REPORT OF SUBCOMMITTEE ON PLANT ECOLOGY*

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During the past year progress has been made by the Subcommittee in determining a few of the answers to the many problems in plant growth which are commonly involved in highway landscape development. Observation in many regions of the country by committee members has, however, served to emphasize particularly our need for understanding the large number of questions still remaining, for which we have as yet no answers. Before landscape methods can become completely satisfactory as the integrated part of regular highway construction and maintenance procedure, a great deal more information will be needed.

More and more as we study the roadside landscape development of past years, we realize that where the original highway design and construction were well done, relatively little landscape work after construction was usually necessary. In other words, adequate right-of-way, good center line location, flattened and well-rounded slope and ditch cross sections, conservation of existing trees, rock and other landscape features, and conservation and restoration of top-soil on new highway relocations are the factors which in the long run will determine success in establishing plant materials on roadsides. Good original alignment and cross section will particularly aid the landscape engineer in locating ground cover plants and trees which will have maximum effect upon improved highway appearance and can be installed with maximum economies in cost of establishment. Ecological conditions on finished highways will in many cases be determined largely by original highway design and construction methods.

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*Plant ecology may be defined as the study of the relationship between a plant and its environment. This relationship involves analysis of local climate, soils, aspect, ground water, and other conditions which will effect plant growth at a particular planting or growing site.

Consider, for example, the fact that a high, steep, sharp angle slope "ecologically speaking" presents a most unfavorable opportunity for the effective establishment of ground cover plants as compared with a more moderate well-rounded slope on the same site, or as compared with the undisturbed ground surface immediately adjacent to such a cut slope.

Relation Between Plant Ecology And Highway Landscape Development.

It has become apparent that by study and accurate analysis of ecological conditions on nearby lands, as well as on finished highway ground surfaces, we can determine:

1. The kinds of trees and ground covers which would tend to become established by natural regeneration on a given section of highway. These existing types of tree and ground cover plants are those from which we should usually make selection for planting, seeding, or sodding operations.

2. The degree of slope flattening and rounding which we must do to effectually establish grasses, plants, and trees on the highway by artificial seeding, sodding, or planting. Or in other words as plant growth conditions become more unfavorable by reason of dry climate or poor slope soils, we must the more carefully flatten and round highway slopes if we are to readily establish a ground cover or are to aid nature to do the work by volunteer growth./1

3. The character and cost of maintenance which will be required to keep trees and ground cover in healthy condition after planting will also be determined by existing ecological conditions on the planting site. For example, under semiarid or desert highway conditions the establishment of high-growing deciduous shade trees will always involve high annual costs for watering and cultivation. Under humid climatic conditions the same deciduous trees, if well selected, can be established without maintenance after the first 2 or 3 seasons.

Ecological Factors Vs. Landscape Methods.

Plant ecology in its many relationships to highway landscape development is too broad a subject for a brief report of this character, but at least we can consider certain basic principles which appear to apply under all climatic conditions. It goes without saying that highway landscape methods must be flexible to permit adaptation to the various climatic, soil, site, and other conditions which will be encountered from the deserts of the Southwest to the extremely moist, humid sections of the Pacific northwest coast, or the moist Atlantic coastal area.

/1 By the term "volunteer growth" is meant the establishment of any type of plant by nature without benefit of "seeding", "sodding", "planting", or any other artificial method.

Plant Growth Types Of The United States.

The list of plant growth types which follows is condensed from the "Atlas on American Agriculture", chapter on "The Natural Vegetation of the United States". (A plant growth type may be said to be nature's answer to a particular set of temperature, annual rainfall, and broad soil character conditions).

1. "Salt or alkali shrub" featured by such "plant indicators" as greasewood, shadscale, seepweed, salt grass species.

2. "Desert shrub" (southern) featured by desert salt bush (atriplex), creosote bush (covillea), yucca-cactus - palo verde, sagebrush (artemesia species), mesquite (prosopis species).

3. "Desert shrub" (northern) featured by sagebrush (artemesia species), purshia, and chrysothamnus; shadscale; salt sage (atriplex); white sage (kochia).

4. "Marsh grass" and "alpine grass" regions; marsh grass types featured by plants belonging to the general genera zizania, typa, scirpus and the alpine grass featured by genera carex and festuca.

5. "Mesquite and desert grass"; the mesquite type featured by mesquite (prosopas), mesquite grass, prickly pear, and the like. The desert grass type featured by such grasses as crowfoot and black gramma.

6. "Short grass plains", featured by genera such as bouteloua, bulbilus (buffalo grass), festuca and aristida.

7. "Tall grass prairie" featured by such grasses as blue stem sod (andropogon furcatus), blue stem bunch grass (A. scoparrus), slender wheat grass (agropyron). Note: A subtype of the tall grass prairie is the "Pacific bunch grass type" featured by species such as wheat grass sod (agropyron spicatum), wheat grass (bunch grass), stipa-poa bunch grass.

8. "Chaparral" featured by scrub oak, manzanita, ceanothus, and sumac species.

9. "Pinon pine and juniper" featured by the occurrence of dwarf types such as the stone pine and western juniper species.

10. "Western coniferous" types including various combinations of western yellow pine, douglas fir, sitca spruce, western red cedar, western hemlock, western white pine, redwood, and other coniferous types of growth.

11. The "northern coniferous forest types" including spruce, fir, white pine, white, red and jack pines, northern cedar and northern hardwood types.

12. "Central hardwood" types featured by various combinations of oaks, sycamores, elms, maples, and similar deciduous trees.

13. "Southern pine" types featured by various (usually pure stands) combinations or combinations of southern pines.

14. "Southern swamp" types including cypress, southern white cedar, and various deciduous trees in pure stands or in mixed stands in combinations.

A more detailed classification of ecological regions has been worked out by Mr. F. R. Mulford of the United States Department of Agriculture, Bureau of Plant Industry. Mr. Mulford's classification divides the country into thirty-two climatic regions based on factors of latitude, altitude, temperature, rainfall, humidity, soil type and character and intensity of sunlight. Dr. Van Dersal uses Mr. Mulford's classification in his recent book "Native Woody Plants of the United States" which has been published as U. S. Department of Agriculture Miscellaneous Publication No. 303. The subcommittee recommends this important book to all those interested in highway landscape development.

After study of many roadside improvement projects and observation of field conditions in most of these climatic regions by members of the committee during the past year, we believe that certain rough principles with tentative conclusions will apply to some degree in all climatic and "plant growth" regions.

Graded Highway Cross Section.

1. All successful methods yet developed for establishing and maintaining a healthy growth of grass, vines, or shrub ground covers on highways require that slopes and shoulders be flattened and rounded to the point of stability for the existing types of soil.

2. Satisfactory ground covers have been readily established on earth slopes, which have been flattened and rounded to complete stability, under nearly all climatic conditions of the United States. Recently, for example, on a western desert roadside it was observed that slopes between 5 and about 20 feet in height flattened to about 1 on $1\frac{1}{2}$ or 1 on 2 with a well-rounded slope crest, were covered by a natural growth of desert grasses, sagebrush, and the like. This, in spite of the fact that the soils involved were both sterile clays and apparently sterile sands and gravels. On the same roadsides, with a rainfall of 5 to 10 inches, and in western Washington where annual

rainfall exceeds 100 inches per year, very little vegetation was found to occur on 1 on 1 or 1 on 1½ slopes which had not been rounded during or after highway construction.

3. It seems a fair presumption, therefore, that satisfactory ground cover vegetation usually cannot be economically established on slopes, under average soil conditions, which are steeper than about 1 on 1½ and which have not been satisfactorily rounded prior to seeding, sodding, or planting. (Note: By satisfactory rounding is meant rounding of a highway slope beginning at a point between about 1/2 and 1/3 the distance between slope stake and ditch line and extending behind the slope stake toward the right-of-way line for approximately the same distance).

4. Observation of roadside conditions under both the most favorable and unfavorable climatic conditions appears to indicate that emphasis in future landscape development work should be placed upon well-rounded highway cross section grading rather than upon seeding or planting methods which cannot but fail unless a satisfactory slope surface is provided. As climatic and soil conditions become more and more unfavorable to plant growth, increased care must be taken in basic landscape grading and other measures which tend to facilitate rapid growth establishment.

Soil Preparation.

1. Emphasis in the past, particularly in the humid regions of the country, has been properly placed upon the need for conservation and restoration of topsoil on roadsides, and upon various methods of preparation of soil for the final stages of seeding, sodding, or planting.

2. The subcommittee is now convinced that opportunities have been overlooked in the selection of type of native ground cover vegetation which may readily be established on existing sterile highway slopes without prior soil preparation other than the simplest kind of raking, harrowing, or otherwise preparing the soil for seed. For example, certain types of grass appear to be worthy of special attention in future highway landscape work, such as beach grass (ammophilla), western wheat grass (agropyron), Indian grass (sorghastrum) and broom sedge (andropogon). Beach grass and western wheat grass have already been successfully used on sterile sands, gravels, and clays under what may be considered very unfavorable semiarid conditions. Indian grass and the broom sedge have a very wide range of occurrence on sterile soils east of the Mississippi and may eventually be proven much more satisfactory than the pasture and lawn grasses which have heretofore been featured in roadside improvement work in the East. Both pasture and lawn grass types have the disadvantage of preferring rich, fairly moist soils.

Selection And Use Of Native Ground Cover Plants.

Field observations and studies of completed landscape projects on highways in many regions indicate that the following factors are important in the selection and establishment of grasses and woody or herbaceous types of ground covers for the protection of bare soil from erosion:

1. Plants to be used on open country roadsides should always be selected by careful analysis of existing dominant ground cover plants near the highway boundary, and of volunteer growth which has come in on barren highway areas. For example, where one of the eastern sumacs is coming in naturally as a predominate ground cover on a particular highway section, this plant would be planted as a ground cover for the major part of exposed slope soils. Or where tall grass prairie conditions feature a roadside, one, or better several of the blue stem (tall grass) type of grasses will probably best be seeded on all highway slopes as a major part of the grass seed formula used. As a rule, native ground covers tend to occur in natural combinations of two or more species. These natural combinations should, of course, be used in seeding or planting work.

2. With very rare exceptions, on the greater part of the roadside mileage of all regions of the United States, existing low native plants (or those which have long been naturalized) should be depended upon for highway slope protection. Observation indicates that if a satisfactory ground surface is provided, certain native plants will tend to dominate highway slopes in each particular locality by natural regeneration. Under dry and semiarid conditions, these native plants which establish themselves naturally can be expected to survive drought conditions which would eliminate any other type of planted or seeded material before the end of the first growing season.

3. Under unfavorable climatic and soil conditions, seeding methods (for both native types of grasses and low woody ground covers) or the planting of large numbers of small individual ground cover plants show prospect of being more successful than the more usual methods of sodding or of planting slopes with a relatively small number of large sized native shrubs or vines.

4. Under semiarid climatic conditions it was recently observed in several of the Western States that good results have followed both tree and ground cover planting of appropriate native materials when limited areas were selected on highway slopes where seepage occurs or where planting was confined to the banks of streams and irrigation ditches and to other points where woody native plants would first have become established by natural regeneration had no seeding or planting been performed. Once ground cover plants have become established at these more favorable points they tend to spread across highway slopes by scattering seed, by underground runners and by other natural methods, to less favorable areas.

5. As a general rule ground cover plants and shade trees should not be used on open country roadsides in semiarid regions where they cannot be maintained without intensive irrigation methods. It is believed that if planting under unfavorable conditions is confined to the stream banks, seepage spots and the like referred to above, no watering or other maintenance should be required after the first two or three seasons (during which watering of newly planted material must be done even in humid regions of the East). If intensive maintenance is required after the first two or three seasons following planting, it must be assumed that an error has been made in one or all of the following directions:

a. The wrong types of materials may have been selected; (for example trees may have been planted under climatic and soil conditions which do not permit tree growth).

b. The most favorable sites for the location of plants or trees may not have been selected.

c. The original planting stock used may not have been in good condition when planted; plant root systems may have been permitted to dry out during the period between digging and final planting; or for example, planting may not have been done during the most favorable season for the particular type of plant material involved.

Observation Regarding The Relation Between Landscape Methods And Cost Factors.

Based on observations of highway and landscape engineers over the last five years or more, the committee believes that in the long run, rounding and flattening of highway slopes followed by seeding, sodding, or planting of well-selected native ground cover types will result in decreased highway maintenance cost. If, however, the cost of annual highway maintenance of a given section of highway tends to increase after the third or fourth season following seeding or planting, it must be assumed for practical purposes that the work is not satisfactory even though the grasses or ground cover plants involved by reason of intensive maintenance methods may have become well-established.

On the subject of costs, the following points are enumerated:

1. Under very erodible soil conditions on highway slopes it has been customary in the past for such costly methods as solid sodding to be used. Experience now appears to indicate that mulching with various types of straw, hay, peat moss, forest duff and similar common local materials, will often serve to control erosion immediately at a much lower cost than by solid grass sodding methods. Irregular spot or colony planting of slopes with native woody ground covers or running vines, in conjunction with mulching methods, will often result in a permanent and complete ground cover at a fraction of the total cost of the solid sodding methods previously used.

2. Under very favorable climatic and soil conditions such as are encountered on the north Pacific coast and the humid regions of the East, continuous solid slope planting with native or naturalized woody shrubs or vines has frequently been done. Under these favorable conditions for plant growth, this method does not always appear to be justified because experience indicates that by methods of mulching and scattered spot or colony planting, a satisfactory ground cover can be established at a fraction of the cost of solid planting. By this combination method:

a. The type of eventual ground cover to be established can be controlled in advance.

b. Erosion can often be easily controlled by the mulching. A complete ground cover can be established by the spreading colonies of planted vines or low shrubs by the time the temporary mulch has been destroyed by decay.

c. Use of a mulch between irregular colonies of planting usually prevents the heavy weed growth which is a factor in increasing the costs of maintaining planted slopes.

3. Under the most arid desert conditions, low highway construction cost per mile, low traffic density, very low adjacent land values, and other factors require that the investment in highway landscape development costs per mile be held to an extremely low figure. Here a maximum improvement in highway appearance, and, considering the conditions, an effective ground cover of desert grasses, sage brush, and other desert plants, has been observed to follow construction within four or five years, provided that -

a. Slopes have been flattened to 1 on $1\frac{1}{2}$ or 1 on 2 and have been rounded to a point about 1/3 to 1/2 the distance between slope stake and ditch line as previously outlined.

b. Blade scraping, broadcast burning, oiling, and other maintenance methods have not been used which tend to discourage the establishment of permanent native growth by natural regeneration (volunteer growth) methods.

4. The element of time in establishment of satisfactory native grasses, shrubs, and other ground covers has not been sufficiently considered in past roadside development work, particularly in humid plant growth regions.

a. With well-flattened and rounded original cross sections, the passing of several growing seasons will often result in establishment of satisfactory native ground covers by volunteer growth where artificial seeding or planting may fail.

b. On erodible types of soils where immediate soil surface protection is required, mulching with available wheat straw, forest leaf litter, and other available materials may be used. Seeding or irregular colony planting of native ground cover plants or grasses may then often be used to establish a permanent sod by natural spread of plants from seeded or planted areas.

c. As far as possible, plant ground covers should be selected with their possibilities of natural regeneration in mind. Therefore, plants which produce abundant seed and which tend to spread by rooting and suckering should be favored in roadside ground cover planting.

Summary And Conclusions.

In conclusion the subcommittee wishes to emphasize the importance of accurate technical analysis of existing vegetation and of local plant growth conditions as a guide to improved landscape development and as a factor in original highway design where considerations of soil erosion control are involved.

Among these basic principles of landscape design which will apply to highway design and landscape development in all plant growth regions are the following:

1. Satisfactory highway landscape treatment must begin with fundamental improvement in original highway design, particularly as regards flattened and well-rounded cross section.

2. Satisfactory and economical methods of establishment of effective ground cover protection are possible only on well-rounded earth slopes properly prepared for seeding, sodding, or planting.

3. Emphasis in future highway landscaping may well be placed on the use of shade trees and ground cover plants and grasses which can be established with a minimum of topsoiling or other soil preparation.

4. Observation of completed highways and existing vegetation along their borders will indicate the kinds of native plants which come in as "volunteer growth" in each locality. Observation will also indicate types of soils and sites where this natural "volunteer growth" occurs. As far as possible, natural volunteer growth should be used as the basis for selection of shade trees, evergreen trees, and native types of ground cover for highway seeding and planting.

5. Plants and trees which require costly intensive maintenance methods, after becoming established, should not be used on open country roadsides.

6. Grading, seeding, sodding, or ground cover planting should tend to reduce the cost of annual highway maintenance on all landscaped sections of highways. If highway maintenance costs are increased by landscape treatment (after the 2 or 3 years necessary for effective establishment of all kinds of seeded or planted growth), a definite need for revision of landscape methods is usually indicated.

The committee would recommend that intensive highway planting methods be largely restricted in future years to primary suburban highways where the investment in private land development, in right-of-way, and in the highway structures is relatively large. At city or town approaches, at special major bridge locations, and within special roadside parks areas, intensive landscaping methods may occasionally be justified on open country highways.

In the main, however, highway landscape development must be "extensive" in character, and calculated to improve highway appearance and safety and to reduce maintenance costs on the greatest possible mileage of each State highway system. Major economies can be effected in the future by:

1. Building landscape principles into original highway design and construction, particularly as regards well-rounded cross sections.

2. Cooperating with nature in providing for a maximum of volunteer growth establishment on bare highway areas.

3. Obtaining the closest possible cooperation of the landscape engineer with the engineers of location and construction, and with highway maintenance organizations, so that mowing methods, weed control operations, shoulder maintenance work and the like will serve to increase the growth of the most desirable permanent native ground covers.