Naturalization of Road Banks
An Integral Part of Highway Construction
By C. R. HURSH

In older countries the naturalized road bank is more frequently seen than are the bare raw banks that characterize public highways in most hilly sections of this continent. But here, quite as commonly as abroad, the naturalized road bank, with its universal appeal to the great traveling public, should be the normal condition and not the lamentable exception. It is a mistake to assume that bare banks are a necessary evil in road construction, even on main highways. With a truly inconsiderable additional effort and expense, naturalized road banks may present along all our roads a continuous display of native plants, with different wild flowers and shrubs coming into prominence in the successive seasons.

Much of the appeal of national forest Specification, calling for precision cutting and national parks roads is due to the case-given by the road engineers to this phase of construction. What is lacking elsewhere is the recognition by the generality of roadbuilders that road-bank stabilization is a legitimate and essential phase of road construction. Once the bare stabilized little additional effort need be exerted to encourage a permanent cover of local shrubs and flowers.

The cost can be relatively small. A method followed is to leave the road-banks in such shape as to favor the preservation of local vegetation—so small an increment of the cost of road construction to make almost inexcusable the scars that disfigure the face of many highways throughout the country. In addition to the inevitable aesthetic values, the naturalized road-bank

Specification: calling for precision cutting of road-bank surfaces do not permit satisfactory naturalization. Rough surfaces are required if good results are to be secured from any naturalizing treatment.

Where vegetation finally has destroyed the road-banks.
sion of the remaining soil cover, maintenance costs have fallen to a small fraction of the former avoidable expense. Many hidden costs, too, are chargeable to bare road banks. These mount high in silted reservoirs, clogged streams, and ruined adjacent arable lands. Slips of the bank surface, smearing clay and mud across the highway, cause serious or fatal accidents.

New Techniques

Naturalization of road banks has already proved its economic worth and aesthetic value in solving many difficult problems of road construction, attracting the attention of roadway engineers throughout the country, and arousing much public interest. Already much effort has been put into this form of stabilization—in some places with high success and at very reasonable costs. Elsewhere the treatments, although successful, have proved to be far too expensive for general use. In numerous other instances, treatments have not produced satisfactory results regardless of cost. It is apparent that road-bank naturalization involves certain new techniques which must be recognized and practised to assure success.

A study of stabilization treatments was begun in 1934 by the Appalachian Forest Experiment Station, testing different methods suitable for national forest roads and truck trails, and from this study very practical results are now available. Plot trials of various treatments have been carried out on several experimental forests, and extensive tests of the results have been made on hundreds of miles of national forest roads.

These experiments have resulted in the working out of certain principles that are here presented, primarily for the use of those engaged with the practical problems of the road-building job. They are concerned first with the factors limiting plant growth and then with naturalization measures, which fall naturally into two classes—those involved in the location and planning of roads, and those concerned with the establishment of the planting and screening vegetation.

The discussion to follow is directed to the cut bank rather than to the fill. This is because the fill may be naturalized by any of the measures proposed for the cut bank when any particular problem of fill naturalization is present. With adequate rainfall, the fill is much more easily naturalized than is the cut bank and seldom
Factors Limiting Plant Growth

The chief factors limiting plant growth on road banks are soil instability, insufficient soil moisture, and inadequate soil fertility. On some banks these factors may so operate from year to year as to preclude the possibility of natural vegetation ever becoming established.

Instability of surface soil is the natural condition for all exposed soil subjected to the stress of alternate freezing and thawing, wetting and drying, and the mechanical effects of wind and driving rain. It opens the way to exposure of plant roots through frost heaving and the washing of soil from around the roots. As a rule, the steeper the slope the more disastrous the results.

Overcoming instability is a matter of encouraging the growth of deep-rooted vegetation on the slope, or covering the bank with a blanket of organic material to serve as mechanical protection. Soils devoid of organic material are generally more subject to erosion than soils abundantly supplied with it. The gradual mingling of any kind of organic debris with the bank soil is beneficial.

Instability may go deeper than the surface soil of the road bank, and manifest itself in major slides that require permanent reduction in volume. A bank so reduced is unstable by road construction, and may operate from year to year as to fertility. On some banks these factors are considered as fixing beyond the scope of the present discussion.

Insufficient Moisture

Lack of moisture due to excessive evaporation and drainage often renders road banks too dry for naturalization or plant growth of any sort. In all such cases of deficient moisture the upper slopes will obviously be much drier than the lower, and the south-facing banks much drier than the north-facing. Treatment to stabilize the slope in one case may not apply in another; each presents an individual problem. One of the most expedient methods for overcoming this difficult condition is the use of organic mulches to conserve whatever moisture reaches the slope.

Infertility

Infertility is too often blamed for poor growth on road banks when the real cause is surface instability and lack of moisture. This mistake is often made in judging road-bank conditions, and it is found that vegetation establishes itself on these "inert" banks as soon as mulching halts erosion and starts to hold moisture.

Even though the new growth may be composed largely of weed species characteristic of poor sites, these species serve to naturalize the bank and prepare the way for other plants. In fact, it may be advantageous on most road banks to obtain plant species of low fertility requirement for the first few years, until this growth has encouraged site improvement.

Under natural conditions, any improvement of fertility comes largely from organic material in the form of wind-blown leaves or other litter and from the biological activity that accompanies the decomposition of such material. Even relatively sterile mineral soil is improved in fertility under a protective cover of organic material. The steeper the bank the more organic material can find lodgment and no improvement in fertility can take place.

High fertility is impractical on road

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<table>
<thead>
<tr>
<th>SLOPE</th>
<th>DESCRIPTION</th>
<th>TREATMENT</th>
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<tbody>
<tr>
<td>½ to 1</td>
<td>Very difficult &amp; expensive to stabilize, particularly in the frost zone belt. Justifiable only in exceptionally steep terrain.</td>
<td>To promote the invasion of natural vegetation on this slope, the surface must be scarified and held in place by a strong mulch tied in place. Can also be seeded to small grain or grasses for a temporary cover.</td>
</tr>
<tr>
<td>3/4 to 1</td>
<td>Still a difficult slope to stabilize. Justifiable only when normal surface is 100% or more.</td>
<td>Can be stabilized by a light mulch well tied in place with brush, stakes over the scarified surface. Can be seeded at once to obtain a temporary cover.</td>
</tr>
<tr>
<td>1 to 1</td>
<td>Requires careful and expensive treatment.</td>
<td>Can be stabilized with a strong weed mulch and a few stakes, or with lighter mulch of litter covered with brush.</td>
</tr>
<tr>
<td>1 ¼ to 1</td>
<td>A practical slope for most construction.</td>
<td>Light mulch is sufficient, with a minimum of tie material and staking.</td>
</tr>
<tr>
<td>2 to 1</td>
<td>Adapted to machine sloping for low banks.</td>
<td>After machine sloping, the surface may require roughening; then seed.</td>
</tr>
<tr>
<td>4 to 1</td>
<td>Use whenever the ground surface is less than 50%.</td>
<td>No other treatment is necessary if the surface is well loosened; may be seeded or planted at once.</td>
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Fig. 1—Schedule for the stabilization of moist banks having deep, rich soils. Natural vegetation will come in readily on such banks at almost any angle if the surface is properly protected. The treatments needed are those that will insure stability of the surface soil, so that seedlings can become established. Loose organic mulches are adequate for this purpose.
Planning for Road-bank Naturalization

Stabilization and naturalization of road banks should be regarded as not merely providing vegetation, but involving as well the complete coordination of both engineering and vegetative-establishment techniques. In short, the engineering job is no longer on a cut-and-run basis, but rather extends up to and includes restoration of the landscape. Once this viewpoint is accepted, naturalization becomes a part of the road plan.

Location of the road is the primary consideration, since bank conditions left after the road is finished will largely determine the treatment to be given the bank and, so far as possible, must be taken into account in planning the road. Again, careful planning avoids excessive bank cutting and rugged terrain and so reduces the cost of naturalization.

Long-Range Planning

Postponing bank stabilization may result in its having to be undertaken after erosion has wrecked both cut and fill. The present trend in new construction is to plan ahead and begin road-bank stabilization with the determination of road location and the adoption of standards of construction. This is the greatest single thing an engineer can do to insure bank naturalization.

At this stage, numerous measures should be incorporated into construction plans that will promote naturalization. If these are carried out while the construction work is in process, adequate stabilization may be achieved at little or no additional cost.

The plan should include provision for disposal of the dirt excavated, protection of fills from stream erosion and other heavy work most economically done by power machinery. Good machine operators can do much to reduce subsequent cost if they are informed of erosion control objectives and methods. An operator of a trail-builder on a widening job can cut slopes in a series of small terraces leaving considerable loose dirt, thus providing very favorable conditions for re-vegetation.

Good drainage is imperative if road-bank stabilization is to be successful. Although beyond the scope of this discussion, the subject deserves brief comment. Faulty drainage, permitting concentrations of water to pass over the bank or fill, may render stabilization impossible, or greatly increase its difficulties. Lack of head walls above culvert inlets may cause undercutting and result in sloughing of the bank. Omission of aprons below culverts will produce similar fill erosion. Inadequate cross drainage often results in damage to the fill as well as to the ditches and road surface.

Securing Topsoil

Conserving natural topsoil is a simple matter if naturalization is recommended.
freshness when applied and its permanence. On old banks, sufficient topsoil can usually dry out all its biological activity. On the other hand, it should not be allowed to leach out in successive rains. The volume of topsoil is not so important as its permanence when applied and its permanence thereafter.

**Stable Slopes**

Construction of stable slopes is, from the engineering viewpoint, merely a matter of cutting the road banks to a natural angle of repose for the particular soil. Actually, however, no exposed soil is stable if it is subjected to alternate freezing and thawing and to the direct action of wind and water.

In the frost zone, a slope that during most of the year is apparently stable may suffer severely from sloughing and erosion during the winter months, unless it has been made stable by vegetation or some mechanical means that prevent surface movement.

Because lower slopes require the removal of more yards of earth at the time of construction, economy commonly dictates cutting the maximum allowable slope—policy that sometimes leads to excessive maintenance costs later on. These steeper slopes also become naturalized much too slowly, and continued erosion from them often results in clogged drainage ditches, washing away of road surfaces, and cutting out of fills.

Disastrous results can sometimes occur when a deep bank has been sloped or the upper portion only, and the loosened material lies unpacked and deeply piled upon a steeper lower slope of relatively invisi-ble material. Such a condition is ideal for minor slides, until such time as large vegetation has become well established on the talus. The only immediate solution is either to slope the entire back, loosening it evenly over the entire surface, or to prepare, by means of shoveling or deep furrows, a firm tie between the talus and the bank.

The most practical slope for roadbank stabilization is that which most favors vegetation establishment and yet involves no unreasonable construction costs. Here, as elsewhere in the process of bank naturalization, there is no fixed rule applicable to all situations. Some indication of how treatment must be varied to obtain even tolerable results on different bank slopes encountered is given in Figs. 1 and 2.

Resloping and other engineering measures are frequently necessary for old banks that have failed to become naturalized. This is particularly true where frost action and caving are active and the talus is being continuously washed away. Such banks do not come to an angle of repose naturally.

**Smooth Surfaces Not Desirable**

Leaving rough surfaces is required practice for satisfactory roadbank naturalization. The idea seems all too well established that a smooth, polished road bank is the sign of good construction. This is partly because contractors are complying with slope specifications most easily measured on a smooth surface, and partly owing to the desire to leave an appearance of precision and to remove loose material that might wash from the bank.

Such practice is not likely to be altered until specification, for the road design are altered. Road engineers must first accept naturalization of banks with vegetation as a necessary part of roadbuilding. A great deal of inertia must be overcome before specifications can be generally obtained that favor rather than hinder naturalization.

Actually, the smooth bank is in most cases quite temporary, lasting only until the first frost action and heavy rains have had an opportunity to loosen the surface, and which puts erosion and frost sloughing will necessitate constant maintenance. Certainly, no vegetation can come in naturally on polished banks till destructive influences have torn down the surface. A very considerable economy would be effected—especially if construction and maintenance costs are given equal consideration—by expanding the equivalent of the labor required to put the final polish on the slope, it applying instead a top dressing and the protection of a simple organic mulch.

Roughening and loosening the slope is a wise precaution to obtain stability between a topsoil dressing and the bank surface. A rough bank favors the collection of litter and wind-blown seed, and increases the infiltration of water that would otherwise flow over the surface. Use of the common mattock for shaping cut banks has led to excessive smoothing off of every irregularity that might allow falling leaves or catch wind-blown seed. The mattock is useful, but a pick is also valuable in loosening the surface. Consequently, the pick-mattock, rather than the common axe-mattock, can be used most advantageously.

Machine techniques that help in getting away from smooth uniform slopes should be further perfected. Most road graders are now being made so that they may be used for sloping low banks to the drainage ditch. By manipulating the blade at different angles it is possible to leave the bank relatively rough.

Benching the cut slope is practiced to give greater visibility or to obtain large quantities of easily available material for grade construction. Benching is a useful technique for bank stabilization, although not a common practice as yet, has been used very successfully. For soils that remain stable when the slope is steep, benching accomplishes two purposes—it favors natural vegetation establishment on the level step surface, and at the same time avoids erosion on the face.

Techniques of benching a long high bank are already known to most road operators. It is only necessary that at the time of cutting the slope, the operator be instructed to leave a bank rough instead of smooth. With a toothed hoe, loosen loose material on the series of benches; naturalization can be obtained with no further treatment and no additional cost. Construction with large shovels makes it possible to leave the banks as rough as desired, and although a certain amount of shaping is necessary, it is as easy to leave a roughened as a polished bank.

**Vegetation Establishment**

Invasion of natural vegetation is to be expected in localities of moderate rainfall on banks so prepared as to favor such growth. The local vegetation that will establish itself in this way and will persist is probably the best obtainable for the particular local conditions and will produce a bank cover that will not deteriorate with the adjacent landscape.

This invasion of local species will occur on banks that to any degree favor vegetation, regardless of what other species may have been planted when the cut was made, and in time they will accept the site. In all preparatory work the local species should be favored rather than the outsiders.

Treatment to obtain vegetation on road banks is most practical when it favors this natural invasion of local species and obviates the necessity of artificial seeding.
the finished pavement. Such condition is ordinarily produced by capillary absorption of water. The per cent of water which can be thus absorbed may be determined by laboratory test. A field test of load supporting value of the subgrade soil mixed with this amount of water may then be made upon a mass of the prepared soil, compacted in a pit approximately 6 ft. in diameter and not less than 2 ft. deep.

THE NATURALIZATION OF ROAD BANKS
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or planting. The following recommendations on the use of various aids to vegetation establishment are for the most part directed solely towards building up and restoring conditions on the road bank that will come as close as possible to duplicating natural conditions of surface-soil fertility, penetrability, and permanence. Where this is accomplished, nothing further in the way of artificial aid is required.

Top Dressings

Top dressings are essential where it is desired to hasten the processes of invasion described above. The ideal dressing to promote naturalization on a sterile road bank consists of surface soil composed largely of organic material containing an abundance of plant roots and stems. Such a dressing combines the good qualities both of a rich soil and a mulch; the organic material has the binding and at the same time the protecting effect so needed to give seedlings a chance to become established. At the same time the roots and stems continue growth on the new location and thus greatly accelerate the naturalizing process with a minimum of effort.

Top dressings obtained elsewhere than from the soil above the slope or from stock piles conserved when the right-of-way was cleared had best be taken from a rich cove or rich bottom land, if these are to be found within a short haul of the road. The soil selected should be as rich as possible in roots and stems. In no case is it feasible to take soil from a depleted, abandoned field merely because it is near at hand. This is poor economy, since such soil, already supporting only poor plant growth, is certain to be too sterile to be any notable improvement on the soil of the cut. It is not worth transporting.

Loose granular soil with little organic material makes a poor bank dressing, be-
cause of the difficulty of binding it to the bank. A single rainstorm may wash the surface soil away. When such dressings are applied to dry banks, some vegetation may start and flourish briefly, only later to succumb from lack of moisture. Also, unless vegetation on such a surface makes unusual growth the first season, frost heaving in the loose soil may uncover it.

The simplest procedure possible in obtaining a top dressing is to rake down organic material and soil from above the slope. If the soil is taken with discretion, the resulting disturbance will be negligible. On land that has been cleared, the soil may be spaded up from a series of small holes. On forested land, the best practice is to use a cutting rake, which will collect the roots and underground stems that are present in the duff and mineral soil. This practice produces no erosion in the surface above the slope except on very shallow shale soils.

The average bank requires only one or two inches of top dressing for plant growth; sterile banks need somewhat more.

Fertilizers

Commercial fertilizers require much less labor than do soil dressings, and are easier of application, but they do not take the place of other dressings for roadbank improvement in all cases because they do not supply the biological activity needed to improve growing conditions. Extreme caution is needed to avoid using too much commercial fertilizer, particularly on cut banks that are likely to dry out quickly. Light applications are always safer than too heavy applications. In general it is safe to conform to the local agricultural practices. A complete 4-8-4 fertilizer, for example, may be safely applied at the usual rate of 400-500 pounds per acre. Heavier applications are always dangerous. Fills with adequate moisture, will rarely need more treatment than seeding with grass on a loosened surface. The seeds of the grains, legumes, and grasses should be raked in very lightly after broadcasting.

Sod planted in furrows on the road bank has rarely proved effective, except where a rich soil aids the roots to penetrate quickly. Elsewhere the soil is frost heaved and washed out by the spring runoff and erosion. Pot-hole planting of woody shrubs requires mulch protection. Where other methods fail, planting the rich top shoulder of the bank with climbing vines will help to hold the soil and gradually cover the bank from above.

Mulches

The use of mulches has been particularly successful in assisting the natural invasion of plants on road banks. Mulches serve to provide shade and to check rapid drying, to correct soil instability occasioned through frost action, wind, and water erosion, to prevent frost heaving of young plants, to increase biological activity of the bank soil, and to improve soil structure by addition of organic material. Also, most mulches bring to the banks large quantities of weed and shrub seed. When a topsoil dressing is also used, the mulch serves to keep it from washing away.

The application of mulches in most localities is not only one of the most simple and inexpensive naturalization treatments, but it has the added advantage of being a treatment that may be elaborated upon to any degree necessary. For example, in case natural vegetation does not appear within a reasonable period, the bank may be seeded without fur-
thei treatment. Fertilizers may be added directly through the mulch. Just how much additional work any particular bank would need depends upon local conditions. No attempt should be made to write rigid specifications; each road bank may call for individual modifications. General techniques may be outlined, but specific techniques have to be developed for each job, depending on local conditions and sources of material.

Staked Weed Mulch

The staked weed mulch is the simplest method known for holding roadside mowings of weeds and briars on a steep slope. Weed mulches are most commonly used in open country, or wherever wild growth such as coarse weeds, briars, grass, meadow hay, etc., can be easily obtained. This material is cut with power mowers, council tools, and scythes, and placed on the road banks either while still green or after drying. If the work is to be done in the winter months, the weeds may be cut in the late summer or early fall, cured like hay, and kept in stacks till used.

If this mulching material contains a large quantity of briars or long-stemmed weeds, together with some finer grass material, it will hold together in a natural mat and stay in place on moderately steep slopes. If it does not, mulches dry out quickly and may then be blown about by the wind. To prevent this from happening, and to insure against slipping on a steep bank, stakes, poles, or heavy brush are used to hold the mulch in place until vegetation has become established. One way of finding out how much work is needed to hold a mulch is to place material on the bank and then observe the minimum amount of work required to keep it in place.

The common method of holding a mulch is with stakes 18 to 24 inches long and about 2 in. through. They are made most readily from straight-grained, easily sharpened wood.

In applying a staked weed mulch, the stakes are usually set first, spaced at whatever distance is necessary to hold a mulch in place, as determined by the length of the mulching material. Frequently stakes are needed only on the upper portion of the bank, or sometimes only in a bottom row with occasional groups on the more difficult portions of the bank. On the average, stakes are set rather uniformly about 2 ft. apart, where needed. Commonly, about 6 in. of the stake are left above the surface. A most serious mistake is to cut stakes too short, so that

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they are grown out by freezing. Stakes should be at least 18 in. long and sufficiently strong to be driven 12 to 18 in. into the ground.

After stakes are in place, the mulching material is laid on this framework to a depth of 2 to 4 in. The coarser material forms a skeleton framework, and the finer material a continuous mulch as close to the bank as possible. The framework should be placed on the bank by hand to insure that it is fully supported by the stakes. The mulch must be thick enough to prevent soil movement, but should not interfere with germination and establishment of natural vegetation. A heavy mulch of fine material may cause composting and kill any seed present.

The above article is based on Technical Note No. 51 of the Appalachian Forest Experiment Station, Forest Service, U.S. Department of Agriculture. The author, C. R. Hursh, is senior forest ecologist at the Station.

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USED CONSTRUCTION EQUIPMENT EARMARKED

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Majesty in the right of any provincial government and any county or municipal government, but does not include any farmer, mining corporation;

(c) "essential work" means any construction, maintenance or operation of any highway, airport, dock, quarry, utility, housing project, lumbering or logging project or other plant, work or undertaking directly or ancillary to the defense of Canada or any of its allies.

2. Within thirty days from the date of this order, every person who owns any equipment enumerated in Schedule "A" hereto, which has heretofore been used, shall, on plain bond paper measuring 8½" x 11" and in the form prescribed in Schedule "B" hereto, report to the administrator on each item or unit of equipment so owned.

3. If at any time hereafter any equipment is idle and the owner thereof has no definite commitment for its use, he shall promptly report such fact to the administrator.

4. Every person who owns any such used equipment which is or may be idle may be used in work other than essential work or which is or hereafter may be idle, shall, at the direction of the administrator either sell or hire such equipment, at the owner's option, to any person requiring its use; provided that such use shall, in the opinion of the administrator, be for the purpose of doing essential work.

5. When the use of any such used equipment is hired to any person at the direction of the administrator, (a) The maximum rental that may be charged for such use shall be:

(i) in the case of monthly rental for the first 240 hours in any calendar month, $ per cent of the initial cost to the owner of such equipment (hereinafter called the basic rate), plus one-half of the hourly rate, established by dividing the basic rate by 240, for each hour in excess of 240 during which the equipment is in actual use during any such month; provided, that when and after the total rental paid by any hirer for any such equipment shall equal the value thereof, as established by the administrator, the rental shall not exceed one per cent of the said initial cost per month for each month or part thereof that such equipment shall continue to be used pursuant to any one rental contract or on any one contract for