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A BRIEF INTRODUCTION TO THE SUBJECT OF REVEGETATION

Revegetation of road cut and fill slopes is undertaken for a number of different reasons:

1. Reduction of surface erosion
2. Improvement of aesthetics
3. Wildlife habitat improvement
4. Soil amendment

Grass and legume mixtures have been used to ensure rapid vegetative cover on disturbed soils. Where grass is established along highway roadsides it is generally maintained so as to be the permanent cover. On the other hand, grassing of forest roadsides is intended to be primarily for erosion control and to act as a 'nurse crop' for the establishment of natural vegetation.

While grasses and legumes reduce surface erosion they do not reduce massive earth movements such as slides or slumps. (Hodder, 1970). The control of deep seated erosion requires the use of engineering measures such as reduction of cut and fill slope angles, and slope drainage methods such as small diameter slope drain pipes, or tile or gravel drain networks.

Although mass soil erosion can be spectacular and can result in appreciable amounts of sediment entering streams, surface erosion is a less spectacular but none the less a very active agent in the erosion process. Dyrness (1970) noted that in order to fully appreciate the magnitude of soil loss, one had only to realize that the loss of one inch of soil over one acre is roughly equivalent to 100 tons. A forest road can disturb anything from 2 to 12 acres per mile. If the surface erosion is only a fraction of an inch over this acreage, soil loss can be very substantial.

In order to be effective, grasses are applied as soon as possible following disturbance. The importance of this practice is not only because the soil is receptive to the seed (i.e. porous and moist), but also because a significant amount of soil erosion occurs during the first winter following disturbance. (Fredricksen, 1965). Method of application is by hand, agricultural implements, helicopter, or hydroseeder.

In seeding it has been found advisable where possible to use locally adapted varieties. Although field tests under B.C. Forest road conditions have been limited, several grass and legume mixtures have been developed by B.C. Highways and the U.S. Forest Service. (Brink, 1964 and MacLaughlan, 1966). Mixtures of grass seed should include a rapid-developing, short

lived species as well as a heavy root producing, long living perennial. The rapid-developing component provides quick ground cover and soil protection while the slower developing perennial is becoming established. Also, where a legume is adapted, it should be included for nitrogen fixation. Although legumes may attract big game which could result in soil compaction and pose a traffic hazard, legumes provide additional ground cover and their value as a source of nitrogen for associated grass is unquestionable (MacLaughlan, 1966). The greater summer activity of legumes also makes the mixture more fire resistant.

Mulches are generally applied with or following seeding. Mulches are beneficial for the following reasons:

1. encourage rapid moisture infiltration thereby improving moisture availability and reducing surface erosion
2. moderate soil temperatures
3. reduce evaporation
4. act as a soil amendment by adding organic matter or furnishing nutrients to the establishing plants
5. provide cover to the roots of the germinating plants and to hold seed on steep slopes
6. act as a cover to reduce seed loss due to animals.

Many types of mulches have been used in roadside revegetation. Among the organic mulches are: wood chips, sawdust, wood fiber, macerated paper, fiber pulp, hay, straw, corncobs, peat moss, manure, and sewage sludge. Among the inorganic mulches are: asphalt emulsions, fiberglass mats, wire mesh, and gravel. Each mulch was developed to meet certain objectives. For any situation the mulch which most effectively satisfies the above six points, and is available, effective, and economical, will be the most desirable.

For use on B.C. Forest roads a number of the mulches used elsewhere may not be available, may be extremely expensive, or may not be effective. Weyerhaeuser Company produces a fiber mulch which is used by B.C. Highways and available through Fallis Turf Equipment Ltd. in Richmond. It has been found to be easy to apply with hydro seeder equipment and is effective in providing cover for grass establishment.

When choosing a mulch, labour costs are an important factor to consider. The use of jute or fiber mats requires intensive labour, while mulching with hay or fiber mulch (hydro-seeded onto the slope) is much faster

and not as labour intensive. Because of this factor, mats have been used only in areas of extreme erosion potential where other methods will not be effective. (Terrio and Broach, 1961).

Soil binders can be used to aid mulches in controlling soil erosion prior to gras establishment. Among the soil binders are: resin-in-water emulsions, liquid polymers, fish solubles, and commercial products such as Terra Tack (Armbrust, 1971; Peters, 1973). Terra Tack has been used locally and found to offer good protection for several months during which time grass cover is developing. Terra Tack is available through Fallis Turf Equipment Ltd.

For grass and legume mixtures to be successfully established on subsoils, attention must be paid to soil fertility and pH. Grasses thrive best at pH 6.0 and application of lime may be necessary to reach this level. From soil analysis fertility deficiencies can be found and the necessary fertilizers applied. Fertilization, especially with nitrogen, is essential to help assure quick dense ground cover. Phosphorus is also beneficial in stimulating early growth and root formation, and contributes to the general hardiness of the plant. Refertilization the year after establishment, and periodically thereafter in some areas, is required to maintain adequate protective cover until natural revegetation has developed. In some cases, reseeding has been necessary.

The cost of revegetating road cut and fill slopes is variable with the amount and type of seed and mulch used, and also with the method of application. From the literature available costs have varied from $50 to over $500 per acre. As an example, for one mile of road with eight acres of cut and fill slopes, the cost would vary from $400 to $4,000. Regarding costs, Hursh (1939) stated:

> "the costs are a small part of the road investment and it is paid back through reduced maintenance, improved appearance, and prevention of stream siltation. No road construction can be considered as finished until bank stabilization has been affected."

The following is an annotated bibliography of a selection of works related to the establishment of grasses and other plants on roadsides. This material is available in either the Main Library or the Forestry/ Agriculture Library at U.B.C.

Further information is available through a number of sources:

1. B.C. Department of Highways - Landscape Supervisor in Victoria, or Regional Landscape Supervisors
2. B.C. Department of Agriculture
3. B.C. Forest Service, Grazing Division
4. B.C. Department of Mines, Reclamation Officer, Victoria
5. Faculties of Forestry and Agriculture at U.B.C.
6. U.S. Forest Service - Pacific Northwest Forest and Range Experiment Station, P.O. Box 3141, Portland, Oregon 97208
7. Fallis Turf Equipment Ltd., Richmond, B.C.
8. Kaiser Resources Ltd., Reclamation Department, P.O. Box 2000, Sparwood, B.C.
9. Buckerfields, Seed Division, Rogers St., Vancouver.

ANNOTATED BIBLIOGRAPHY

1. Altpeter, L.S. 1944. Use of vegetation in control of streambank erosion in northern New England. Journal of Forestry, Vol. 42, No. 2 Page 99-5pp.

Control of streambank erosion is greatly needed in the narrow valleys of northern New England for the protection of both agricultural lands and permanent improvements. This article presents preliminary conclusions with respect to the basic principles of control and describes in detail the use made of vegetation as an essential part of the control program on the Winouski River, Vermont. (Read roadbank for streambank and fisheries for farming.)

2. American Pulpwood Association. 1965. Willow plantings. Technical Release 65-R-24. 1pp.

A short general article on the establishment of willow cuttings as a means of erosion control and beautification. Cuttings are made in early spring after frost ends, and should be used on moist sites inserted to a depth of 1 to 3 feet, depending on the size of the cutting. Cost is variable with stock availability, preparation, and area. A.P.A. felt willow was useful as a quick means of obtaining trees and foliage to combat erosion, beautification through shielding undesirable areas, and as cover for birds and game.

3. Armbrust, D.V. and J.D. Dickerson. 1971. Temporary wind erosion control: cost and effectiveness of 34 commercial materials. Journal of Soil and Water Conservation, Vol. 26 #4, 1971.

Thirty-four commercially available materials to stabilize soil or control erosion were evaluated for the rate needed to prevent wind erosion, the length of protection provided under natural weathering, and the effects on plant germination and emergence. Six of the 34 materials met the following four criteria: (1) cost of materials (not including freight or application) less than $50 per acre, (2) prevent erosion initially and reduce it for at least 2 months, (3) not reduce plant germination and growth, and (4) ease of application. Of the six, one was a resin-in-water emulsion, the others were liquid polymers. Possible environmental pollution was not considered.

4. Baldwin, H.I. 1959. Seeding logging roads to control erosion. Fox Forestry Notes No. 76. 1959. New Hampshire Forestry and Recreation Commission, 1pp.

An article on the seeding of roads used only in the winter. (Sod does not stand up to heavy trucks in the summer). Experience has shown that only fair results are obtained without fertilizer, but good cover on bare subsoils is achieved with lime and fertilizer applied at time of seeding. The soil is hand raked, and water bars and ditches are constructed. Twenty-five years of experience shows that only roads without sod cover wash out in heavy rains.

5. Bethlahmy, N. 1960. Fertilizer helps establish grass seedlings on abandoned logging roads. Journal of Forestry 58(12). 1960. Page 965-2pp.

Roads are put to bed (culverts removed, water bars constructed, etc.) following logging operations to forestall excessive erosion. In some cases a quick cover of vegetation is also a good insurance against excessive erosion. Experimental plots were established on a road after being abandoned for 1 year. (Location: Mt. Hood National Forest, West Slope of Cascades, on soil derived from basalt and igneous rock). Fertilization at the rate of 450 lbs/ac. of 6:10:4--helped obtain satisfactory grass and clover. Raking further increased the number of established plants.

6. Bethlahmy, N. and W.J. Kidd. 1966. Controlling soil movement from steep road fills. Forest Service. U.S.D.A. Intermountain Forest and Range Experiment Station. Research Note INT-45. 1966. 4pp.

Describes a soil stabilization experiment in Idaho on erodible loose weathered granitic material of the Idaho Batholith. Treatments: seed + fertilizer; seed + fertilizer + straw mulch; seed + fertilizer + mulch + netting. The last treatment was most effective with netting holding mulch in place and thus minimizing overland flow and raindrop impact.

7. Blaser, R.E., and C.Y. Ward. 1958. Seeding of highway slopes as influenced by lime, fertilization, and adaptation of species. NAS-NRC, 1958 Roadside Development Conf., Highway Research Board Publication 613, Washington, D.C., page 21-9pp.

This paper gives some information on species adaptation with different lime, fertilizer, and mulching practices. Gives information on some of the soil, climatic, and biotic factors associated with successfully turf establishment. Emphasizes that adequate lime and fertilizer, proper choice of seed mixtures, suitable seeding dates, and not excessive applications of mulch are necessary for successful establishment.

8. Blaser, R.E. and W.H. McKee. 1967. Regeneration of woody vegetation along roadsides. NAS-NRC, Highway Research Record 161, Washington, D.C. 1967, page 104-12pp.

To reduce erosion and cover bare soil for aesthetic reasons grass is most beneficial. However, grass is not practical to maintain in many areas since it is not the climax vegetation, but rather only serves as an ecological and microclimatical environment for the encroachment of naturally seeded woody species. For aesthetic and maintenance reasons, the regeneration of woody vegetation was felt to be more favourable than maintaining grass.

9. Blaser, R.E. 1963. Principles of making turf mixtures for roadside seeding. NAS-NRC Roadside Development Conference, Highway Research Record 23, Washington, D.C. page 79-6pp.

The author discusses the various characteristics of different grass species: 1. Sod forming capabilities 2. Rate of establishment 3. Drought resistance. Due to these various characteristics a mixture of different grass species should be applied in order to obtain a good sod. Mixtures should be reasonably simple with a maximum of four different grass spcies. A species should be used in a mixture only if it makes a desirable perennial sod. If legumes are added as a nitrogen source, competition between different grass and legume species can be expected unless mixtures are chosen with care.

10. Briggs, W.M. 1969. Roadside erosion survey. Soil Conservation, Volume 35, #2, Sept. 1969, page 28-2pp.

In Wisconsin it had been recognized that roadside erosion is one of the principle sources of material causing filling of water channels and fouling of surface waters. A survey showed that there were 21,000 sediment producing sites - a total of 7,300 acres or 3,711 miles (4.5% of the total road mileage in Wisconsin). Natural revegetation was cited as being too slow, so site rehabilitation measures (sloping, fertilization, seeding, mulching, or engineering structures) were recommended.

11. Brink, V.C. 1964. The selection of plants for roadsides and highways in the Pacific Northwest. Proceedings of the First Western Canadian Roadside Development Conference, 1964, U.B.C. Extension Department. page 57-5pp.

The proper selection of plants for roadsides and highways entails first and foremost, knowledge of topography, soils, and climate. These factors are discussed and it is noted that B.C. has a great variety in these factors. A table of 18 grasses is presented giving such information as plant longevity, costs (as of 1964), seeds per pound, plant habit and habitat, height, speed of establishment, and seeding rate per acre. Six legumes are also discussed. These plants are on the whole available and are all suitable to B.C. conditions.

12. Brink, V.C., Maxwell, J.W. 1965. Soil mulching for turf establishment. Proceedings of the Second Western Canadian Roadside Development Conference; U.B.C. Extension Dept., 1965.

A literature review of soil mulches for turf establishment. Mulches are classified as: 1) continuous layer mulches, 2) discontinuous layer mulches, and 3) contact mulches. The classes are discussed from the point of view of their usefulness in: 1) controlling erosion, 2) moderation of evaporation and soil moisture, and 3) modifying soil and air temperatures.

13. B.C. Research Council and B.C. Dept. of Highways. 1960. "Fish Solubles" as a fertilizer-binder for roadside cuts and embankments. B.C. Research Council, U.B.C. Vancouver. 30pp.

This paper reports an experiment in North Vancouver testing several methods of establishing vegetation on freshly cut soil banks. Fish solubles, straw mulch, asphalt emulsion were used as stabilizers for seed. All treatments

resulted in the growth of grass, fish solubles producing the most vigorous growth, and was the only one to persist a 45 day drought period. Methods of preparation and application, costs and photographs are included.

14. Brooks, C.R. and Blaser, R.E. 1963. Effect of fertilizer slurries used in hydro-seeding on seed viability. NAS-NRC Highway Research Record, No. 53, Washington, D.C. page 30-5pp.

Reports the results of experiments which were conducted to study seed germination as influenced by soaking in fertilizer slurries and by moisture stress where seed and fertilizer are placed in contact on the soil surface. The soaking of seeds for short periods (20 min.) did not cause significant injury to germination of the perennial grasses and legumes. Results with Kentucky 31 fescue showed that fertilizer-seed contact fertilizer (not watered in) is injurious to germination under low available moisture (i.e. aggravated the stress for soil moisture).

15. Bureau of Public Roads. 1937. Experimental erosion control on forest highway fills. Public Roads. Volume 18, No. 9. November 1937. Page 176-7pp.

An experiment to determine the most practical methods of preventing erosion and encouraging revegetation under varying soil and climatic conditions. (Location - California). Types of treatment included broadcasting seed, covering with forest duff, use of various types of wattles, and willow cuttings. The first winter had very severe precipitation, but the greater part of the work successfully prevented erosion. On medium to low erosion sites willow was found to be sufficient. On more erodable sites, brush wattles incorporated into the road construction proved successful, as did hay wattles with stakes, and a covering of 4 inches of hay.

16. Butler, J.B., Nare, W.R. and R. R. Yoerger. 1970. Roadside cover equipment. NAS-NRC HIghway Research Record No. 335, Washington, D.C. 1970. Page 60-12pp.

A report on the development, idea evaluation, and formulation of design leading to the production of equipment for more effective and economical roadside development and maintenance. Covers: tillage, seeding, fertilization, roadside mulching, mowers, sprayers, vehicle stability. Mainly to do with highways.

17. Chittenden, D.B. 1973. Prevention and control of soil erosion. NAS-NRC Highway Reserach Board, Washington, D.C. Special Report 135, Page 129-12pp.

A general article on the 'state of the art' of soil erosion prevention and control. Deals with: the fundametnals of erosion, erosion control structures, use of heraceous materials for erosion control, chemical stabilizers, promising methods and materials for erosion control, the Pennsylvania Highway Department's approach to erosion control, the effect of highway construction on sediment loads in streams, and concludes that the job of accelerated erosion control is everybody's job--not just a small group of specialists. Stresses that public interest and support is necessary.

18. Coffman, B.S. and Sawhney, J.S. 1965. Fertilization and erosion on a new highway. NAS-NRC, Highway Research Record No. 93. Washington, D.C. 1965. Page 2-23pp.

A four year study into post construction fertilization (P.C.F.) of turf on an Ohio highway. The highway had originally been seeded, mulched, and fertilized. It was found that P.C.F. was essential to the prevention of erosion in locations of high erosion potential. Also found that even though grasses have the potential to reduce surface erosion, they may occasionally fail where exposure (soil shrinkage, drought, aspect, runoff, or frost) is greater than the resistance of the turf. In areas of initially high potassium and low phosphorus, both N and P are essential for the production of vigorous grass for the prevention of erosion.

19. Currey, L.E. et al. 1964. Lime and fertilizer requirements as related to turf establishment along roadsides. NAS-NRC, Highway Research Abstracts, 34(6). Washington, D.C. Page 26-4pp.

A study in Illinois conducted to evaluate the lime and fertility of roadside soils, and the inadequacies of blanket application rates of fertilizers and lime. Stresses the value of soil testing programs in determining the necessary rates. Noted that the application of lime to sites with a pH 5.5 or higher (6.0 optimum for grasses) may cause a tie up of essential nutrients such as phosphorus.

20. Dudeck, A.E., Swanson, N.P. and Dedrick, A.R. 1967. Mulches for grass establishment on steep construction slopes. NAS-NRC, Highway Research Record, No. 206, Washington, D.C. 1967. Page 53-7pp.

Evaluation of 13 mulches on a 3:1 roadside cut in terms of their effect of soil temperature, soil moisture, and seedling grass cover during the critical period of germination and establishment. All treatments caused significantly higher minimum soil temperatures than no mulch, (excelsior mat, having the highest minimum temperature). The excelsior mat, prairie hay, and asphalt emulsion plots contained significantly higher soil moisture than did the no mulch plot. The excelsior mat, prairie hay anchored with a paper net, a combination of emulsifiable asphalt on woodchips, prairie hay, or wood cellulose, had significantly more grass cover in one month than the no mulch plot.

21. Dyrness, C.T. 1967. Grass-legume mixtures for roadside soil stabilization. U.S.D.A. Forest Service, P.N.W. Forest and Range Experiment Station, Research Note. P.N.W. 71. 1967. 18pp.

Dyrness reports on a two part study. Part 1 describes a search for legume species suitable for inclusion in grass-legume mixtures. Dyrness notes that since legumes are highly palatable to deer, heavy concentration of deer may result on highly erodable slopes. Part 2 describes the performance of several grass-legume mixtures. Mulches proved important, thus underscoring the necessity of other cultural practices in addition to the composition of the seed mixture.

22. Dyrness, C.T. 1970. Stabilization of newly constructed road back-slopes by mulch and grass-legume treatments. U.S.D.A. Forest Service, P.N.W. Forest and Range Experiment Station. Research Note P.N.W. 123, 5pp.

Dyrness found that the amounts of soil lost from unprotected newly constructed backslopes was 2 to 4 times greater than the loss from a comparable slope 5 years after construction. Of six roadside treatments studied, only those without straw mulch covering showed large amounts of soil loss during the first critical rating period. Dyrness noted that contrary to appearances, a luxurient growth of grass and legumes during the first growing season following fall treatment is not conclusive evidence that soil loss was negligible during the preceding months.

23. Errington, J.C. 1973. A study of natural revegetation of disturbed sites in B.C. Unpublished manuscript. U.B.C. compiled under contract to the Canadian Forest Service.

A study of the natural revegetation of logging roads and mine sites on the coast and in the interior of B.C. On logging roads it was found that revegetation was strongly correlated with time. Red alder gained dominance on coastal roads within twenty years. In the interior no single species gained dominance, rather a great variety revegetated the road surface. On coastal road right of ways, species of vegetation differed from the adjacent forest due to a lack of organic material on the disturbed soil. This difference was not found in the interior.

24. Fredricksen, R.L. 1965. Sedimentation after logging road construction in a small western Oregon watershed. Federal Interagency Sedimentation Conference. 1963. U.S.D.A. Miscellaneous Publication 970. Paper No. 8, 4pp.

This paper reports the change in suspended stream sediment concentration following construction of 1.65 miles of logging road in a 250 acre watershed. Runoff from the first rainstorms following construction carried 250 times the sediment concentration carred in an adjacent undisturbed watershed. Sediment levels continued to be higher but after two years a trend toward normality was evident. Cutbanks had been treated with grass and mulch, however only a poor stand of grass resulted.

25. Goss, R.L. 1969. Research on turf grass for highway use. Proceedings of the Sixth Western Canadian Roadside Development Conference, U.B.C. Dept. of Extension, Vancouver.

Goss presents a general discussion on some of the soil problems associated with the vegetating of road side areas. He reports on some of the results of erosion control studies in Washington with three grass species and four legume species. He recommends soil testing and follow up fertilizer programs. Several muches were tested: where erosion was not severe wood cellulose fiber was the quickest and easiest to apply; and excelsior matting and asphalt emulsion on straw were given high ratings.

26. Hafenrichter, A.L. and Others. 1963. Grasses and legumes for soil conservation in the Pacific Northwest and Great Basin States. U.S.D.A. Agricultural Handbook. No. 339. 69pp.

A massive work summarizing thirty-two years of systematic testing of grasses and legumes for conservation in Washington, Oregon, Idaho, Utah, Nevada, and California. Describes many species of grass and legumes with regard to soil, precipitation, and land use.

27. Haupt, H.F. 1959. A method for controlling sediment from logging roads. U.S.D.A. Forest Service. Miscellaneous Publications. Intermountain Forest and Range Experiment Station. No. 22. 1959. 22pp.

Natural or artificial revegetation of the roadway eventually provides some degree of erosion control as the plant cover thickens, but at best Haupt felt revegetation does not eliminate the need for controlling concentrated runoff. This article does not specifically deal with grasses but rather with the controlling of runoff from roads through the use of cross ditches and debris, or obstacles downslope of the road. Haupt develops an equation to determine the distance down a slope sediment will flow and applies this to questions regarding buffer strip widths.

28. Haupt, H.F. and W.J. Kidd. 1963. Laboratory methods for determining the downward movement of seed on road fills. U.S.D.A. Forest Service. Intermountain Forest and Range Exper. Stat. Research Note INT -2, 1963, 7pp.

The authors report that attempts to seed fill slopes of granite derived soils in Idaho often fail because the seed is not retained on the hardened, compacted, crusted surface of the fills. Model "road fill slopes" were set up in the lab to test several soil surface treatments for arresting the downward movement of broadcast seed: soil moistening, pockmarking, mulches - hay and narrow mesh paper netting, (plus combinations of these treatments). All methods help, however seeding onto a mulch resulted in not all the seed reaching the soil. The authors also looked at seed shape as a factor influencing downslope movement.

29. Hodder, R. 1970. Maintenance for erosion control. 7th Western Canadian Roadside Development Conference. 1970. University of B.C. Extension Department.

A paper concerning the problems of roadside maintenance with a

thumbnail economic sketch of the costs involved if revegetation is ignored. The author stresses that vegetation is effective in controlling wind and water erosion, but that it will not and should not be considered as a means of controllin mass earth movements. The author notes that slopes must be mechanically stable before they can be effectively vegetated. Hodder notes that a slope does not have to have 100% vegetative cover to control surface erosion - anything from 35% can be effective depending on soils and slope.

30. Hubbard, W.A. 1969. The grasses of British Columbia. B.C. Provincial Museum, Department of Recreation and Conservation, Handbook No. 9. 205pp.

A handbook of the grasses of B.C. (over 300 species). Includes a key and many drawings for identification. For each species a physical description is given with notes on distribution throughout North America, B.C., and remarks as to origin or some feature of the species.

31. Hursh, C.R. 1939. Roadbank stabilization at low cost. U.S.D.A. Forest Service, Appalachian Forest and Range Experiment Station, Technical Note. No. 38. 20pp.

In 1939, it was "obvious that some form of roadbank stabilization was necessary to keep the roadsides more attractive, to prevent soil from eroding into the streams, and to reduce the cost of road maintenance". This article outlines procedures and materials involved, stressing local plants for re-vegetating. Stakes were used to hold mulch (weeds, briars, brush, and litter) in place. Slopes were either seeded or revegetated with seed from mulch. Hursh notes that costs are a small part of the road investment and that it is paid back through reduced maintenance, improved appearance, and prevention of stream siltation. He concludes that "no road construction can be considered as finished until bank stabiliaation has been affected".

32. Jackman, R.E. and N. N. Stoneman. 1973. Roadside grassing -- a fast logging practice for redwood forests. Journal of Forestry. February 1973. Page 90-3pp.

The authors note that forest roadbuilding, landings, and skid trails expose a great deal of soil to rainfall in the first few winters until natural vegetation becomes established. They report on grass species, fertilizers, and costs involved in providing suitable ground cover during this period.

33. Jackobs, J.A. and others. 1967. Turf establishment on highway right-of-way slopes--a review. NAS-NRC Highway Research Record #161, Washington, D.C. 1967. Page 71-33pp.

The purpose of this review was to summarize pertinent information (152 references) on turf establishment under conditions found along newly established highways. It covers: soil characteristics influencing turf establishment (structure, crusting, moisture, temp., aeration, soil types, nutrients, pH); cultural practices (seedbed preparation, soil fertility, mulches and films); effect of climate on turf establishment; adaptation of turf species (grasses and legumes-a listing and discussion of the species adapted to the U.S. Midwestern region); and mixtures of grasses and legumes.

34. Kidd, W.J. and H.F. Haupt. 1969. Effects of seedbed treatments on grass establishment on logging roads in Central Idaho. U.S.D.A. Forest Service. Research Paper. Intermountain Forest and Range Exp. Stat. no. 53, 1969. 9 pp.

The authors note that on highly erodible soils in Idaho it is necessary to put unused logging roads to bed. Variable results of grass establishment are due to the lack of road surface preconditioning. This paper is a report on preconditioning research. Scarification with a ripper (12 inches in depth) and then seeding, resulted in slightly better plant establishment that no scarification. Fertilization also increased plant density, but not significantly.

35. McKee, W.H., Blaser, R.E. and D.G. Barkley. 1964. Mulches for steep cut slopes. NAS-NRC Highway Research Record No. 53, Washington D.C. 1964. Page 35-8pp.

This paper reports the results of a two year mulch study in Virginia on steep (1:1) cut slopes. The mulch materials were nets, straw mulch, asphalt emulsion, glass fiber, woodfiber cellulose, and combinations of these. Various nets, glass fiber, straw with asphalt emulsion and wood stakes, turfiber, and Silvacel gave satisfactory to excellent results. For large scale seedings, a practical method recommended by the authors was woodfiber cellulose - fertilizer - seed slurry applied hydraulically in one operation. To ensure good sod, reseeding and refertilization was recommended regardless of the method of mulching.

36. McKee, W.H. and others. 1965. Microclimatic conditions found on highway slope facings as related to adaptation of species. NAS-NRC Highway Research Record No. 93. Washington, D.C. Page 38-6pp.

The authors report on measurements of microclimatic conditions which were made on slope facings at various times during the season and under several conditions of plant cover. Close relationships were found between soil surface temperature and light intensity, density of sod, clipping height, and slope facing. On the basis of these observations, slope facings should be considered in selecting species, mulches, and fertilizers. To take advantage of favourable temperature conditions, it was recommended that south facing slopes might be seeded earlier in the spring and later in the fall than north-facing slopes.

37. MacLauchlan, R.S. 1966. Grasses and legumes for stabilizing silt producing areas in the northwest (U.S.A.). Symposium on practical aspects of Forest Watershed Management. Oregon State University. March 1966. Page 75-11pp.

The author notes that the northwest has a wide variety of soils, climate and elevation, and therefore in a paper it is not possible to provide details on all the variables influencing the use of vegetation in stabilizing silt-producing areas. The author refers to the U.S. Soil Conservation Service which offers such assistance. Therefore the paper discusses the principles of seeding and fertilizing, and emphasizes that grasses do not control massive earth movements. The author includes a table of 21 grasses and 6 legumes, adapted to the region, giving information such as growth habit, length of life, necessary precipitation, cold tolerance, and number of seeds per pound.

38. Mater, J. 1971. Utilization of bark in highway landscaping. Forest Products Journal, Volume 21, No. 8, August 1971, 4pp.

An article orientated toward the selling of bark as a mulch in highway landscaping and erosion control. Of 46 U.S. states polled, 23 used bark in highway landscaping. However, practically none of the states used bark for mulching fill slopes, road cuts, or disturbed areas. The author sees this as a potential market but notes that much research will be necessary before the value of bark as a mulch on erodible sites can be determined.

39. Moessner, K.E. 1960. Estimating the area in logging roads by dot sampling on aerial photographs. U.S.D.A. Forest Service, Intermountain Forest and Range Exp. Stat. Research Note 77, 4pp.

A paper reporting the use of dot sampling on aerial photos in estimating the area bared by haul roads, landings, etc., during timber harvesting. 20 chain maps and a 256-dot-per-square-inch sampling grid were used. This method was found to be relatively accurate and consumed only 10% of the time needed for ground measurements.

40. Olsen, R.K. 1963. Advantages and disadvantages of sewage sludge as a mulching material. NAS-NRC Highway Research Record 23. Page 70-5pp.

Searching for cheap mulches (defined as anything spread over the surface of the soil to protect soil or roots from heat or cold, and, or, to improve soil conditions) the U.S. Park Service tried sewage sludge. The author notes that there are basically two types of sludge: (1) Activated - processed by aeration - good organic fertilizer but expensive. (Milorganite - Milwaukee Sewage Commission), and (2) Digested - anaerobic bacterial digestion and sedimentation, a cheap low grade fertilizer, little better than horse manure. The Parks Service used the second type and found it best when the sludge was worked into soils. Odour was harmful to public relations so the use of this mulch was discontinued.

41. Peters, J.D. and others. 1973. Promising materials and methods for erosion control. NAS-NRC. Highway Research Board. Washington, D.C. Special Report No. 135, Page 105-13pp.

The authors report on the results of trials with emulsions to find a simple and effective procedure to reduce erosion on and around airfields. The paper describes properties, applications, field experience, tentative specifications, and testing procedures. The products selected were cationic oil-in-water emulsions containing a high strength elastomer or resins or both. It was felt that these were promising materials for fortifying earth surfaces against a variety of forms of erosion.

45. Thornton, R.B. 1965. Establishment of vegetation on sub-soils. NAS-NRC. Highway Research Record No. 93. Washington, D.C. 1965. Page 31-7pp.

Thornton notes that the intial seed source for roadside erosion control was from feed and forage crops--species selected specifically to give high yield of top growth (not root mass) and which were also selected to be grown on the best agricultural land. As a result this vegetation was generally not successful. This paper summarizes the results of a study on low-growing ground cover plants and grasses which require minimum fertilization and maintenance, as well as being thrifty. Emphasizes the need for good seed mixtures to provide cover through both warm and cool (dry/wet) seasons.

46. Turelle, J.W. 1973. Factors involved in the use of heraceous plants for erosion control on roadways. NAS-NRC. Highway Research Board. Washington, D.C. Special Report 135. Page 99-6pp.

A general article dealing with roadbank cutslopes (recommended to be 3:1 or less where feasible), selection of plant species adapted to the locale--native species if possible since they require less maintenance, and some techniques used in establishing plants (sodding, seeding, the necessity of soil tests to identify pH and nutrient conditions). The author emphasizes the necessity of mulching, and maintenance (fertilizer treatments).

47. Weyerhaeuser. Hydraulic planting: the one step system for seeding and mulching. Weyerhaeuser, Box B. Tacoma, Washington. U.S.A. 98401.

A folder of fact sheets on Silva Fiber--a wood fiber mulch product of Weyerheauser. Includes a description of the mulch and 16 case studies of its use in soil erosion control.

48. Woolum, A.G. 1962. Grass seeding as a control for roadbank erosion. U.S.D.A. Forest Service, Pacific Northwest Forest and Range Experiment Station, Research Note No. 218, 5pp.

This is a report on the results of a study measuring the effectiveness of grass in controlling soil erosion from exposed roadbanks. The author found that grass reduced erosion from 12.7 tons per acre to 2.3 tons per acre. Runoff increased from 6.2 inches to 13.6 inches--probably due to the matting effect of the grass--causing water to runoff just as a

thatched roof. Woolum noted that water ran over and through the matted grass but was not in contact with the soil.

49. Woodruff, J.M. and R.E. Blaser. 1970. Establishing crown vetch on steep acid soil slopes in Virginia. NAS-NRC HIghway Research Record No. 335, Washington, D.C. Page 19-10pp.

The authors report that grass vegetation, even with high initial fertilizer applications soon degenerates because soil materials are low in organic matter and available nitrogen. The authors note that the encroachment of natural woody vegetation is very desirable, but usually slower than the rate of grass degeneration. Leguminous plants that are persistent and fix atmospheric nitrogen are especially desirable. This paper is a review of research findings during twelve years of establishing crown vetch on bare slopes. The authors discuss the slope environment, liming, fertility, seeding rates, and grass associates on establishing and maintaining crown vetch.

50. Zah, J.M. and others. 1972. Direct seeding along highways of woody plant species under a wood chip mulch. NAS-NRC Highway Research Record No. 411, Washington, D.C. Page 24-4pp.

The article reports on greenhouse and field experiments of direct seeding of a number of woody plant species under a wood chip mulch. Four different depths of mixed hardwood chips (which passed through a 1½" mesh screen) were used as mulch. Emergence of plants through different depths of mulch was proportional to their seed size, with 1 inch to 2 inch depth being the optimum. Field experiments showed that the method was successful for species adapted to the area. The mulch prevented erosion (slope 2:1) and was weed-free.