

CLIMATIC FACTORS CONTROLLING ROADSIDE DESIGN AND DEVELOPMENT

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In addition to blending the highway into the countryside, vegetation along the roadside strip serves other practical purposes. One of these is the air conditioning effect that vegetation has on the highway right of way. Some measurements of the nature and extent of this air conditioning effect can be obtained from experimental studies in which the specific effect of vegetation on temperature, moisture, wind, etc. has been investigated. Studies have been directed principally toward finding out the effect of tree plantings for sheltering cropland against drying winds and for protecting habitations against the heat of summer and the rigors of winter. Measurements have also been made of the effects of complete denudation of the natural vegetation cover in comparison with adjacent areas in forest and grass. Research findings in these studies have many applications to roadside development problems.

For example, land areas under tree and grass protection have more uniform air and soil temperatures than areas of bare soil. In general, maximum summer temperatures are lower, and minimum winter temperatures are higher, in the vegetated area. Here, also, there is always more moisture in the air because plants are natural air humidifiers. Wind velocities near the ground are much lower under brush and trees. All of this adds up to something well worth considering in terms of making the roadside attractive, pleasant, safe, and economical to maintain.

Protection Against Wind - Dense foliage masses of brush and low trees have a sufficient retarding effect on wind movement to be of practical value in preventing snow drifts. The State of Michigan has recognized this fact by reserving 400-foot strips of forest cover along state highways. The strips are reserved to prevent the cutting of the trees and opening up of the highway, with the resulting possibility of high drifts of snow forming along the traffic way. These strips also serve in the air conditioning of their immediate vicinity by favorable influence on temperature, wind, and moisture.

Surface wind velocities are increased when soil is bared of its natural vegetation. At the height of two feet over compacted bare soil, wind velocities have been found to be 15 times as great as in an adjacent forest area, and eight times as over grassland. The drying effect of these increased wind velocities is not in direct proportion to the differences given, but it is certainly much greater over bare area. Drying out of the soil leads to its progressive deterioration as a potential growing site for plants. At the same time increased wind velocities over dry exposed soil can stir up local dust storms in some localities, a dangerous factor to highway safety. Such facts emphasize the need for early revegetation of bare soil areas as an integral part of highway construction.

Temperature Control - Temperature and air moisture are essential parts of the "air-conditioning" brought about by vegetation. Air temperatures on hot summer days may be 10-20 F lower in brush and forested areas than in areas of bare soil.

There is relatively more moisture in the air in the presence of vegetation which makes driving more pleasant so far as comfort of the traveler is concerned.

Maximum summer soil and air temperatures have been found to be much higher for bare soil areas than for areas covered by vegetation. The mean daily range of soil temperature at a depth of 1.2 inches has been found to be 33.5 F for compacted bare ground lacking in organic material as compared with only 10.9 deg. under heavy vegetation. Such extreme daily changes as are found on infertile bare soil are not only unfavorable to growth of young plants, but they contribute to the rapid drying out of soil moisture. Since annual species of plants generally germinate in the spring and must establish themselves during the summer, they are easily killed by the rapid intense drying of newly exposed soil that is lacking in organic material and structure. In the revegetation of poor soils subject to extreme temperature changes, recourse must be made to the use of mulches and to seasonal planting so that the plant roots can get deeper into the soil before the season of rapid surface drying begins.

Insulating Against Frost - On winter mornings you will see good examples of the protecting and insulating value of vegetation anywhere in the frost belt of the United States. On bare exposed shoulders and banks repeated freezing and thawing brings about soil heaving by the formation of ice crystals. This is the principal cause of surface instability on bare soils in the frost belt of the United States. Localities of open winters where the soil does not stay frozen and where there is little or no snow are most subject to frost heaving of the soil. Alternate freezing and thawing of exposed soil can occur 50 to 75 times during a single winter. Frost action is most severe on moist south facing slopes where it will account for the erosion of one foot of soil in a single winter season from a 1-1 slope clay bank. South facing slopes alternately freeze and thaw more frequently than north facing slopes. Ice crystals up to four inches high are not uncommon. These crystals raise fragments of stones and soil at a right angle to the slope of the bank. The crystals melt in the sun and the fragments settle several inches further down the bank from where they were lifted, or roll into the roadside ditch. This surface soil creep is active on cutbanks originally left smooth during road construction. In fact, uniform and smoothly polished banks appear to be particularly subject to this type of frost action. In any case vegetation will be needed to prevent frost erosion.

In addition to the soil creep and bank surface sloughing that is brought about by alternate freezing and thawing, surface instability makes the establishment of vegetation exceedingly difficult. Most perennial and biannual species of plants germinate in the fall, and small seedlings are actually thrown out of the ground by frost heaving. In the severe frost zones of the Southern Appalachian mountains and adjacent plateaus, shallow rooted vegetation is sometimes heaved out of the ground even after it has become established by a full season's growth. This does not mean that planting is not practical, but rather that it must be done with an understanding of the problems and the different sites to be encountered. In fact all of the above observations are convincing evidence of the value and need of planting the roadside strip as soon as possible in the course of highway construction as an erosion prevention measure.

Variation in Planting Results - Everyone experienced in extensive roadside naturalization projects is familiar with the lack of uniformity in the successful establishment of vegetation on newly exposed shoulders, roadbanks and fills. The

locations where vegetation has failed will be found on areas subjected to repeated freezing and thawing, maximum desiccation by wind and sun, high soil temperatures, etc. South facing banks will have maximum temperatures of 130-150 F on warm summer days as compared to 80-90 F on opposite north facing roadbanks. The south facing bank may require many times the amount of effort in order to obtain satisfactory vegetation establishment. Recognition of these potentially difficult sites "in advance" is extremely helpful in carrying out roadside development programs. Present practices generally give about the same amount of revegetation effort to one location as another. In some locations this may be much more than is needed, in others it may be entirely inadequate. This difference is generally due to the manner in which physical changes in land surface have modified the nature and intensity of certain climatic elements.

Difficult Planting Sites - In road building, soil conditions are greatly altered by engineering actions needed for proper grading and drainage. In rolling topography, cutting and filling create extensive areas of raw exposed earth slopes. The newly exposed material is frequently quite infertile. In fills it must be thought of as being about the same as the material brought out from a newly excavated house basement. Fills are generally not fertile for growing plants, but because the soil is loose and aereated, vegetation can be established with the aid of fertilizers and light mulches without too much difficulty. On the other hand, smooth, steep cutbanks and slopes of compacted subsoil are about the most difficult site for plants that can possibly be created by men. Slopes are usually left quite uniform and smooth and for the first few months give the impression of engineering precision and symmetry. Although the soil mass beneath is usually tight and compact, the surface few inches become very unstable when subjected to repeated freezing and thawing, and washing by driving rains. Temperatures can be extremely high, and rapid temperature changes take place in the soil due to exposure to wind action. The soil will dry out easily because of the lack of organic material and make it difficult for plants to live. The establishment of vegetation on these banks can be a nightmare to the landscape architect. Anything that can be done such as benching or roughening of the surface of steep slopes will aid in their vegetation.

Value of Mulches - The development of mulching technics is a direct effort to overcome the unusual climatic stress to which newly exposed soil areas are subjected. For this reason mulching should be adapted to meet the requirements of a particular location where it is to be employed. Mulching is most required on the upper slopes of dry, steep banks, subjected to extreme desiccation by wind and exposure to the sun. Low banks of rich moist soil may need little or no mulching. On the other hand, mulches are valuable wherever soil structure and soil fertility levels are extremely low and where the moisture retention power of the soil is lacking, as is frequently the case whenever a large amount of soil has been disturbed by road grading.

Conclusion - Physical conditions of the land surface create distinctive growing conditions for plants, for example, north and south facing roadbanks. Maximum soil temperatures of 130-150 F have been recorded at the depth of one inch on bare and dry south facing banks as compared with 80-90 deg. on corresponding north facing roadbanks. It is obvious that the requirements for successful vegetation of these two banks are quite different. These opposite banks constitute two different "plant growth climates," sometimes called "microclimates," "spot climates," "soil

climates," or "local climates," or even "modification of the local climate." In fact the question of terminology still remains to be settled by the specialists in the field. Regardless of what term is used it is the concept that is important. Namely, highway construction creates exceedingly difficult surface conditions for plant growth and at the same time creates an urgent necessity for the early revegetation of these very surface conditions. That is the important thing that the road builder needs to keep in mind. He can then make the necessary plans ahead for revegetating the highway strip as a part of the whole job to be done.

On the premise that roadside development is an integral part of highway building, cooperation and coordination between design, construction, and landscaping is necessary to obtain the best final results in terms of efficiency and economy. This cooperation should begin when the original design for the highway is being drawn up. The designer and the construction engineer can both unintentionally make it tough for the landscape architect if no attention is given to the revegetation job ahead. On the other hand during construction many things can be done with little or no additional expense that will make the vegetation job a lot easier. An understanding of the aims and requirements of plant establishment is the first step. These requirements relate to surface soil stability, to temperature and moisture, to slope and direction of exposure, and to the drying effect of increased surface wind velocities. A better knowledge of how such elements of the local climate are modified by engineering works and how they affect plant growth will expedite roadside naturalization.

COMMENTS

Dr. Hursh answered the following questions concerning his slides which showed a series of field tests in controlling erosion on highway cuts and fill slopes in the mountains of Georgia, North Carolina, and Tennessee.

Questions:

(1) What is best mulch material for use on highway slopes in the region where tests were made?

Answer: Field cuttings and roadside mowings from nearby areas have given best results. Clean hay and straw from oats, rye or wheat are among the worst. Long, fibrous materials with mixed briars, weeds, grasses and thin woody stems stay on slopes best, without staking or with least possible staking.

(2) Is a partial mulch, mostly at top of cut slopes, of advantage where mulch material is in limited supply?

Answer: Yes. Slopes should be examined and areas where erosion is, or will be, most active should be mulched first.

Note: Dr. Hursh reemphasized value of mulch in preventing frost action on bare cut slopes. Frost loosens surface of soil, any rain following washes off loosened material. Over 50 freezings and thawings were observed and recorded on a single road cut in one winter. Steep (1:1) slope lost 12 inches of surface soil during this period.

(3) Was not the erosion condition in the copper basin (in Tennessee) due to fumes from copper smelting plant? What was done to counteract acid conditions?

Answer: Elimination of smelter fumes at the source is the only cure for this condition.

(4) Was seeding done in conjunction with mulching operations on slopes? Would this speed growth of vegetation rather than depending on mulch only?

Answer: As a rule in Southern mountain country natural volunteer growth of vegetation soon comes up through the mulch. Seeding of fast growing grasses or grains is often of advantage in holding mulch on slopes.

(5) Do you find that you can apply mulch too heavily to get proper cover of living vegetation? Will heavy mulch smother growth on slopes?

Answer: Local hay or brush mowings rot down quite rapidly. If grass or legume seeds are sown into mulch already in place good stands should be expected. Heavy mulch over a seeded area is something else again.

(6) What methods were used to hold mulch in place on steep banks shown?

Answer: Stakes were driven at fairly close intervals in 1:1 cut and fill slopes, projecting some inches above the ground surfaces. These stakes prevented mulch from sliding down the slopes.

Later Comments Concerning Various Mulch Materials

(7) Does straw mulch result in the addition of appreciable amounts of organic matter to soil? Since asphaltic mulch materials certainly do not, should they be termed "mulches" at all?

Answer: Straw mulches add very little organic matter to soil after they have been broken down by soil organisms. By contrast grass or legume roots during continuing process of death and decay add very large amounts of organic matter to the sites on which they grow.

Comments on Comparative Costs of Mulching

It was reported that asphalt materials are usually more costly than other "mulch" materials. Asphalt mulching on large acreages of airfield and on mounds where ammunition and other materials were stored has cost as much as \$300 per acre. By contrast hay and straw mulching has averaged somewhere in the neighborhood of from \$40 to \$60 per acre.



Figure 1. The insulating value of vegetation is well illustrated by the appearance of frost crystals on this roadbank and the complete absence of crystals above the bank.



Figure 2. Alternate freezing and thawing may take place more than 50 times in a single winter season within the frost belt of the United States. Note loose material dislodged by frost action lying at foot of this cut slope.



Figure 3. Sloughing due to frost action will remove as much as one foot of bank in a single season. Here the bank has eroded completely away from the large honeysuckle root clumps that were planted in deep pot holes two years earlier.



Figure 4. Recognition of difficult planting sites is important. The south facing slope to right will require many times the amount of effort to achieve vegetation establishment as a north facing slope on the left. Both banks were planted in the same manner.



Figure 5. It is difficult to establish vegetation on slopes like this facing toward the south or west. Mulching this slope between the planted vines would have resulted in better and more rapid growth.

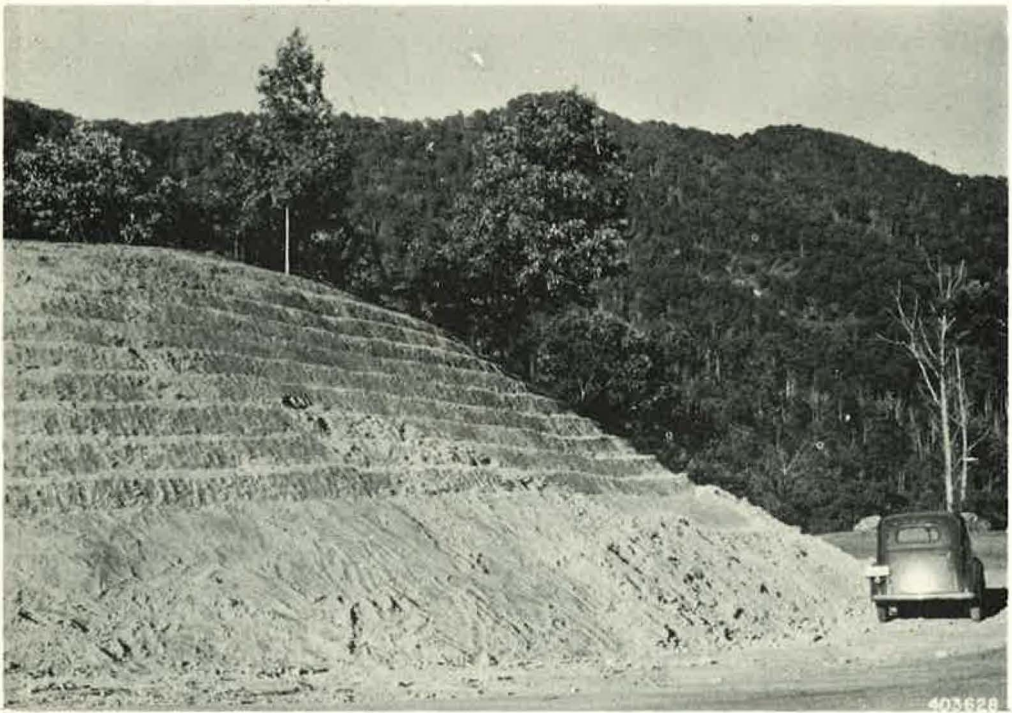


Figure 6. Under exceptionally difficult conditions, benching of dry infertile slopes before mulching and planting may sometimes pay off in the long run.



Figure 7. Highway development is not finished until the entire right-of-way has been completely naturalized with vegetation and blended into the countryside. Here the job still remains to be done.

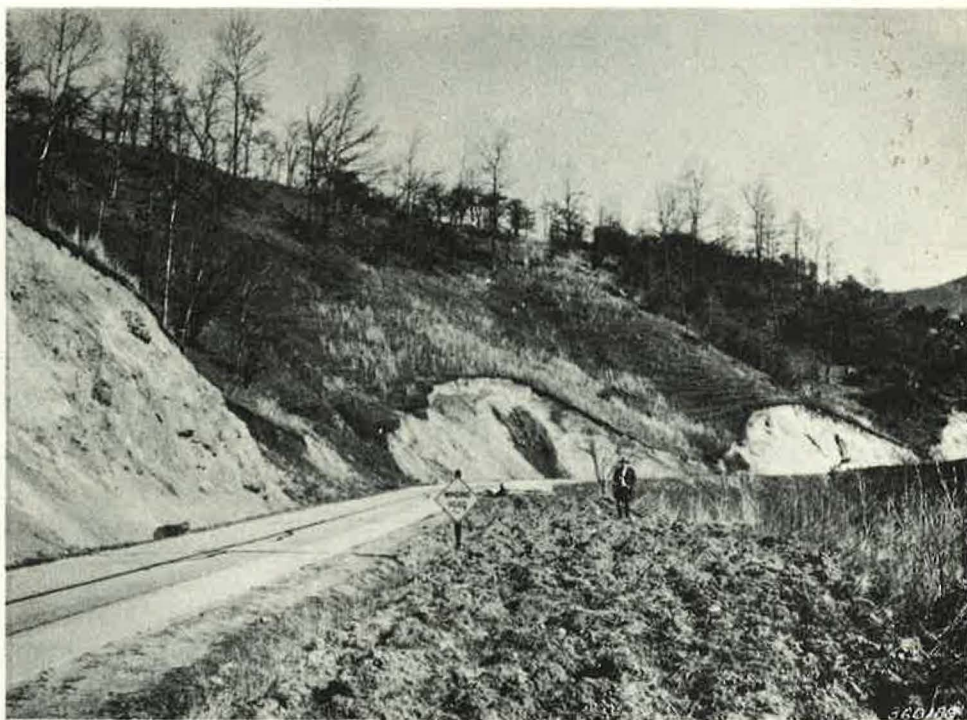


Figure 8. Road construction in broken topography sometimes creates unusual and difficult sites for plant growth. Here is a continuous line of severely eroding cut banks.



Figure 9. Natural vegetation cannot be depended upon to take over steep banks. This cut is known to have had much the same appearance for more than fifty years.

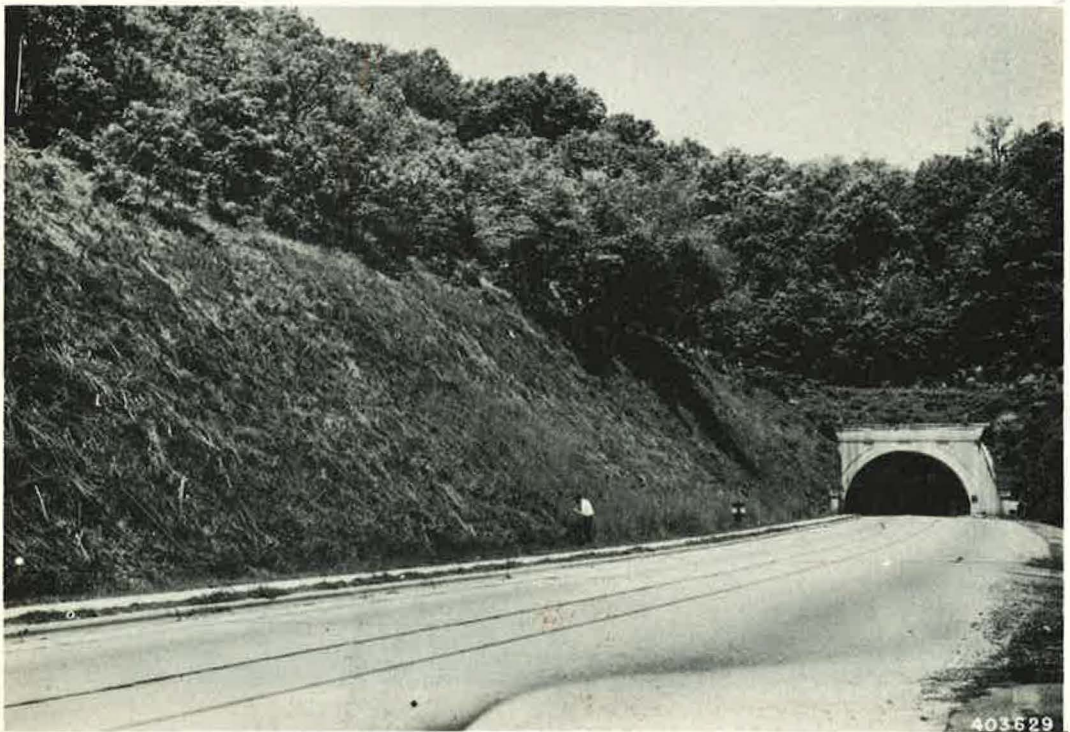


Figure 10. This mulching job ties an important trafficway into the countryside and prevents all slope erosion. These banks are now well covered by small shrubs.



Figure 11. Blending steep slopes into the landscape presents some difficult mulching and planting problems, but the job can be done. This slope was bare a few years before the photograph was taken.



Figure 12. A cover of mulch, and seeded or planted ground cover would have saved money in maintenance here. The shoulder was seeded but erosion on the cut slope requires cleaning out of ditches after every storm, and after the frost action of every winter.