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Vegetation of Roadside Slopes in Massachusetts

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The achievements and conclusions of some of the research carried out on the establishment of roadside vegetation and sand-dune control from 1962-1977 are reviewed. Fall and early spring seedings of basic grasses—creeping red fescue *(Festuca rubra)*, Kentucky-31 tall fescue *(Festuca elatior* var. *arundinacea)*, ryegrass *(Lolium* spp.*)*, redtop *(Agrostis alba)*, and Kentucky bluegrass *(Poa pratensis)*—and a legume, white clover *(Trifolium repens)*, are successful for erosion control and vegetative cover on roadsides properly limed and fertilized. Hay, excelsior mat, wood cellulose, and wood-chip mulches provided excellent erosion control and assistance in seedling establishment. For more permanent cover, low-maintenance leguminous species that can be substituted for grasses are crownvetch *(Coronilla varia)*, flat pea *(Lathyrus sylvestris)*, and lespedeza *(Lespedeza cuneata)*, but they require more precise soil preparations of liming and fertilization for establishment. Methods were found of establishing woody species quickly and inexpensively through the use of root cuttings of sweet fern *(Comptonia peregrina)*, bristly locust *(Robinia fertilis)*, and sumac species *(Rhus* spp.*)*; spot seeding of other woody species and even legumes is successful and inexpensive. Proper wood-chip depth is important. Moving sand dunes on Cape Cod initiated experiments that showed that American beachgrass *(Ammophila breviligulata)* can be successfully grown by machine planting with the use of a complete fertilizer; during the second season, the area was completely covered with beachgrass. Coastal panicgrass *(Panicum amarulum)*, weeping lovegrass *(Eragrostis curvula)*, and tall fescue provided good cover after having been seeded with a grain drill modified to plant the seeds 2 in. deep. Woody species such as pines *(Pinus* spp.*)* and bayberry *(Myrica pensylvanica)* can be planted on stabilized dunes as climax vegetation.

With the rapid expansion of the U.S. Interstate system of highways, the Highway Research Board in 1932 created a joint committee to help guide the practical application of roadside development. Some years later, another committee of the same organization was formed to consider the technical and research aspects. Roadside development, then, is concerned with the many facets of a progressive highway construction program, including the historical background of an area, aesthetics, conservation of natural resources, rest areas, scenic overlooks, erosion control, landscaping, safety considerations, right-of-way ramifications, and future development (1).

From 1962 to 1977, the University of Massachusetts was involved in a roadside development research program, the purpose of which was to test new methods and materials for practical and economic stabilization on roadsides in the state.

Field studies showed the value of fescue grass species for stabilizing sandy slopes. The seeds of some of these species were incorporated into the grass slope seed mixture and the per-acre rate of seeding was cut to 100 lb from the previously used 180-lb/acre rate. The value of lime and fertilizer for permanent slope cover, especially for legumes like crownvetch, was investigated and recommendations were accepted by the Department of Public Works. As wood-chip use increased for erosion control on slopes, investigations were directed to the seeding of legumes, shrubs, forbs, and trees into mulched areas. Root cuttings for shrub establishment in mulched areas were also studied. The results of these studies with the seeding methods mentioned above showed that both methods of vegetating slopes produced rapid cover at a minimum cost.

BACKGROUND INFORMATION

The soils in Massachusetts are classified as Brown Podzolic forest soils, which are formed under deciduous, mixed deciduous, and coniferous forests in a cool humid climate. So the challenge in Massachusetts initially was to grow grasses and legumes, which are the best species for rapid erosion control, in an ecological environment of climate and soil that is conducive to shrub and tree vegetation. Fortunately, the climate is favorable to grass growth.

Some of the problems one encounters when trying to establish grasses, legumes, and forbs along newly constructed highways in Massachusetts are listed below:

1. Shallow topsoil: More than 60 percent of Massachusetts land area is in forest cover, and in areas where tree removal is necessary during construction, a large portion of the topsoil is inevitably removed from the site along with the tree stumps.
2. Acid soils: The topsoil and subsoil are acid due to leaching losses of calcium and magnesium.
3. Sandy soils: The texture of many of the soils is sandy. Such soils have a very low organic-matter content, low percentage of water-holding capacity, and a low basic exchange capacity.
4. Low natural fertility: Most of the soil fertility is in the organic fraction of the soil. Soluble plant-food elements have been lost by leaching, and the original granitic parent material from which the soil was formed contains only low amounts of plant-food elements.
5. Rocks and boulders: Most areas in Massachusetts are glaciated and contain rocks and boulders that interfere with seed-bed preparation.

A typical analysis of an undisturbed sandy loam soil (Merrimac) showed a pH of 4.6; 0.85 percent organic carbon; a total exchange capacity of 6.1 meq of calcium, magnesium, potassium, sodium, and hydrogen; a 30 percent base saturation; and low phosphorus content. The above soil analysis illustrates the low availability of nutrients in the state, and if such soils are to be seeded to grasses and legumes, there is need for the addition of lime, nitrogen, phosphorus, and potassium.

GRASS ESTABLISHMENT

Because many existing slopes in Massachusetts that had been seeded originally to grass were deteriorating and seriously eroded, it was necessary to investigate the adaptability of specific grass species to this environment and also to determine optimum seeding dates and rates of seeding of these grass species. It was found that better soil stabilization was obtained on slopes by using a seed mixture that included a high percentage of basic grasses--creeping red fescue (Festuca rubra), hard fescue (F. ovina var. duriuscula), Kentucky-31 tall fescue (F. elatior var. arundinacea), and Kentucky bluegrass (Poa pratensis)--and a small percentage of temporary grasses. As time went on, Kentucky bluegrass was eliminated from the seed mixture used on sandy slopes but was retained for seeding flat areas. Our final modified seed mixture contained creeping red fescue, tall fescue, domestic ryegrass (Lolium spp.), redtop (Agrostis alba), and white or ladino clover (Trifolium repens). This mixture was used at reduced rates (one-half the standard rate of 175 lb/acre used by the Department of Public Works), and it produced a good stand of grass and performed adequately in checking soil erosion (2).

The recommended grass mixture for median and loamed areas was 50 percent creeping red fescue, 20 percent domestic ryegrass, 5 percent redtop, and 25 percent Kentucky bluegrass.

The time-of-seeding experiment indicated that quality turf can best be established in this area in the fall and spring of the year. Weeds and drought are responsible for poor-quality sod when seedings are made at other times of the year (2).

Mulches

In comparison studies of various mulches for grass seed germination and establishment and for erosion control on steep banks, it was found that hay, excelsior mat, and wood chips were most helpful. The hydroseeding method of establishing grass with wood cellulose as a mulch produced good results when the wood cellulose was used at a rate of 1,500 lb/acre (2). This hydroseeding method was incorporated into the standard specifications of the Massachusetts Department of Public Works.

Various chemical mulches were also compared for their effectiveness in controlling wind and water erosion during seedling establishment. It was found that DCA-70 (product of Union Carbide) mixed with water at a 1:20 rate and applied at 2 gal/yd^2 showed excellent sand-binding power and very good erosion control with no adverse effects on germination and seedling establishment of grasses (3).

Lime and Fertilization

Ground limestone is readily available in Massachusetts and performs satisfactorily in correcting soil acidity because its coarse particles are effective over a period of years. Lime corrects soil acidity best when mixed into the soil, but satisfactory stands of grass were established with surface applications. Limestone rates were based on the lime-requirement test for each soil (2).

During the roadside development research studies, it was found that satisfactory turf was grown when a complete fertilizer (10-10-10) was applied to the study area at the rate of 800-1,000 lb/acre. Higher rates can be used on soils that have not been loamed. However, established grasses deteriorate if they are not limed and fertilized regularly. This deterioration is especially visible and striking on slopes consisting mostly of subsoil. On median strips, good-quality turf that had not received lime or fertilizer for more than 5 yr continued to produce satisfactory cover, but it was showing signs of thinning and weed encroachment (2). A comprehensive program for liming and fertilizing turf was set up during the early part of the research period, but lack of maintenance funds prevented full implementation of the program by the Department of Public Works. Therefore, in the late 1960s, the focus of the research changed and emphasis was placed on establishment of trees, shrubs, and legumes rather than on grasses and legumes.

LEGUME ESTABLISHMENT

Another major focus of the roadside development research program was the establishment of legumes. Crownvetch (Coronilla varia) had been grown successfully in the Northeast for several years for control of erosion and reduction of maintenance costs. Early efforts to grow this legume in Massachusetts failed, so a study was initiated to find a method of growing it here. Through research conducted in a greenhouse in which different soils were used, it was found that good establishment and growth could be obtained provided the limestone deficiencies of the soils were remedied and applications of 0-20-20 fertilizer were made at the rate of 800 lb/acre. Also helpful was the addition of 20 lb/acre of nitrogen on infertile soils to help crownvetch establish itself until the nodules have formed. Crownvetch generally has poor seedling vigor. Attempts to establish this species in combination with grass species were generally not successful, because the crownvetch was choked out by the rapid growth of the faster-growing grass (3).

Nurse crops seeded with crownvetch were very beneficial in controlling erosion on newly constructed cut-and-fill slopes. It is important that the nurse crop be seeded at a rate of no more than 20 lb/acre to prevent competition with the crownvetch. A few of the more compatible nurse crops that can be recommended as a result of our research are creeping red fescue, perennial ryegrass (Lolium perenne), and Kentucky-31 tall fescue (3). An extension bulletin was published that gave recommendations for seeding and planting crownvetch in Massachusetts.

Research showed that boron deficiency occurs in crownvetch when it is seeded on subsoil slopes. This deficiency appears on new growth as yellowing and slight browning of the leaf edges; the inflorescence is underdeveloped (a few clusters of florets), and later stages show few and small seed pods in contrast to those found on healthy plants. The application of 10 to 15 lb/acre of borax before seeding crownvetch, it was found, prevents boron deficiency (4).

Another perennial legume that is excellent for erosion control, requires no maintenance once established, and allows encroachment by no other types of vegetation is flat pea (Lathyrus sylvestris) (5). It does not have the showy pinkish-purple flowers of crownvetch but is established in the same way and does the job as well. Other leguminous species recommended for seeding in Massachusetts as a result of our research are goat's rue (Galega officinalis), false blue indigo (Baptisia australis), birdvetch (Vicia cracca), Cicer milkvetch (Astragalus cicer), bristly locust (Robinia fertilis), and dyer's greenweed (Genista tinctoria). The legumes listed above plus sericea lespedeza (Lespedeza cuneata) and shrub lespedeza (Lespedeza bicolor) were all successfully spot seeded on 4- to 5-ft centers onto slopes and flat areas covered with wood chips as mulch (3,6).

The lime requirement seed dormancy treatment, seeding rate, and time of seeding were tested on the seeds of 25 legume, shrub, and forb species for use on roadside sites. Recommendations for their establishment were provided to the Department of Public Works for incorporation into their standard specifications.

The success of the research project in finding methods of making crownvetch grow in Massachusetts is shown by full implementation of the results in all districts of the state by the maintenance division of the Department of Public Works. Both crownvetch and flat pea seed are included in the prime contract and the department itself estimated that it saved some $300,000 yearly in erosion repair costs and an even greater amount in roadside and interchange mowing costs.

TREE AND SHRUB ESTABLISHMENT

At the time that the emphasis of the research was redirected from grass to shrub establishment, a no-burning law was instituted in Massachusetts. This meant that instead of trees being burned on construction sites, they could be converted to wood chips, which were beginning to be recognized as excellent mulch material for erosion control. The Department of Public Works now had the use of 100,000 yd^3 of chips annually and the new environmental approach of covering slopes immediately under the prime contract was a natural and practical solution to the erosion problem. Wood chips can be spread with a slope cat, a grade-all, or a crane with a large clam bucket. One company has developed a machine that blows and spreads wood chips up to 100 ft away at the rate of 1 ton/min (6).

Research has shown that wood chips do not have to be composted before they are used. They decay slowly because they are large and seldom cause the problem of nitrogen deficiency in plants, as is the case with sawdust mulch. If nitrogen deficiency does occur, a small amount of nitrogen fertilizer broadcast around each plant will correct the problem (7).

Some slopes were being covered with 4 to 5 in. of wood chips at this time by the Department of Public Works to keep erosion under control until natural invasion by shrubs and trees occurred. To speed the process of vegetating such areas, studies were initiated with spring and fall seedings of woody species under a 2-in. cover of chips. After one growing season, all species showed good seedling emergence. Two growing seasons later, the following species were well established and on their way toward stabilizing the roadbank: black locust (*Robinia pseudoacacia*), autumn olive (*Elaeagnus umbellata*), bayberry (*Myrica pensylvanica*), red cedar (*Juniperus virginiana*), fragrant sumac (*Rhus aromatica*), Arnot bristly locust, and mountain indigo bush (*Amorpha glabra*).

A critical factor in growing woody plants from seed is, of course, seed dormancy. Various treatments for overcoming dormancy were tested in the laboratory before the seeds were planted on roadsides. Some success was realized with some species, but the proper treatment for other species was not determined (6).

Another critical factor requiring attention when woody species are seeded under wood chips is the correct depth of chips to use in relation to the size of the seed being planted. Greenhouse investigation revealed that Arnot bristly locust, a relatively large-seeded species (25,000 seeds/lb), emerged easily through a 2-in. mulch. However, tatarian honeysuckle (*Lonicera tatarica*), a somewhat small-seeded species (118,000 seeds/lb), had difficulty pushing through the 2-in. depth but did very well at a 1-in. depth of chips, which is too shallow a depth to prevent erosion on steep roadbanks. Small-seeded species, it was found, can be spot seeded with a Panama seeder into areas mulched with wood chips and covered with hay or other type of mulch. Spot seeding onto sites mulched with wood chips was successful for most species (6).

Establishment of vegetation by root cuttings was rapid and successful on sites mulched with wood chips for species of sweet fern (*Comptonia peregrina*), bristly locust, and several sumacs (8).

By 1977 some 500 miles of slopes had been covered with vegetation under wood chips and mowing costs were reduced by more than 25 percent.

CAPE COD SAND DUNES

A totally different phase of the roadside development research was a study involving control of drifting sand dunes on Cape Cod. These moving dunes were depositing some 10,000 ft^3 of sand annually on Route 6, a major state highway on the Cape. During stormy periods, cars traveling this route experienced severe sandblasting and pitting of windshields. Winds of 100 mph have been recorded at the Race Point Coast Guard Station in Provincetown. As a consequence, roadside areas and median strips are in constant need of repair.

What was needed was a rapid and effective means of controlling the moving dunes. It was found that American beachgrass (*Ammophila breviligulata*) planted by machine on a wide spacing with fertilizer produced a solid stand of grass cover the second year and was effective in stabilizing movement of the sand. Over a summer, 3 to 5 beachgrass culms developed 18 to 30 clumps with rhizomes more than a yard long. Our method of machine planting reduced the number of transplants required per acre from 19,360 to 9,680 (9).

Dune building and repair in blow-out areas were successful with the use of snow fences; several dunes were rebuilt in this way. Once a dune has been rebuilt, it should be planted immediately with beachgrass, or, in all likelihood, it will be blown away the following year.

Direct seeding of grasses on sand dunes was accomplished on a large scale with a grain drill. The planting units of the drill were modified to allow the seed to be planted 2 in. deep; shallow seeding is unsuccessful. Direct seedings in the spring of coastal panicgrass (*Panicum amarulum*), weeping lovegrass (*Eragrostis curvula*), Kentucky-31 tall fescue, and cereal grasses did well in stabilizing moving sand in somewhat protected areas and on the leeward side of dunes.

After a dune has been stabilized with grass, climax vegetation should be established. Excellent woody species to serve as climax vegetation are bayberry, Japanese black pine (*Pinus thunbergii*), Austrian pine (*P. nigra*), Scotch pine (*P. sylvestris*), and the native pitch pine (*P. rigida*). Plants should be mulched with hay after being set. No fertilizer is recommended, but 500 to 600 lb/acre of castor pomace (5 percent nitrogen) should be applied the second year (9).

Dune stabilization is difficult but critical if the sand dunes in Provincetown and other Cape Cod locations are to be saved. This sand dune research made a valuable contribution to the state, the Department of Public Works, and the country as a whole. In the late 1960s, the decision was made by the federal government to take over care of seashore areas and this work ceased.

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Right-of-Way Forestry

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Since World War II, the landscape-architecture approach to the maintenance of the right-of-way (ROW) of our major highway systems has been most commendable. The grade of the nonpaved portion of the ROW has been aesthetically maintained by planting grass and a combination of woody shrubs and trees. This was accomplished at relatively low cost compared with the annual new-highway construction budget. Since 1973, widespread inflation has caused a marked reduction in annual transportation department budgets, which has made a review of maintenance costs necessary. An alternative approach to ROW maintenance is forestry. This should reduce costs considerably and under normal economic conditions should actually yield a net profit. In addition, ROW forestry will produce many thousands of tons of biomass annually for energy, food and fodder, and feedstock for the chemical industries.

When the U.S. highway system was primarily gravel roads, the width of the right-of-way (ROW)--owned, easement, or both--was usually one chain or four rods, which is 66 ft. The advent of the Interstate highway system in the 1950s encouraged an expanded ROW at least 300 ft wide with a median strip of variable width. This permitted better use of existing grades to meet the standards of the new highway system. The most practical way to keep the nonpaved portion of the total ROW in place at the desired grade was by planting grass. Then interest and concern with the overall aesthetic appearance of the highway system led to the planting of perennial woody shrubs and trees to supplement natural vegetation.

It was logical to turn to the landscape architects for support in ROW maintenance, because their training and philosophy fitted into the perceived needs of ROW management as delineated above. During the 1950s and 1960s, when all of the states were participating in the construction of the Interstate highway system, the ROW maintenance budget was small compared with the new-road construction budget. With the funds available to them, a comparatively small corps of landscape architects and supporting technicians did a magnificent job of maintaining and beautifying the Interstate highway system, for which they deserve much credit. As construction of the Interstate highway system slowed in the 1970s, the annual maintenance budget, which had not increased substantially, appeared to be a larger portion of the total annual budget. Now in the 1980s each state transportation department is being forced to reduce every component of its annual budget, including maintenance. Under these circumstances it is appropriate to raise such questions as: Why mow grass? Why plant perennial woody shrubs and trees? Are there alternative uses of the nonpaved portion of the ROW that might produce essential usable material and income? The purpose of this paper is to explore answers to these questions from the point of view of forestry.

FORESTRY

From a strategic point of view, forestry has been defined by the Society of American Foresters as the science, the art, and the practice of managing and using for human benefit the natural resources that occur on and in association with forest land. The tactics of forestry have followed the wave theory (1) proposed for the development of human society. The first wave, the use of solid wood, began thousands of years ago similar to the evolution and development of agriculture and encompasses building, boats, furniture, and so forth. The second wave,