The naturalized road bank at the right blends into its surroundings and gives an appearance of completeness to the road construction, in contrast to the ugly scars that will persist for years on the road at the left—a too-common sight in mountain country.

Naturalized Road Banks

Local vegetation established on cut banks at reasonable cost will cover disfiguring scars and lower future maintenance expense

Charles R. Hursh
Senior Forest Ecologist, Appalachian Forest Experiment Station, U. S. Forest Service

[This article has been condensed from a bulletin prepared by Dr. Hursh and issued by the Appalachian Forest Experiment Station, Asheville, N. C., as Technical Note No. 51. The illustrations are U. S. Forest Service photographs taken from the bulletin. The second part of the article will appear next month.—Editor.]

In older countries the naturalized road bank is more frequently seen than are the bare, raw banks that characterize public highways in most hilly and mountainous sections of the United States. But here, quite as commonly as abroad, the naturalized road bank, with its universal appeal to highway travelers, 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. With inconsiderable effort and expense, naturalized banks along all our roads may present 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 and national-park roads results from the attention given to this side of construction. What is lacking elsewhere is the recognition by the generality of road-builders that road-bank stabilization is a legitimate and essential part of road construction. Once the bank has been stabilized, little additional effort is needed to encourage a permanent natural cover of local shrubs and trees.

The cost can be relatively low if the method followed is to leave the bank in a shape that will favor the gradual invasion of local vegetation—so small a fraction of the cost of road construction as to make almost inexcusable the wounds and scars that disfigure the course of so many highways throughout the land.

In addition to the inestimable gain in esthetic values, the naturalized road bank has a very practical and utilitarian value, determinable in dollars of maintenance cost per mile of roadway saved. Eroded soil from bare banks on many mountain roads in the southern Appalachians, by choking ditches and culverts and subsequently cutting out fills, has cost each year $100 to $300 per mile of roadway in maintenance.

Where vegetation finally has pushed its way on to these bare banks, halting
erosion of the remaining soil cover, 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.

On federal lands, naturalization of road banks has already proved its economic worth and esthetic value in solving many difficult problems of road construction, attracting the attention of 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 stabilization involves certain new techniques, which must be recognized and practiced to assure success.

Several agencies have contributed to the development of these techniques. The watershed-protection section of the Tennessee Valley Authority, the National Park Service and the Soil Conservation Service have all had an active part. The landscaping sections of the state highway departments for many years have been doing excellent work, and of late have begun stabilization as a first step towards erosion control and reduction of maintenance costs. The Public Roads Administration and the Highway Research Board also have taken active interest in road-bank stabilization.

A study of stabilization treatments was begun in 1934 by the Appalachian Forest Experiment Station, testing the 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 in 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 presented here for the use of those engaged with the practical problems of roadbuilding. They are concerned first with the factors limiting plant growth, and then with naturalization measures, which fall into two classes: those involved in the location and planning of roads, and those concerned with the establishment of healing 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 is difficult to stabilize after adequate road drainage has been provided. Exceptions to this rule occur on long, steep fills occasioned by extra-heavy road construction in dry regions. Here special mechanical structures may be needed, such as cribbing and retaining walls. Structures of this type are beyond the scope of the present discussion.

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 that natural vegetation will ever become established.

In the tidewater counties of Virginia road banks that have remained bare of vegetation for more than a century and a half because of the unstable condition of the surface soil. The principal factor here has not been fertility or moisture, but rather the sloughing caused by repeated deep freezing and thawing.

In the southern Appalachian many banks are known to have been bare throughout the memory of the oldest inhabitants. Such banks are continually being reduced by erosion; but the change in appearance is so gradual that it frequently escapes attention.

A review in detail of the principal factors responsible for such havoc on old and more recently built roads, with some illustrations of their operation, will make clear the fundamental obstacles in the way of road-bank naturalization and how to avoid them.

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 a 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 no formation of vegetative cover alone will correct. Construction of roads through rough terrain may cut off the supporting toe of long talus slopes and result in continuous sliding. Occasionally deep slides, particularly those formed in place and characterized by shearing planes such as are formed in the older Appalachian Mountains, are also rendered unstable by road construction, resulting in large-scale slides and mass movement of soil, sometimes completely blocking the highway.

Lack of moisture resulting from excessive evaporation and drainage often makes 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 of overcoming this difficult condition is the use of organic mulches to conserve whatever moisture reaches the slope.**

Infertility is too often blamed for poor growth on road banks when the real causes are surface instability and lack of moisture. This mistake is often made in judging road-bank conditions in the piedmont and southern Appalachian regions. Vegetation has established itself on these "infertile" banks as soon as mulching has halted erosion and started to hold moisture.

Even though the new growth may be composed largely of dewberry and 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.

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 material. Even relatively sterile mineral soil is improved in fertility under a protective cover of organic material. The steeper the bank, the less the organic material that can find lodgment and the less the improvement in fertility that can take place.

High fertility is unpractical on road banks as a rule. It is sufficient if the bank will support plant growth of any kind. Where mulching fails to improve surface stability and moisture, top dressings are most useful. The best treatment for such unusually sterile banks might be a dressing that combines the characteristics of an organic mulch with those of a rich topsoil, with abundant

[Continued on page 24]
They were familiar with our inadequate road laws and also knew the political fences that had to be hurdled in order to get any study made of them.

During this period, agents for road-making machines and steel-bridge salesman, together with the supervisors and members of the town clerk’s association, furnished lively opposition. Concrete was being advocated for paved roads, and the brick manufacturers were very uneasy about this new kind of road. Men who knew nothing about proper concrete mixtures were building stretches of road whose surfaces cracked in a short time, and much was made of these failures.

There were 4,800 township highway commissioners in Illinois in those days—three for each township. As nearly as could be estimated, this army of commissioners spent about $7,000,000 in 1911—$3,000,000 on bridges and the remainder on roads.

The average highway commissioner was a good man who became commissioner because he was asked to do the job. He got paid from $200 to $1,000 a year. He knew nothing of anything, of course, about road construction or maintenance. The road tax in the average township amounted to about $2,500 a year, and a good share of this amount was absorbed by the commissioner as pay for his services. The millions of dollars spent through these channels produced virtually no permanent roads.

A lively interest in roadbuilding was being shown by the Illinois Bankers Association, of which S. F. Bradt was president. The association’s committee on good roads, with S. E. Bradt as chairman and Daniel Sudduth, secretary, had an imposing list of members. Governor Edward Dunne had come into office, of course, about road construction or maintenance. The road tax in the average township amounted to about $2,500 a year, and a good share of this amount was absorbed by the commissioner as pay for his services. The millions of dollars spent through these channels produced virtually no permanent roads.

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Mr. Bradt invited a special meeting in Springfield on Feb. 18, 1913, which was attended by the governor, all other state officials, members of the Illinois general assembly and other persons interested in agricultural and vocational education and good roads. Mr. Bradt’s talk expressed the beliefs of good-roads advocates of those days.

He urged that the number of township road commissioners be reduced from three to one so that “by centralizing the authority in one experienced man we would get a higher efficiency and better economy.”

Other recommendations made were (1) that road taxes be paid in cash instead of labor, (2) that dragging earth roads be compulsory, (3) that the fill be made of convict labor, (4) that a three-member state highway commission be appointed, which would hire a state highway engineer, (5) that a county highway engineer be appointed in each county from competitive civil service examinations, (6) that the township road commissioner work under the county engineer in improving township roads, (7) that a uniform system of state aid-roads and bridges be paid for one-half by the state and one-half by the county, and (8) that township roads be improved by vote of the township’s residents, with the county and township sharing the cost. An appropriation of “not less than $500,000” was recommended to be available by July 1, 1914.

Many of these recommendations were enacted in the Tice road law, which was passed by the legislature largely through the personal influence of Governor Dunne and Homer J. Tice, of Greenview, who risked their political futures to back the measure.

During all these years, meetings were held all over the state under the auspices of the Illinois Commercial Federation, the Illinois Manufacturers’ Association, the Illinois Bankers Association and others. All these efforts by leading citizens were creating a reasonable doubt in the minds of our opponents, and even such papers as the Champaign News commenced to interview citizens and were surprised to find that sentiment was changing rapidly. Illinois was getting sick of fighting the mud year after year, and its citizens were learning that roads could be built without bankrupting anyone.

Then came the World War, bringing with it a heavy load on the railroads and every other means of transportation. It also brought Frank O. Lowden to the governorship of Illinois. At our first meeting with him he asserted that he would veto any financing plan that laid a direct tax on land—no matter how small. After a number of meetings, Governor Lowden suggested a $60,000,000 bond issue with which to start building 4,800 miles of paved roads connecting the leading trading centers in the state. The bonds would bear 4 per cent interest, would be sold and issued as needed, and would be fully paid up in 25 years out of motor-vehicle license fees.

The total principal and interest on this proposal would amount to $82,000,000, making the annual payment $3,280,000. This was in 1918, and it was shown that the previous year there had been more than 340,000 automobiles registered at an average fee of $10 each, and that this fee would thus produce $3,400,000 a year if no more than the 1917 number of cars were registered. This sum was more than enough to meet the interest and retire the bonds. Details of the construction of the roads were to be determined by the state department of public works and buildings.

The election was set for Nov. 5, 1918, and I was appointed to the committee set up to plan the campaign for the bond issue. One of the first important citizens to be interviewed was General Charles G. Dawes, who received us graciously but refused to head the organization as wanted formed. Instead he referred to William G. Edens, who could devote his entire time to the campaign. Colonel Edens was made president of the Illinois Highway Improvement Association, assisted by five vice-presidents, including the author.

Many of the best-known men in Illinois served as directors and on executive committees, and committees were chosen in each county in the state. I have never seen a more complete and perfect organization developed for any cause than the one Colonel Edens built in Illinois.

Part of our support resulted from the fact that Frank O. Lowden was governor and the plan for the bond issue was his. The men who had fought our good-road movement in its infancy—even up to the time Governor Lowden was elected—were quick to climb on the bandwagon. Our battle-cry was “Pull Illinois Out of the Mud,” and that is exactly what happened when the election was won and the machinery set in motion.

Road Banks ---

[Continued from page 15]

plant nutrients and biological activity. Such dressings are usually available within working distance of the roads.

Soil infertility merits particular attention on large banks where much of the exposed slope is representative of the lower soil horizons. A basic consideration is that banks exposing B-horizons or soils lower are improved by the incorporation of some A-horizon soil with other organic top dressing and commercial fertilizer. Necessity for such improvement in any specific case depends upon local conditions.

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 vegetation-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 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.

Postponing bank stabilization may result in its having to be undertaken and
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 stabilization.

The plan should include provision for disposal of the dirt excavated, protection of hills from stream erosion, and for having the heavy work most economically done by power machinery. Good machine operators can do much to reduce subsequent costs if they are informed of erosion-control objectives and methods. An operator of a trailbuilder on a widening job can cut slopes in a series of small lines, thus providing very favorable conditions for revegetation.

Night Guides Helpful

Four years ago, in April, 1938, the Michigan State Highway Department completed an installation of reflectorized guide guides on U. S. Route 16 between Detroit and Lansing. Guides were also installed on a section of U. S. Route 24 between Pontiac and Toledo.

A survey recently undertaken by the department indicates that the guides proved their value by decreasing night accidents and increasing the feeling of security of drivers.

Each delineator consists of three shatter-resistant plastic reflecting disks, set in a vertical line in a metal housing atop the standard. The delineators are placed at 100-ft. intervals along the highways. They are placed 8 ft. from the edge in rural areas and 4 ft. in urban areas where the road surface is bordered by a curb. Reflectorized guides of this type have been used in other states, and a notable installation is that of the Pennsylvania Turnpike.

Michigan records covering 2 years before and after the guides were installed on U. S. Route 16 show that death and injury accidents at night dropped from 2.618 to 1.892, while the number decreased from 6.949 to 4.448 per million vehicle-miles.

On the reflectorized section of U. S. Route 24 the accident rate was reported to have dropped from 2.618 to 1.892, while the death rate decreased from 0.494 to 0.448 per million vehicle-miles.

Comparing the record of the Detroit-Lansing highway with experience in three similar highways without reflectors, it was found that night accidents had decreased 25 per cent on the reflectorized highway in a 2-year period in which there had been a composite increase of 5 per cent on the unreflectorized section of the road. A similar comparison for another 2-year period shows a 9 per cent decline in night accidents on the reflectorized section of the Pontiac-Toledo highway, and a composite 16 per cent increase on the three without reflectors.

Do the reflector units increase maintenance costs appreciably? Experience seems to vary. Michigan reports a slight increase in the cost of road-side mowing, but feels that this is more than offset by the benefits derived. The Illinois Division of Highways, on the contrary, found that snow removal, mowing of weeds and shoulder maintenance were slowed down seriously along a 14-mile installation. Replacement and straightening of lost or damaged markers also created a problem. The experience of the Utah State Road Commission has paralleled that in Michigan: some shoulder-maintenance problems have been incurred, but they have not been serious.

Foster Kunz, traffic and safety engineer of the Utah State Road Commission, summarizes Utah's experience with the guides as follows: "Much favorable comment has been received from drivers. The markers seem to add considerably to the ease of night driving, in that the road is clearly defined for a safe distance ahead." He feels that the reflectors make their greatest contribution in marking sharp curves or dangerous sections of winding road.

The Michigan State Highway Department has had many comments from drivers on the additional value of the reflectors in adverse weather—particularly during the first few hours of a snowstorm, when the edge of the pavement is covered and cannot be located.

The Crossroad Critic Asks—

Why Do They Do It?

It seems odd that maintenance gangs in so many states are so careless in the attention they give to expensive pavements. Ordinarily when we acquire a costly piece of goods, we take care of it and never let our investment go to the dogs; but apparently some highway maintenance men are of a different turn of mind.

A year or so ago I visited a road meeting of national prominence. On the program was a well-known engineer who gave us all a jolt by saying that his state had the most expensive roads in the country, but that he was certain there wasn't a first-class workman there. We were somewhat skeptical, but he asked us to visit his state some day and see for ourselves.

I have just finished touring in his state, and so far as I can judge, he told us the truth. The roads I journeyed over were of excellent design, well-built, of good materials, and yet you had the feeling that you were riding over second-class highways. Certainly they looked it. It puzzled me so much that finally I got out of the car and examined the pavements. The reason they were so faulty was solely the kind of maintenance they had received. Instead of first-class workmanship being evident, an observer could readily see that only bunglers had been at work. Here were thousands of miles of asphaltic, brick and concrete pavements, all of them in deplorable condition.

It's hard to believe that all the maintenance crews in this state should be so worthless. Of course, the answer one always gets is—politics. But in other states where political influence is equally strong you do find an occasional capable maintenance gang, and you don't get shaken to pieces when you travel over the state system. We hope that the "don't care" attitude does not spread to other localities, now that men are hard to find and materials are even rarer.

Those of us who are old-timers should see to it that our maintenance men keep on their toes throughout the war period, even though traffic is falling off on some routes. More than ever before, we must wring every cent of value from our maintenance dollar, because less traffic today means just that much less money tomorrow. Before we know it, the roads that are not suitably cared for will be worthless for fast traffic, and then we will have to put up additional billions of dollars to pay for neglected highways.
No exposed road-bank soil is stable if it is subjected to freezing and thawing, and to the direct influence of wind and water.

Charles R. Hursh
Senior Forest Ecologist, Appalachian Forest Experiment Station, U. S. Forest Service

[This is the second and concluding part of an article condensed from a bulletin prepared by Dr. Hursh and issued by the Appalachian Forest Experiment Station, Asheville, N. C., as Technical Note No. 51. The photographs, taken by the U. S. Forest Service, are from the bulletin. The first part of the article appeared in June.—Editor.]

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 headwalls 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.

Conserving natural topsoil is a simple matter if naturalization is coordinated with new construction, since it can be readily obtained from the right-of-way clearing, along with needed brush and other native materials. Costs can be held down by handling the topsoil with machinery and avoiding long hauls—on new jobs by stockpiling or shoving it to one side as the work advances. It should not be allowed to leach out in successive rains or dry out all its biological activity. On old banks, sufficient topsoil can usually be obtained by rounding off the upper shoulder and raking it down over the roughened and loosened bank. The volume of topsoil is not so important as its freshness when applied and its permanence thereafter.

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.

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

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

Disastrous results can sometimes occur when a steep bank has been sloped on the upper portion only, and the loosened material lies unpacked and deeply piled upon a steep lower slope of relatively impervious 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 bank, loosen it evenly over the entire surface, or to prepare, by means of shelving or deep furrows, a firm tie between the talus and the bank.

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

Schedule for the stabilization of moist banks having deep, rich soils. These conditions are rarely met with on banks more than 6 ft. high. Natural vegetation will come in readily on moist, rich banks if the surface is protected. The treatments needed are those that will insure stability of the surface soil till seedlings can become established. Loose organic mulches are adequate for this purpose; topsoil may not be needed. Banks should always be left rough, and should not be allowed to pass through the winter in the frost belt without mulch protection.

Use of the common mattock for shaping cut banks has led to excessive smoothing off of every irregularity that might lodge falling leaves or catch windblown seed. The mattock is useful, but the 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 can 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.

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 windblown seed, and increases the infiltration of water that otherwise would flow over the surface.

The invasion of natural vegetation is to be expected in localities of moderate rainfall, on banks so prepared as to favor time of cutting the slope they be instructed to leave a bank rough instead of smooth.

Such practice is not likely to be altered until specifications 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 naturalization.

Actually, the smooth bank is usually quite temporary, lasting only until the first frost action and heavy rains have had an opportunity to loosen the surface, after which gully erosion and frost sloughing will necessitate constant maintenance. Certain vegetations 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 expending the equivalent of the labor required to put the final polish on the slope in 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 windblown seed, and increases the infiltration of water that otherwise would flow over the surface.

Dry Banks, Sterile Soil

Schedule for the stabilization of relatively dry banks having sterile soils. Natural vegetation will come in only if the soil moisture is improved, and the surface loosened, protected, and fertilized. Top dressings of soil rich in organic material, and light mulches of woods and weeds are used very successfully. For soils that remain stable when the slope is steep, step benching accomplishes two purposes—it favors natural vegetation establishment on the level step surface, and at the same time it avoids erosion on the riser.

Techniques of benching a long, high bank are already known to most machine operators. It is only necessary that at the time of cutting the slope they be instructed to leave a bank rough instead of smooth.

The invasion of natural vegetation is to be expected in localities of moderate rainfall, on banks so prepared as to favor growth of fertilized right half of mulched bank contrasts with slower growth on the unfertilized left half.

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>MOIST, FERTILE SOIL, SUBJECT TO FROST-HEAVING, SLOUGHING AND EROSION</th>
<th>SUGGESTIONS FOR BANK TREATMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>Very difficult and expensive to naturalize, particularly in the frost belt. On old roads re-slope where possible.</td>
<td>Natural vegetation will be favored by a strong weed mulch held in place with brush and stakes. Light straw mulches do not last long enough.</td>
</tr>
<tr>
<td>1:1</td>
<td>A very feasible slope to naturalize. Frequently met with in areas of irregular topography.</td>
<td>Light mulch is sufficient to promote natural vegetation. Minimum of loose material and staking necessary, but treatment should be carried out as soon as possible after construction.</td>
</tr>
<tr>
<td>1:1</td>
<td>Requires thorough treatment immediately after construction. Surface usually too smooth.</td>
<td>Can be naturalized with a strong weed mulch over a loosened surface held by stakes, or with a lighter mulch of litter covered with brush and poles. For this treatment and those above, round shoulder to a 3-ft. radius and treat as part of bank.</td>
</tr>
<tr>
<td>2:1</td>
<td>Used very successfully. For soils that require treatment immediately but do not need a top dressing and the protection of litter and windblown seed.</td>
<td>Light mulch or brush for protection of natural seedlings.</td>
</tr>
<tr>
<td>4:1</td>
<td>Surface usually too smooth. Should be cultivated.</td>
<td>No treatment may be necessary if the surface is well loosened and a source of weed seed is available. May be cultivated with farm machinery.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>DRY AND INFERTILE SOIL, NOT FAVORABLE TO VEGETATION</th>
<th>SUGGESTIONS FOR BANK TREATMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>South-facing slopes extremely dry. Difficult to prepare for vegetation establishment. On old roads where re-sloping is possible, this may be necessary to insure naturalization.</td>
<td>Requires a light top dressing of 1 to 2 in. of rich soil over a well-loosened surface; also a weed mulch held with poles and stakes. Fertilizer needed.</td>
</tr>
<tr>
<td>1:1</td>
<td>Difficult and expensive to naturalize; moisture must be improved by mulching; topsoil dressings hard to hold in place.</td>
<td>Leave rough surface. Cultivate with farm machinery; drill in fertilizer and seed. Use light mulch with brush to retain moisture.</td>
</tr>
<tr>
<td>2:1</td>
<td>Roughtened surface necessary where topsoil is used.</td>
<td>Leave rough surface. Cultivate with farm machinery; drill in fertilizer and seed. Use light mulch with brush to retain moisture.</td>
</tr>
<tr>
<td>4:1</td>
<td>Leave rough surface.</td>
<td></td>
</tr>
</tbody>
</table>
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 best harmonize with the adjacent landscape. 

This invasion of local species will occur on banks that favor vegetation to any degree, regardless of what other species may have been planted when the cut was made, and in time they will occupy 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 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 extending 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 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 of both 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. Simultaneously the roots and stems continue growth on the new location, and thus greatly accelerate the naturalizing process.

Top dressings obtained elsewhere than from the soil above the slope, or from stockpiles 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. In no case is it feasible to take soil from a depleted abandoned field 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 because 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. Unless vegetation on such a surface makes unusual growth the first season, frost-heaving in the loose soil may uproot 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. 

The average bank requires only 1 or 2 in. of top dressing for plant growth; sterile soils need somewhat more.

Commercial fertilizers require much less labor than do soil dressings and are easier to apply, but they do not always take the place of other dressings for road-bank improvement, 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 fertilizer, for example, may be safely applied at the usual rate of 400 to 500 lb. per acre. Heavier applications are both unnecessary and dangerous.

The use of lime on acid road banks may but retard the natural invasion of native plants thriving best in acid soil. Yet it is impossible to obtain a growth of some grasses and legumes without lime. Consequently, it is well worth while to consult the county agent about the local soils, and to harmonize the use of fertilizer and lime with other plans for naturalizing the road banks.

Seeding and planting are resorted to as a means of obtaining special landscaping effects, or to increase the representation of attractive local plants, or to obtain a sod on low banks and wide shoulders.
that are to be kept mowed. They are of greater importance, however, as a temporary means of holding the surface until an invasion of local species can take over. Greater importance, however, as a temporary means of holding the surface until an invasion of local species can take over. 

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Whether or not to seed mulched banks depends on what seed the mulch contains. If weeds cut in the fall are used, seed will be plentiful, but spring-cut weeds have little seed. Mixed seed is best on all larger projects because of the different site requirements of different species. Above the range of Bermuda grass in the southern Appalachians, a successful mixture is ryegrass, orchard grass and redtop, with some bluegrass to form a sod. The grass mixtures should be applied at the rate of 20 to 30 lb. per acre. Grasses can be sown right on the mulch in wet weather. Rapid spread is not the only requisite. Ryegrass spreads rapidly, but may soon become a pest.

Fills with adequate moisture will rarely need more treatment than seeding with orchard grass or Italian ryegrass on a loosened surface. The seed of the grasses, 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 sod is frost-heaved and washed out by the spring runoff and erosion. Pothole planting of woody shrubs requires mulch protection. Where other methods fail, planting the soil in or near the base of the bank, will help to hold the soil, and will gradually cover the bank from above.

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 or 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 the 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 not only is one of the most simple and inexpensive naturalization treatments, but has the added advantage of being a treatment that may be elaborated on to any degree necessary. For example, if natural vegetation does not appear within a reasonable period, the bank may be seeded without further treatment. Fertilizers may be added directly through the mulch. Just how much additional work any particular bank needs, depends on local conditions. No attempt should be made to write rigid specifications; each road bank may call for individual modifications.

The staked woof mulch is the simplest method known of holding roadside mowings of weeds and briers on a steep slope. Weed mulches are most commonly used in open country or wherever a wild growth such as coarse weeds, briers, 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 until used.

If this mulching material contains a large quantity of briers 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, it dries out quickly and may then be blown about by the wind. To prevent this 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 amount of work required to keep it in place.

The common method of holding a mulch is with stakes 18 to 24 in. long and about 2 in. through. They are made most readily from straight-grained, easily sharpened wood. 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; 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 is left above the surface. A serious mistake is to cut stakes too short, so that they are thrown out by freezing.

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.

**State Aids Increase**

Approximately $2,500,000,000, or $1 in every $6 of the $17,300,000,000 tax bill collected by federal, state and local governments in 1941, was transferred by the Federal government to another level of government, according to the Federation of Tax Administrators. The exchange of funds was mainly through grants-in-aid and shared taxes.

Last year, state governments played the most prominent role in the intergovernmental transfers, supplying funds to localities totaling $1,700,000,000, of which $500,000,000 represented shared tax revenue. Federal grants-in-aid to the states totaled $744,000,000, and federal grants to local governments amounted to $96,000,000.

Thus while the federal government collected 45 per cent of the nation's taxes, the states 26 per cent and the local governments 29 per cent, the final tall of revenue allocation showed division of the tax dollar to be approximately 40 per cent federal, 21 per cent state and 39 per cent local.

Comparison of the federal and state aid distributed in 1941 with the grants and shares exchanged shows a larger proportion was transferred last year for welfare purposes. Allocations for education remained almost constant, and highway aid diminished.