^3$/ha in an area receiving relatively low precipitation. Carr (1977) found 2.3 cm of soil loss on south Vancouver Island at the end of a seven-month period between September 1976 and April 1977 on a 3-year-old forest road. On vegetated test plots all erosion values were negative (trapped sediment and accumulated biomass), ranging from -0.8 to -1.6 cm, which translates to -80 to -160 m$^3$/ha. Commandeur and Walmsley (1993) determined surface erosion rates on
clearcuts outside the road right-of-way on biomass-harvested and conventionally harvested plots. Corresponding figures were 0.78 and 0.37 m$^3$/ha/year, respectively. In comparison, road slope erosion values are high, indicating that forest road slopes constitute a substantially greater erosion hazard. The highest rate of road slope erosion occurs during the first few years following road construction. Dyrness (1970) found 0.51 cm or 51 m$^3$/ha/year erosion rate on his studied plots even five years after road construction.

There are several techniques for measuring erosion, with inherent advantages and disadvantages (Commandeur and Walmsley, 1993).

- Sediment dams are good for comparing erosion responses of various treatments, but are not accurate enough where small erosion volumes are involved.
- The accuracy of the erosion bridge is not known because of freeze-thaw cycles of soil density, vegetation growth, and eventual movements and displacement of the metal rods. Number of measurements should be matched with plot size.
- The portable rainfall simulator was designed for small areas. It cannot entirely create the conditions under which rainfall and infiltration would normally occur, but this technique is useful for point measurements of soil infiltration capacity. Larger simulators have been used quite successfully on forest road segments (Burroughs and King 1989).
- The rill meter (McCool et al. 1976) used in this study to record surface soil profile and elevation changes can be used accurately, and factors affecting the computations can be accounted for. However, this instrument is quite bulky. It is best suited to research work when accuracy is a prime requirement, but its use in large-scale application is rather tedious and time-consuming.
- Sediment traps
  Larger plywood construction traps (McGreer 1981; Megahan 1978; Mersereau and Dryness 1972)
  Small aperture traps, 10 cm by 30 cm (Wells and Wohlgemuth).

2 OBJECTIVES

The aim of the study was:
- to test the assumption that soil netting can provide additional soil surface protection and can enhance vegetation cover establishment, thereby significantly contributing to surface erosion control on forest roadside slopes, and
- to determine the cost-effectiveness of the tested material.
3 STUDY AREA

The study area is located in the Prince George Forest Region, Prince George Forest District, in the Rocky Mountain Trench, near the McGregor River on the Walker Creek Forest Service Road between 30 and 31 km. This area falls into the Sub-boreal Spruce very cool (SBSvk) biogeoclimatic subzone. Map co-ordinates: 53°55’44” latitude north, and 120°52’17” longitude west. The soil is an erodible glaciofluvial deposit with a sandy silt loam texture with less than 10% coarse fragment content. Road construction was completed in late 1980. Soil movement was still intense in 1983, evidenced by numerous gullies and rills on the slopes and sediment accumulation in the ditch. The test plots are located on a gentle cutslope of about 43–45% steepness. The slope is fairly uniform, aspect is west.

4 MATERIALS AND METHODS

Materials used in the investigations were three types of erosion control netting and the components of the slurry. Methods involve the layout, experimental design, assessments of slope cover and species composition, and the measurement and computation of erosion.

4.1 Materials

4.1.1 Erosion Control Netting The three types of netting were chosen on the basis of flexibility to be fastened to the exposed surface with appropriate staples and pegs.

- **Vexar Plastic Netting** (Canadian Forestry Equipment 1983a). This material is a light-weight, low-cost netting extruded from polypropylene. Its life expectancy is 2–3 years in direct sunlight. Mesh size is about 2.5 cm by 5.0 cm (1” by 2”). Dimensions of one roll: 1.2 m by 3.7 m (4’ by 12’). It weighs about 0.013 kg per m². Area covered: 4.44 m². Cost1: $2.86 per roll or $0.64 per m².

- **Ludlow Soil Saver** (Canadian Forestry Equipment 1983b). This is a simple, flexible, biodegradable jute net. Dimensions of one roll are 1.2 m by 68.5 m. Area covered: 83.5 m². Cost1: $125.10 per roll or $1.49 per m².

- **Enkamat 7010** (American Enka Company 1980). This is a non-biodegradable, three-dimensional, geomatrix netting made of heavy nylon monofilaments, fused at intersections. Ninety percent of this geomatrix is open space. Dimensions of one roll: 0.97 m ± 3% by 150 m ± 3%. Area covered: 145.5 m². It weighs about 40 kg. Cost1: $1920 per roll or $13.20 per m².

1 1983 prices.
4.1.2 Components of the Hydroseeding Slurry

Components are based on Land Management Report 4 (Carr 1980) and on E.P. 818 field trials (Homoky 1984, and 1987).

- **Fertilizer**
  
  Type: 20-24-15
  
  Rate of application: 380 kg/ha

- **Soil binder**
  
  Type: Ecology M-1
  
  Rate of application: 45 kg/ha

- **Grass-legume mix**

<table>
<thead>
<tr>
<th>Species</th>
<th>% by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual rye grass (<em>Lolium multiflorum</em>)</td>
<td>10</td>
</tr>
<tr>
<td>Perennial rye grass (<em>Lolium perenne</em>)</td>
<td>10</td>
</tr>
<tr>
<td>Intermediate wheat grass (<em>Agropyron intermedium</em>)</td>
<td>15</td>
</tr>
<tr>
<td>Creeping red fescue (<em>Festuca rubra</em>)</td>
<td>20</td>
</tr>
<tr>
<td>Kentucky bluegrass (<em>Poa pratensis</em>)</td>
<td>5</td>
</tr>
<tr>
<td>Redtop (<em>Agrostis alba</em>)</td>
<td>5</td>
</tr>
<tr>
<td>White clover (<em>Trifolium repens</em>)</td>
<td>15</td>
</tr>
<tr>
<td>Alsike clover (<em>Trifolium hybridum</em>)</td>
<td>10</td>
</tr>
<tr>
<td>Rhizomatous alfalfa (<em>Medicago sativa</em>)</td>
<td>10</td>
</tr>
</tbody>
</table>

  Rate of application: 84 kg/ha

4.2 Methods

4.2.1 Design, layout, and establishment

A randomized block design was used with two blocks (replicates), each containing five treatment levels (four treatments and control), and each treatment level containing two lines (subsamples) for measurements as shown in Figure 1 below.

![Figure 1 Randomized design](image)

Treatment levels:
- E = Enkamat 7010 net and hydroseeding
- J = Jute net and hydroseeding
- V = Vexar plastic net and hydroseeding
- N = Hydroseeding without net
- C = Untreated, "control"

figure 1 Randomized design.
Analysis of variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Error term for F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replicate (R)</td>
<td>1</td>
<td>MS(R) / MS(RxT)</td>
</tr>
<tr>
<td>Treatment (T)</td>
<td>4</td>
<td>MS(T) / MS(RxT)</td>
</tr>
<tr>
<td>Interaction (RxT)</td>
<td>4</td>
<td>MS(RxT) / MS(RxTxs)</td>
</tr>
<tr>
<td>Sampling error</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

The five randomly assigned treatments in two replicates were:

- Enkamat 7010 net and hydroseeding (E)
- Jute net and hydroseeding (J)
- Vexar plastic net and hydroseeding (V)
- Hydroseeding without net ("No-net") (N)
- Untreated, "control" (C)

The field layout is illustrated in Figure 2 below. Plot size was 5 m by 5 m.

![figure 2 View of the layout.](image)

Nets were stapled or pegged to the slope according to suppliers’ specifications (American Enka Company, 1980; Canadian Forestry Equipment 1983a, 1983b). The two measurement lines on each plot were delineated on contour lines (Figure 3), each 2 m long, where subsequent soil profile changes were monitored. Both ends of these lines were marked with 30-cm-long iron stakes with 10-cm-square plates welded to the top, to facilitate the positioning of the supporting poles of the rill meter (McCool et al. 1976).
Elevations of the 40 iron stakes were obtained with an engineer’s level at ± 2.5 mm precision, and with reference to a permanently established bench mark above the cutslope. The first profile recordings took place in July, 1983. These were the “zero-base” data. Following these procedures, all plots except the “controls” were hydroyseeded in late September 1983.

4.2.2 Assessments The plots were subsequently monitored in 1984, 1985, and 1986, all in July. Assessed features were: percent slope cover, vegetation composition and soil loss or gain.

Estimated Percent Slope Cover by Established Live Vegetation Slope cover is the projection in the horizontal plane of the portion of the seeded slope area covered with live grass-legume vegetation. An ocular estimate of this percentage proved to be more practical over the past years during test plot assessments than the more elaborate photographic observations, as the “shadow effect” created by tall vegetation on a horizontally taken photo may mask the uncovered areas as stated by Carr (1977) and Carr and Ballard (1980).

Vegetation Composition of the Established Live Plant Cover, Estimated by a Frequency Test A small frame with dimensions of 0.25 m by 0.25 m covering an area of 0.0625 m² is thrown randomly over the vegetated slope. Ten random samples are taken and each species found within the area of the frame is given a frequency of 10 percent. For instance, if Agrostis alba is noted in five of ten samples, it would be assigned to a 50 percent rating on the sampled plot. The higher the frequency of a species, the more likely it is to contribute to the cover of the plot (Carr 1977). All those species having a frequency rating of 50 percent or higher are considered “Dominant” species. All others are classed as “Subordinants.”