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Foreword

This RECORD consists of five technical reports sponsored by the Committee on Roadside Development. These reports are intended for those interested in the art and science of roadside development.

Committee D-A5 functions within the Department of Design and works closely with the Board's Departments of Maintenance and Legal Studies. Through this Committee, the Board cooperates in practical roadside landscape architectural and engineering research currently in progress or in prospect and in other aspects of highway development programs.

The papers have been published in a sequence which associates their respective scopes to environmental values, historic sites, and the control and management of grasses and weeds.

The first paper presents a comprehensive highway route selection method. The author identifies and uses a number of criteria intended to yield a highway location having a maximum of social benefit at a minimum of social cost. He considers social, resource, and aesthetic values in addition to physiographic, traffic, and engineering requirements. His method is applied to a section of I-95 between the Delaware and Raritan Rivers in New Jersey.

The second paper contends that many variables can influence the location of a highway facility, one of these being the presence of sites. The author describes a study and method used in Massachusetts to identify, classify, and evaluate the historic sites in 40 communities in eastern Massachusetts affected by proposed highways by 1975.

The third paper discusses the management of turf treated with maleic hydrazide. The authors describe the controls and management practices applied to a field experiment in Rhode Island, concluding that under certain conditions MH will retard the growth of grasses.

In the fourth paper, the authors stress the need for specifying two- or three-step seeding and fertilization practices for establishing sod on highways, with the objective of developing a sod cover that will persist and require low maintenance. They cite their research findings as conducted in Virginia.

The last paper concerns the problem of grasses and weeds growing in asphalt pavements. The authors discuss their research on herbicides used on specific plant materials found along roadsides in eastern Texas.

Contents

A Comprehensive Highway Route Selection Method

IAN L. McHARG, Department of Landscape Architecture and Regional Planning, University of Pennsylvania

The major deficiency in prevailing highway route selection method has been the inability to include social values, including natural resources and aesthetic values, within the criteria utilized. In this study, an attempt has been made to identify components of social value, natural resources, and scenic quality, and to locate these geographically. It is presumed that the area of lowest social value, if transected by a highway, incurs the least social cost. The normal determinants of highway route selection, topography, soils, etc., have been expanded to include management or impairment of ground and surface water resources, susceptibility to erosion, etc. When highway corridors of minimum social cost and minimum physiographic obstruction were revealed, they were tested against their effect on scenic values. The objective of providing an excellent scenic experience was considered as a social value created by the highway. The corridor of least social cost was next tested against the degree to which it could create new and productive land uses where these would be necessary and welcome. The sum of least social cost and highest benefit alignment was identified. It is described as the rate of maximum social benefit.

The method revealed the route of least social cost and least physiographic obstruction as a funnel of land parallel to Jacobs Creek, proceeding along the base of Pennington and Sourland Mountain and widening into a trumpet as it meets the Raritan River.

This alignment has the added merit of permitting management of the aquifer recharge area which it parallels to the benefit of ground water resources in the Delaware-Raritan area. It provides an excellent scenic experience. It should additionally induce new and productive land uses in the West Trenton area and the Raritan River communities.

•THE importance of highways is incontrovertible. They are essential components of the economy. The modern highway incorporates high levels of engineering skill in its geometric characteristics and traffic performance. Yet the increasing opposition to proposed highways reveals a fundamental weakness. The route-selection process has, to date, been unable to recognize and respond to important social and aesthetic values. As a result, the major highway is increasingly viewed as a destroyer, carving remorselessly through the hearts of cities, outraging San Francisco and Boston, humbling Faneuil Hall, destroying precious urban parks as in Philadelphia, offending great sectors of metropolitan population, and threatening resources and values such as Rock Creek Park and the Georgetown waterfront in the nation's capital. Examples abound. The major highway is increasingly regarded as a tyrant, unresponsive to public values, disdainful of the people it purports to serve.

The cause can be simply identified. It lies in the inadequacy of the criteria for route selection. These have been developed for rural areas where social values are scarce

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Paper sponsored by Committee on Roadside Development and presented at the 47th Annual Meeting.

and engineering considerations paramount. These criteria have not been enlarged to deal with situations where social values hold a primary importance and engineering considerations are accorded a much lower value. The remedy lies in inverting the criteria to obtain a balance between social-aesthetic values and the orthodoxy of engineering considerations.

This study seeks to develop a more comprehensive route-selection method including social, resource, and aesthetic criteria for a section of proposed I-95 between the Delaware and Raritan Rivers.

SOCIAL VALUES IN HIGHWAY ROUTE SELECTION

The method utilized by the Bureau of Public Roads for route selection involves calculating the savings and costs derived from a proposed highway facility. Savings include savings in time and in operating costs and reduction in accidents through construction of a new highway facility. The costs are those of construction and maintenance necessary to obtain these savings with a minimum ratio of savings to costs of 1.2 : 1.0. Any qualitative factors are considered descriptively after the conclusion of the cost-benefit analysis.

The Bureau of Public Roads seeks to enlarge this method and develop a land-use model in which more parameters can be included in both cost and benefit calculations. The Bureau was instrumental in initiating the Penn-Jersey Transportation Study which sought to advance the science of highway location. It seems reasonable to assume that it would welcome any serious effort to improve highway route selection method.

The objective of an improved method should be to incorporate social, resource, and aesthetic values in addition to the normal criteria of physiographic, traffic, and engineering considerations. In short, the method should reveal the highway alignment having the maximum social benefit and the minimum social cost. This poses many difficult problems. It is clear that many new considerations must be interjected into the cost-benefit equation and that many of these are considered nonprice benefits. Yet the present method of highway cost-benefit analysis merely allocates approximate money values to convenience, a commodity as difficult to quantify as health or beauty.

The relevant considerations will vary from location to location, with land and building values preponderant in central urban areas and scenic beauty dominant in certain rural areas. It should, however, be possible to identify a number of critical determinants for each area under consideration.

CRITERIA FOR INTERSTATE HIGHWAY ROUTE SELECTION

Interstate highways should maximize public and private benefits by (a) increasing the facility, convenience, pleasure, and safety of traffic movement; (b) safeguarding and enhancing land, water, air, and biotic resources; (c) contributing to public and private objectives of urban renewal, metropolitan and regional development, industry, commerce, residence, recreation, public health, conservation, and beautification; and (d) generating new productive land uses and sustaining or enhancing existing land uses.

Such criteria include the orthodoxy of route selection but place them in a larger context of social responsibility. The highway is no longer considered only in terms of automotive movement within its right-of-way, but in context of all physical, biological, and social processes within its area of influence.

The highway is thus considered as a major public investment that will transform land uses and values and that will affect the economy, the way of life, health, and visual experience of the entire population within its sphere of influence. It should be located and designed in relation to this expanded role.

Positively, the highway can

- Facilitate safe, convenient traffic movement;
- Provide key investment for urban renewal, metropolitan and regional development;
- Maximize the visual quality of movement;
- Locate new, productive land uses;
- Reveal the physical and cultural identity of the region it transects;

•Provide access to existing inaccessible resources;
•Link scenic and recreational resources.

Negatively, the highway can

•Constitute a health hazard due to stress, anxiety, lead, hydrocarbons, ozone, carcinogens, positive atmospheric ionization;
•Constitute a nuisance due to noise, glare, fumes, dust, danger, ugliness;
•Destroy existing resources—scenic, historic, ground and surface water, forests, farmland, marshes, wildlife habitats, areas of recreational value, and areas of natural beauty;
•Reduce property values by any of the above, plus division of property, creation of barriers, and loss of access;
•Destroy existing communities and their hinterlands by transecting them, denying access, inconsiderate alignment, and dissonant scale, in addition to the preceding deleterious effects.

It is clear that the highway route should be considered a multipurpose rather than a single-purpose facility. It is also clear that when a highway route is so considered, there may be conflicting objectives. As in other multipurpose planning, the objective should be to maximize all potential complementary social benefits and reduce social costs.

This means that the shortest distance between two points meeting predetermined geometric standards is not the best route. Nor is the shortest distance over the cheapest land. The best route is that which provides the maximum social benefit at the least social cost.

The present method of cost-benefit analysis as employed for route selection has two major components: the savings in time, operating costs, and safety provided by the proposed facility; and the sum of engineering, land and building purchase, financing, administrative, construction, operation, and maintenance costs.

On the credit side it seems reasonable to allocate all economic benefits derived from the highway. These benefits accrue from the upgrading of land use, frequently from agricultural to industrial, commercial, or residential uses. On the debit side, highways can and do reduce economic values; they do constitute a health hazard, a nuisance, and danger; they can destroy community integrity, institutions, residential quality, scenic, historic, and recreational values.

This being the case, it appears necessary to represent the sum of effects attributable to a proposed highway alignment and distinguish these as benefits-savings and costs. In certain cases these can be priced and can be designated price benefits, price savings, or price costs. In other cases, where valuation is difficult, certain factors can be identified as nonprice benefits, savings, or costs.

A balance sheet in which most of the components of benefit and cost are shown should reveal alignments having the maximum social benefit at the least social cost (Tables 1 and 2).

Considerations of traffic benefits as computed by the Bureau of Public Roads can be computed for alternative alignments. The cost of alternative routes can be calculated. Areas where increased land and building values may result can be located, if only tentatively, in relation to the highway and prospective intersections. Prospective depreciation of land and building value can also be approximately located. Increased convenience, safety, and pleasure will presumably be provided within the highway right-of-way; inconvenience, danger, and displeasure will parallel its path on both sides. The degree to which the highway sustains certain community values can be described, as well as the offense to health, community, scenery, and other important resources.

APPLICATION OF THE COMPREHENSIVE METHOD TO I-95 BETWEEN THE DELAWARE AND RARITAN RIVERS

This area under consideration is defined by a discontinuous ridge composed of Baldpate, Pennington, and Sourland Mountains to the northwest, and the Delaware-Raritan Canal to the southeast; the Delaware and Raritan Rivers form the remaining southwest

TABLE 1

COMPONENTS OF BENEFITS AND COSTS ATTRIBUTABLE TO A PROPOSED HIGHWAY ALIGNMENT

Benefits	Costs
Price Benefits	Price Costs
Operating Economies Function of distance × volume × constant for operating economies and safety.	Costs Function of distance × engineering, land and building acquisition, construction, financing administration, operation, and maintenance.
Economic Values Created Increment of increased land and building values attributable to the highway within its sphere of influence.	Economic Values Lost Increment of reduced land and building values due to the same cause.
Nonprice Benefits	Nonprice Costs
Values Added Increased convenience, safety, and pleasure provided to drivers on the facility.	Values Lost Decreased convenience, safety, and pleasure to populations and institutions within the sphere of influence; health hazard, nuisance, and danger.
Price Savings	Price Costs
Construction Economies Propitious conditions of topography, geology, drainage foundations, and minimum structures.	Construction Costs Inordinate costs in excess of 1 due to difficult topography, geology, drainage, foundations, and the necessity for many and/or expensive structures.
Nonprice Savings	Nonprice Costs
Social Values Saved	Social Costs
Community	Community values lost
Institutional	Institutional values lost
Residential	Residential values lost (other than 2)
Scenic	Scenic values lost (other than 2)
Historic	Historic values lost (other than 2)
Surface water	Surface water resources impaired
Ground water	Ground water resources impaired
Forest water	Forest water resources impaired
Wildlife	Wildlife water resources impaired

and northeast boundaries. Urbanization is concentrated in and around Trenton to the southwest, New Brunswick-Bound Brook-Manville-Somerville to the northeast, with the intervening area substantially rural piedmont landscape with localized settlement in the town of Princeton and the villages of Pennington, Hopewell, and Griggstown. The majority of the area falls within the Stonybrook-Millstone watershed.

The entire area constitutes a segment of the Philadelphia-Trenton-New York corridor running southwest-northeast in the piedmont, paralleling the fall line dividing piedmont from coastal plain.

This is an attractive landscape defined by wooded hills, drained by pleasant streams, and graced by decent farms. Princeton is its spiritual capital, and the quality of this institution and its surrounding landscape constitutes a prime locational value for the area. While terminated by industrial locations in Trenton and New Brunswick—Bound Brook and Somerville, the intervening valley is predominantly a rural-residential area. In such an area certain social values can be described, if only in normative terms—scenic beauty, residential quality, the integrity of institutions, towns, and villages. The diminution or impairment of these values can be described, again only in normative terms, as social costs.

Towards this end a number of maps have been prepared. They share the description of approximations as follows:

1. Sequence related to construction savings and costs
   a. Topography
   b. Land values
2. Sequence related to social values
   c. Urbanization

TABLE 2

SUGGESTED CRITERIA FOR INTERSTATE HIGHWAY ROUTE SELECTION

Benefits and Savings	Costs
Price Benefits	Price Costs
Reduced time distance	Survey
Reduced gasoline costs	Engineering
Reduced oil costs	Land and building acquisition
Reduced tire costs	Construction costs
Reduced vehicle depreciation	Financing costs
Increased traffic volume	Administrative costs
	Operating and maintenance costs
Increase in value (land and buildings)	Reduction in value (land and buildings)
Industrial values	Industrial values
Commercial values	Commercial values
Residential values	Residential values
Recreational values	Recreational values
Institutional values	Institutional values
Agricultural land values	Agricultural land values
Nonprice Benefits	Nonprice Costs
Increased convenience	Reduced convenience to adjacent properties
Increased safety	Reduced safety to adjacent populations
Increased pleasure	Reduced pleasure to adjacent populations
	Health hazard and nuisance from toxic fumes, noise, glare, and dust
Price Savings	Price Costs
Nonlimiting topography	Difficult topography
Adequate foundation conditions present	Poor foundations
Adequate drainage conditions present	Poor drainage
Available sands, gravels, etc.	Absence of construction materials
Minimum bridge crossings, culverts, and other structures required	Abundant structures required
Nonprice Savings	Nonprice Costs
Community values maintained	Community values lost
Institutional values maintained	Institutional values lost
Residential quality maintained	Residential values lost
Scenic quality maintained	Scenic values lost
Historic values maintained	Historic values lost
Recreational values maintained	Recreational values lost
Surface water systems unimpaired	Surface water resources impaired
Ground water resources unimpaired	Ground water resources impaired
Forest resources maintained	Forest resources impaired
Wildlife resources maintained	Wildlife resources impaired

d. Residential quality
e. Historic value
f. Agricultural value
g. Recreational values
h. Wildlife value
i. Water values
j. Susceptibility to erosion

3. Scenic value

4. Physiographic obstructions

In every case three values are allocated to each parameter. The presumption is that the corridor of maximum social utility will transect the zones of lowest social value and provide the major social benefit.

The method employed uses transparent overlays for each parameter. Each of these has three values, the highest representing the greatest physical and engineering obstruction to highway location. The highest value of obstruction is represented by a dark tone, the intermediate value by a light tone, while the lowest category is the residue and is fully transparent. When all of the parameters are overlaid on the base map, it is presumed that the maximum darkness represents the greatest aggregate physiographic and social value obstruction. In contrast, light areas, representing the least physiographic obstruction and the least social value, offer prospective corridors for consideration.

It is immediately conceded that all of the parameters are not coequal. Existing urbanization and residential quality are more important than scenic value or wildlife. Yet it is reasonable to presume that where there is an overwhelming concentration of physiographic obstruction and social value that such areas should be excluded from consideration; where these factors are absent, there is a presumption that such areas justify consideration.

This is not yet a precise method for highway route selection, yet it has the merit of incorporating all existing parameters, adding new and important social considerations, revealing their locational characteristics, permitting comparison, and revealing aggregates of social values and costs. Whatever limitations of imprecision it may have, it does enlarge and improve existing method.

The preceding discussion has emphasized the identification of physiographic corridors containing the lowest social values as the preferred route for highways. In discussion of cost-benefit analysis, reference has been made to the role of the proposed highway in creating new values. This view deserves a greater emphasis. Within limits set by the points of origin and destination, and responsive to physiographic obstructions and the pressure of social values, the highway can be used as conscious public policy to create new and productive land uses at appropriate locations. In any such analysis, cost-benefit calculations would require that any depreciation of values would be discounted from value added. In addition, scenic value should be considered as possible added value. It is, of course, possible that a route could be physiographically satisfactory and could avoid social costs, create new economic values at appropriate locations, and also provide a satisfactory scenic experience.

The highway is likely to create new values whether or not this is an act of conscious policy. Without planning, new values may displace existing ones, but even if a net gain results there may well be considerable losses. An example would be a highway transecting a good residential area that then became used for industrial purposes. The increase in land and building values might well be destroyed. The same effect, adjacent to industrial zones in existing urban centers, would accomplish the same benefits without comparable social and economic costs.

Figure 1. Topography.

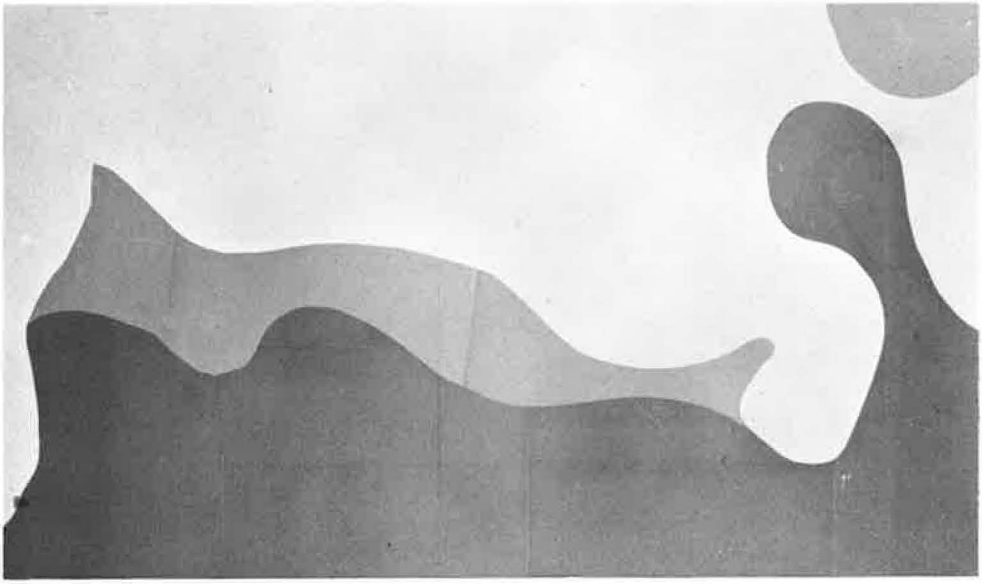


Figure 2. Land values.

Parameter Analysis

1. Topography—The area under consideration is a broad valley extending from the Delaware to the Raritan, limited by the Baldpate, Pennington, and Sourland Mountains and divided by Rocky Hill. It contains two major drainage systems—the Stonybrook, draining the area to the west of Rocky Hill, and the Millstone, draining the area to the east (Fig. 1). As a result of this physiography, fans of tributaries run tangentially across any direct line between West Trenton and the northeast. Rocky Hill represents a major topographic obstruction.

The two obvious topographic corridors are to the north and south of Rocky Hill. The northern corridor follows Jacobs Creek, may proceed either north or south of Pennington Mountain, and then follows the base of Sourland Mountain and widens into a broad swath towards Somerville and New Brunswick.

The southern corridor is less defined but falls south of Rocky Hill and parallels US 1 and the Pennsylvania railroad.

2. Land Values—Land values reflect urbanization and residential quality in nonurbanized areas. Land values are highest in a swath of land including Trenton along US 1 to New Brunswick, with an intrusion of high values in and around Princeton (Fig. 2). Values tend to decrease generally from this base line to a band on the summit of Sourland Mountain and rise northward. Lowest land values occur in the northern corridor; highest in the southern corridor, influenced by Route 1.

3. Urbanization—Trenton, Princeton, New Brunswick, Bound Brook, Manville, Somerville, and Raritan constitute the major areas of urbanization (Fig. 3). The villages of Hopewell, Pennington, Lawrenceville, etc., constitute the remainder. Thus urbanization is concentrated at the termini of the area under consideration—in Trenton at one end and the broad band of communities united by the Raritan River at the other. Princeton and the remaining villages are islands between these urban extremes. Southern alignments will affect Lawrenceville, Princeton, Rocky Hill, and recent subdivisions on Dead Tree Run Road, Willow Road, and Township Line Road; a northern alignment will affect the village of Hopewell.

4. Residential Quality—Princeton and its environs constitute the major concentration of residential quality as measured by value (Fig. 4). Land and building values of $120,000 per acre exist in Princeton alone. An acre to the east contains average values in excess

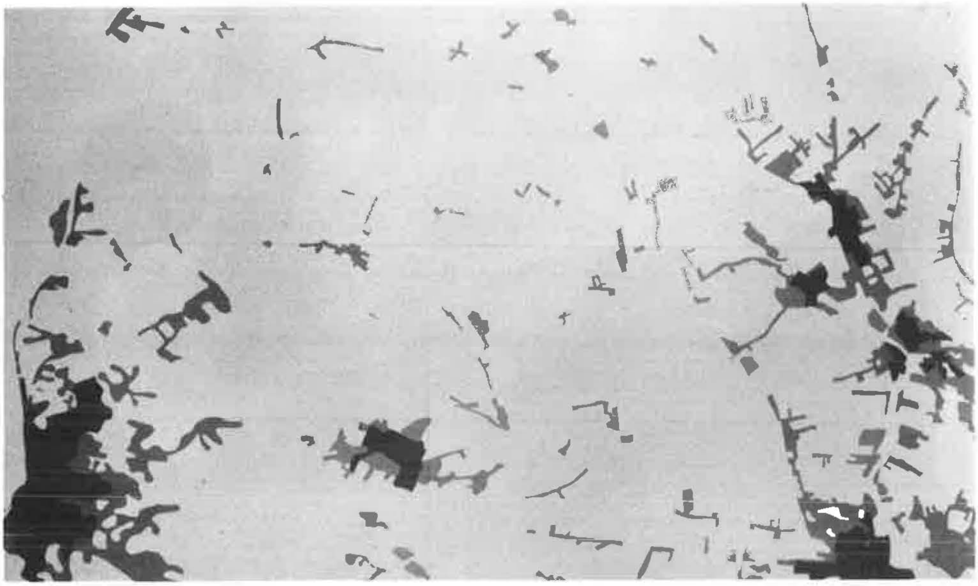


Figure 3. Urbanization.

of $60,000. Values fall fairly regularly from the Princeton centroid. Destruction of residential quality will rise as Princeton and its environs are transected and will diminish as distance from Princeton increases. The northern corridor transects areas of lesser residential quality as reflected by value.

5. Historic Value—Only one value has been shown reflecting historic importance. Three areas are discerned: the first, Washington's Crossing, Delaware—Trenton; the second, Princeton and environs; and the third, the Millstone River corridor (Fig. 5).

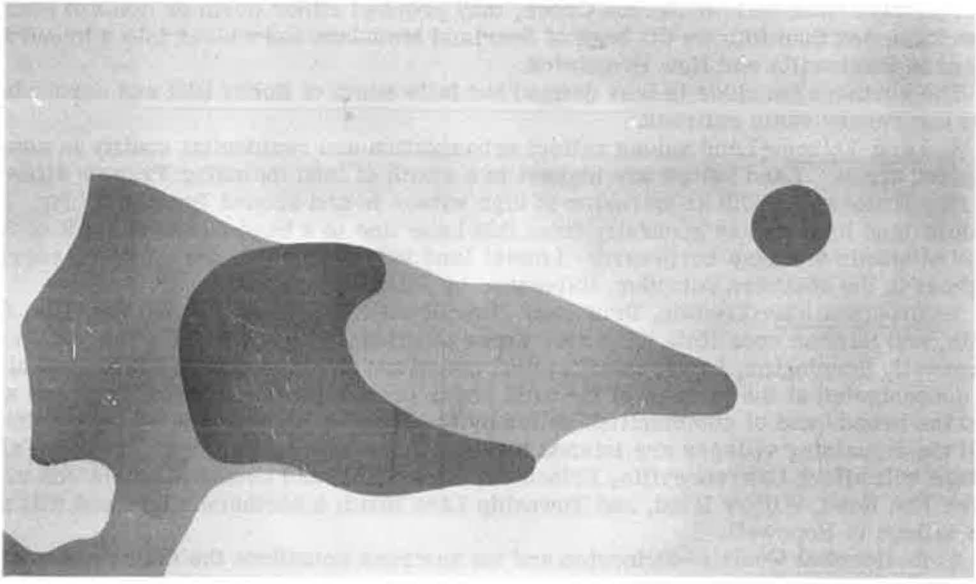


Figure 4. Residential quality.

Figure 5. Historical value.

Northern and southern routes avoid conflict with historic values. A central route does profoundly affect the historic values adjacent to the Millstone River.

6. Agricultural Value—The value of agricultural land is twofold: as a source of food and (even more so, in this area) as a land use that sustains an attractive landscape and maintains it. There is no prime agricultural land in the area, and intrinsic value is quite low, with the single important exception of the visual landscape quality provided by farming. Second-class agricultural land is limited to a triangle of Trenton-Princeton-Pennington (Fig. 6). This is more accurately identified as scenic quality.

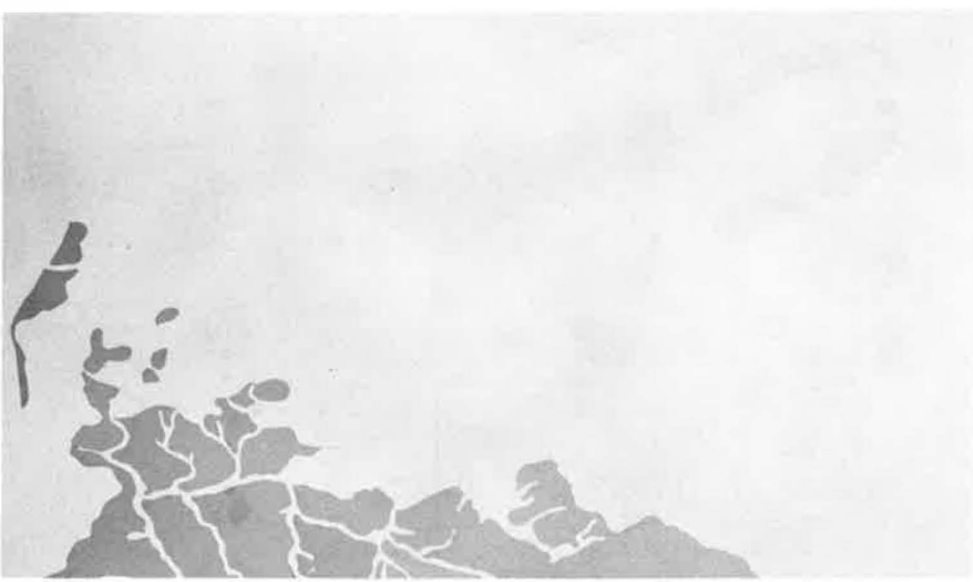


Figure 6. Agricultural value.

Figure 7. Recreational values.

7. Recreational Value—Existing open space is a major constituent of recreational value. This is concentrated in the Stonybrook-Rocky Hill-Millstone-Six Mile Run Impoundment areas (Fig. 7). These unite a crescent of land bordering Rocky Hill and the Millstone River. Within this area fall the major open spaces (public and private), the major rivers and streams, and the majority of the recreational potential, with the exception of the mountain ridge. These represent a major social value. Avoidance of these resources would divert the highway corridor to either the north or south of Rocky Hill and outside of the mountain ridge.

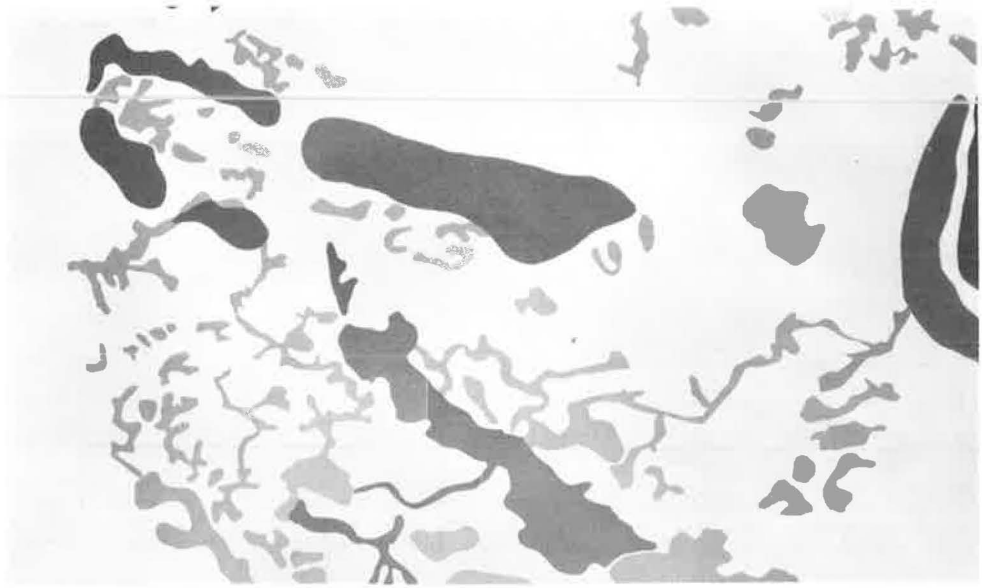


Figure 8. Wildlife values.

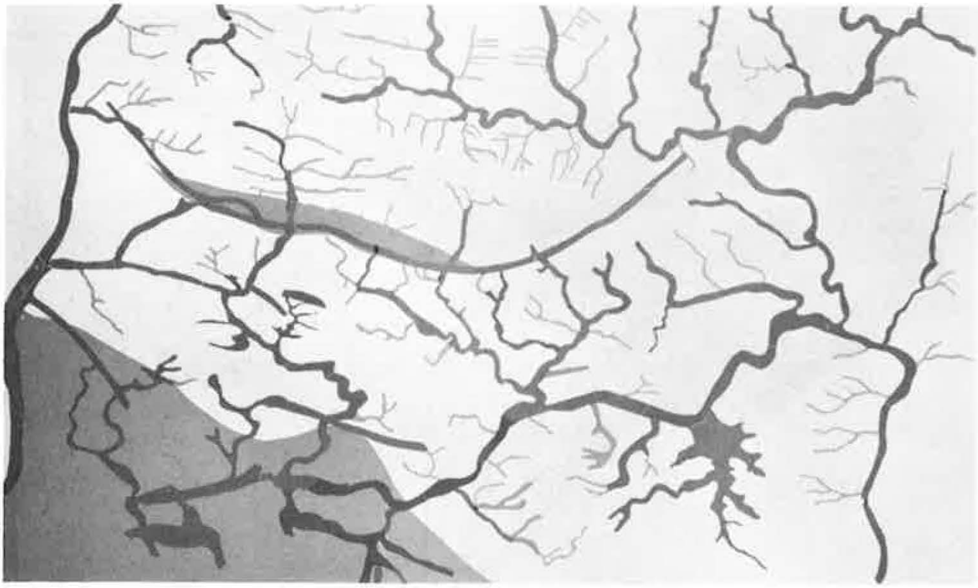


Figure 9. Water values.

8. Wildlife Value—These values are concentrated on the forested uplands—Baldpate, Pennington, Sourland Mountain, and Rocky Hill; and the forests and large woodlands, the major rivers, and marshes (Fig. 8). There are thus two major divisions of habitat, the forested hills and the water-related system of marshes, streams, and rivers, and their containing valleys. Highways constitute a major hazard to terrestrial wildlife; filling of marshes is a threat to fish-spawning and wildfowl. The forested uplands are concentrated in the defining mountain ridge and Rocky Hill. Both northern and southern corridors can avoid conflict with wildlife resources. The fissures of rivers and streams run tangentially across the major axis of the valley, and any central corridor will adversely affect these resources.

9. Water Values—Water resources fall into two categories: surface and ground water. As has been observed, the Millstone River is the major drainage, with the Stonybrook as secondary (Fig. 9). Toward these run a number of tributaries, generally tangential to the long axis. A highway that follows the central axis of the valley will interfere with surface runoff and affect the behavior of existing streams. This will be exacerbated when the highway is either in cut or fill. It will have the effect of a trench interceptor drain in cut or of a dam in fill. This can be obviated in two ways. The first is by following ridge lines throughout its length, a proposal barely feasible. The second is to locate the highway near the source of the watershed where the effect is minimized. A northern alignment would accomplish this objective.

The inadvertent function of a highway in behaving like a trench drain or dam has an effect on ground water resources. It can be utilized as a conscious device for management of ground water. In the negative sense, the highway will cause least offense by passing over the least valuable aquifer—that of Brunswick shale. It will commit a minor offense by passing over the intermediate aquifer of Stockton sandstone. It will create the greatest offense by paving the major aquifer recharge areas.

Positively, the highway, in fill, acting as a dam, can be used to recharge the aquifer and as such would perform a supplementary service. A route south of, and parallel to, the aquifer recharge area at the foot of Sourland Mountain and north of Pennington Mountain would avoid a destructive role on the water regimen and perform a function in ground water management.

10. Susceptibility to Erosion—Highway construction is a process which exacerbates erosion and sedimentation. Excavation and grading combined with hundreds of acres

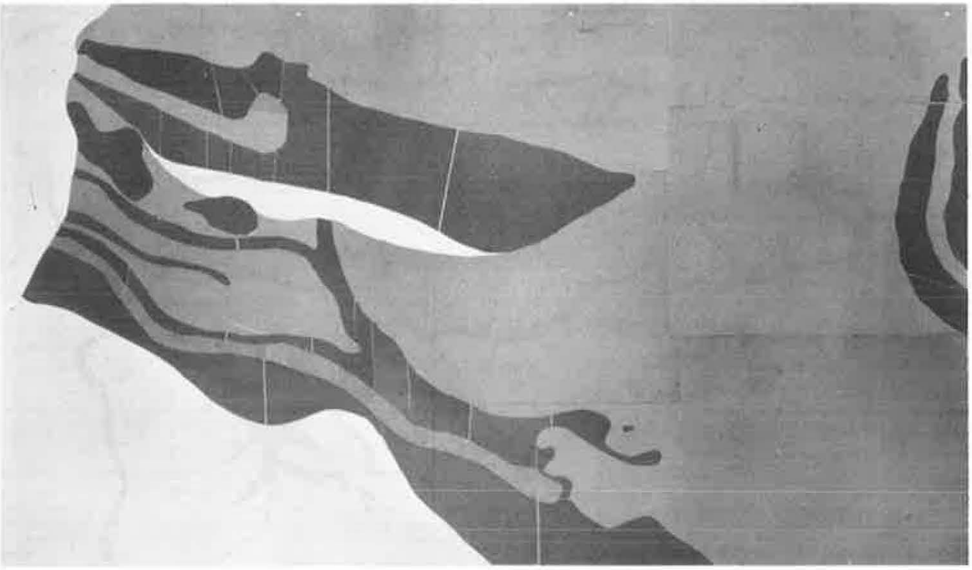


Figure 10. Susceptibility to erosion.

of bare soil guarantee that surface water channels will be surfeited with sediment. This increases the turbidity of streams, and reduces photosynthesis and thus the biotic population. It is often unsightly. It raises flood plains and deposits alluvial silts.

The Stockton sandstone is least susceptible to erosion; Brunswick shale is intermediate; Argillite and Diabase are most susceptible (Fig. 10). A southern route crosses mainly Stockton sandstone and Brunswick shale. A central route crosses bands of Lockatong Argillite, Brunswick shale, and Diabase. A northern corridor can follow

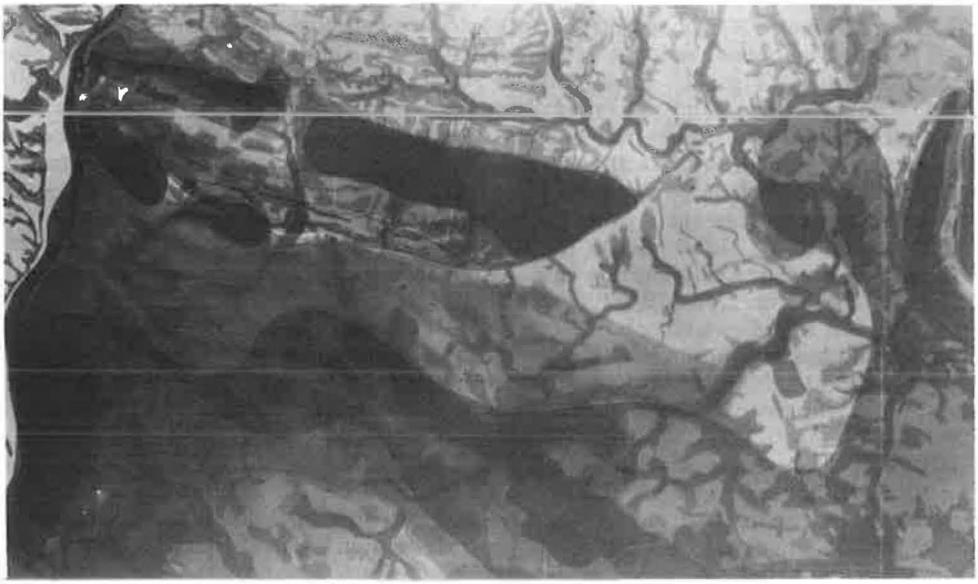


Figure 11. Composite of all values in the area.

either Brunswick shale or Stockton sandstone. A central corridor appears to produce the maximum erosion and sedimentation.

INTERPRETATION OF SUPERIMPOSED MAPS

Ten maps were prepared, representing a range in values for the selected parameters. Each of these has been analyzed independently. The method, however, suggests that (a) the conjunctions of social values represent an obstruction to a highway alignment, (b) the conjunction of physiographic difficulties represents an obstruction to a prospective highway, and (c) the aggregate of these obstructions, social and physiographic, represents the sum of obstructions to a highway corridor.

In contrast, the lightest area, representing the lowest social values and the least physiographic obstruction, indicates the highway alignment of least social cost and least physiographic difficulty.

When maps of social values and physiographic obstructions are superimposed, it is immediately apparent that the concurrence of obstruction occupies a broad belt between the Delaware and Raritan Rivers, Trenton, and New Brunswick (Fig. 11). This aggregate obstruction diminishes to the south, but the continuous area containing the least obstruction occurs as a trumpet with its northern limit at the base of Pennington and Sourland Mountains, narrowest at Hopewell, and widening eastward between Sourland Mountain and the Millstone River.

If social values are accepted as criteria for route selection, in addition to normal factors of topography, it is clear that the route of least social cost proceeds parallel to and west of Jacobs Creek, either north or south of Pennington Mountain, and thence along the base of Sourland Mountain. At the tail of this mountain the corridor widens, permitting a route to proceed either to I-187 near Pluckemin or to South Bound Brook (Fig. 12).

In addition to providing an alignment of minimum social cost, this route, if located south of the major aquifer recharge, permits the highway to enhance the water regimen by permitting managed aquifer recharge.

<u>Tests of the Area of Lowest Social Value Against Physiographic Restraints</u>

A map was prepared which showed three levels of physiographic obstruction:

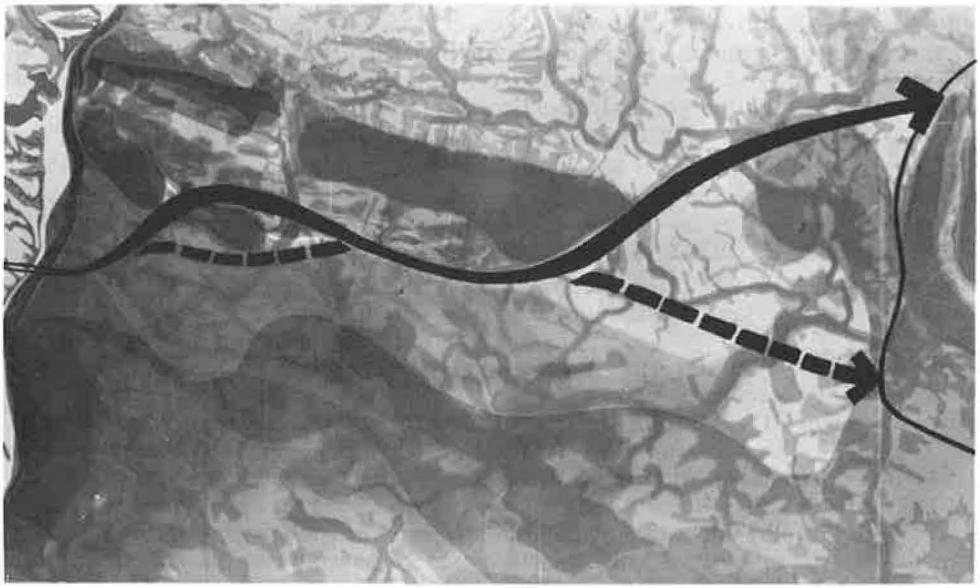


Figure 12. Least social cost alignment corridor.

Zone 1—Areas having slopes in excess of 10 percent. Areas requiring major rivers, highway, and railroad crossings.

Zone 2—Areas having slopes in excess of 5 percent but less than 10 percent. Areas requiring minor river and highway crossings.

Zone 3—Areas having slopes of less than 5 percent. Areas without consequential bridge crossings.

When the corridor of least social cost was tested against this finer-grain analysis, it was seen to follow a route of least physiographic obstruction.

Test of the Area of Least Social Cost and Least Physiographic Obstruction Against Scenic Value

In order to measure the highway corridor against the scenic experience it could provide, a map of scenic value was prepared. Three values were determined as follows:

Zone 1—A broad band embracing the Delaware River, Washington's Crossing, Pennington Mountain, Rocky Hill, the Stonybrook watershed, and narrowing to include the Millstone Creek and the Duke Estate.

Zone 2—In general, this zone includes the Sourland and the area of farmland on either side of the Millstone River.

Zone 3—Remainder of area.

The valley of Jacobs Creek, Baldpate Mountain, the valley of Stonybrook and the Pennington Mountain, Rocky Hill, the Millstone River valley, Beden Brook, and Sourland Mountain constitute the major elements of scenic value in the area. They fall into two major elements: the northern ridge as one, and the heartland, composed of Stonybrook, Rocky Hill, Millstone River, and Beden Brook as the second.

Scenic value can be considered in two opposing ways: as a value that the highway should avoid, or as a resource the highway should exploit. If avoidance is the objective, then the corridor should fall south of the Stonybrook and Millstone. It should positively avoid transecting the heartland or paralleling the Millstone River. If exploitation is the criterion, then two possibilities are apparent. The first would select the Rocky Hill Ridge and the Millstone River corridor. The other alternative is the northern corridor at the base of the Baldpate, Pennington, and Sourland Mountains.

The Rocky Hill-Millstone River corridor, while undoubtedly scenic, transects the area of highest social values and high physiographic obstructions. It does not correspond to a reasonable direction for the highway. The alignment on Jacobs Creek, skirting the base of Pennington and Sourland Mountains, equally offers an excellent scenic experience, but avoids areas of high social value and areas of physiographic difficulty—and it corresponds with the general direction of the prospective route.

The proposed corridor skirting the base of the mountain ridge not only satisfies the criteria of low social value and low physiographic difficulty, but offers an excellent scenic experience.

The Highway as a Conscious Device To Locate New and Productive Land Uses

If one assumes that not only can the highway avoid unnecessary social costs but also create new productive land uses, then it becomes important to decide where these might best be located.

In the area under consideration, industrial and commercial land uses exist in Trenton and in the band of communities bordering the Raritan River. In the intervening area industry is sparse. The ethos of the heartland, Princeton-dominated, is residential and institutional. The creation of new industrial land uses would be unwelcome in the heartland but welcome at either end, in Trenton, New Brunswick, Bound Brook, Manville, Somerville. This being so, the highway corridor should be selected to locate new productive land uses at the extremities but avoid the creation of conflicting land uses in the central valley. In addition, any direct central route would inflict not only dissonant land uses but also a corridor of noise, glare, dust, health hazard, nuisance, and danger on the rural-residential-institutional land uses of the heartland.

If this analysis can be substantiated, the optimum highway corridor would follow an alignment and locate such intersections as to benefit both the Delaware River and Raritan River termini with new productive land uses and would avoid such conflicts in the intervening area. A northern route could induce new land uses adjacent to West Trenton and the Raritan River communities, where new industrial and commercial land uses would be both consonant and welcome.

Note: An appendix documenting the sources for the social and physiographic parameters was included in the original paper and is not presented here. It is available at cost from the Highway Research Board. When ordering, refer to XS-19, Highway Research Record 246.

Historic Sites Study

MEGAN C. SEEL, Bureau of Transportation Planning and Development,
Massachusetts Department of Public Works

Massachusetts has for many years led the nation in concern for recognition of historic sites and areas. A first-of-its-kind project has been initiated in the Massachusetts Department of Public works to utilize an inventory of historic sites as a variable to be considered when making decisions for transportation facility location. This paper discusses (a) a method for conducting and compiling a comprehensive historic sites inventory, (b) a means for encouraging local community participation in completing the inventory, (c) a technique for obtaining professional and qualified historical evaluation of inventoried sites, (d) a system for geographic location of sites by X and Y coordinates, (e) a system for recording historic data for computer storage and retrieval. This survey is not meant to be a demi-preservation program; it is rather an "early warning system" which will supply, in advance of final transportation facility designs, information on potentially valuable historic sites and areas.

•THERE are numerous variables that can influence a planner's decision for locating a transportation facility. Some of the variables are of major importance: predicted population growth, the economic needs of and opportunities for this population, land use and open space requirements, and transportation demands. Other variables, taken individually, are of less importance: historic sites, parks and recreation areas, scenic views. This second group, the "aesthetic" variables, has not until recent years been given proper consideration by the planner. (See Appendix A for legislation pertaining to this.)

In coordination with the Massachusetts Historical Commission, the Massachusetts Department of Public Works is collecting inventory data on historic sites in 40 eastern Massachusetts communities affected by the proposed 1975 highway network. The inventory is not limited to those structures and areas that are well known in the commonwealth or those open to the public, but it includes structures of architectural or historic significance to the local community.

The Historic Sites Study was undertaken to aid in planning decisions. The information on each historic site, the location of sites by X and Y coordinates, the use of the computer to store and retrieve information—all these are geared to the planner's needs. The planner's function is to anticipate the future; the preservationist's to save the past. This program will not pretend to cover the ground of experts in the field of the historcial. The goal is only to establish an early warning system, to build up a comprehensive bank of information that will tell a transportation planner in advance what sites the plan may affect. Alternatives for dealing with the site, i.e., integration into the total design, elimination of the site, preservation by relocation of the site or the highway, will be considered when the need arises. The choice of alternatives will be left to the experts.

Paper sponsored by Committee on Roadside Development and presented at the 47th Annual Meeting.

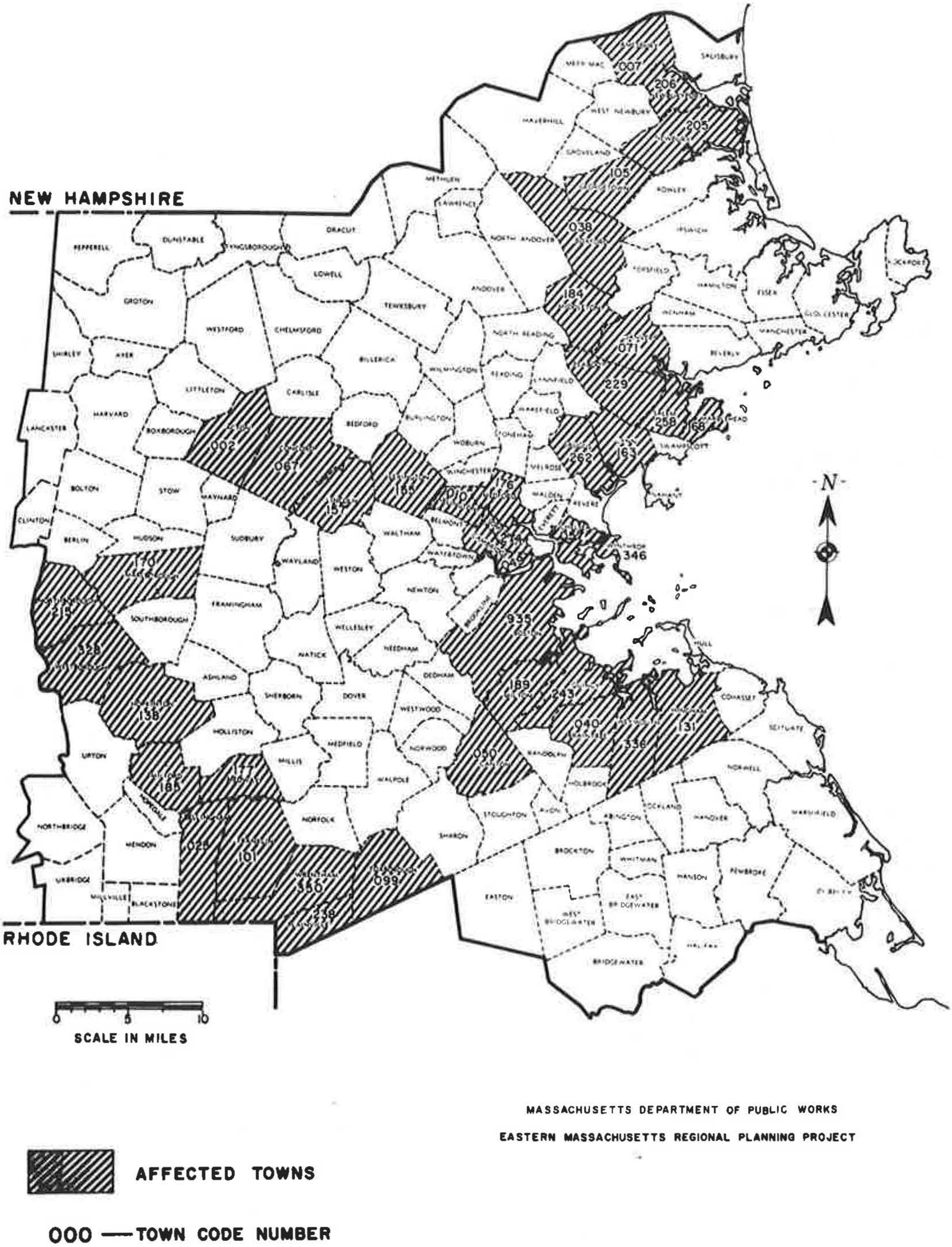


Figure 1. Towns affected by the 1975 network.

This program, in its effort to preserve a rapidly vanishing historical heritage, has several advantages. It has fostered understanding between state planning and preservation agencies. It has achieved close coordination and communication between local communities and state agencies. It offers, by presenting a broad picture of Massachusetts historical assets, the possibility of an integrated plan of highways and historic sites.

Methods

The steps necessary to complete the Historic Sites Study will be briefly delineated here and discussed in detail in the following section. The first step is the completion of the initial inventory. Because of limited time, the study concentrates on the 40 cities and towns in the eastern Massachusetts area affected by 1975 proposed highways (Fig. 1). In many of the communities the inventory is conducted by local volunteers.

Completed inventory forms are returned, checked, and corrected. All inventoried sites are then rated numerically under two categories: history and architecture. This classification is done for the Eastern Massachusetts Regional Planning Project by Architectural Heritage, Inc., a nonprofit organization that evaluates the historic and architectural worth of structures and makes suggestions for preservation and restoration.

The historic sites having significant ratings are located on aerial photos and assigned X and Y coordinate locations. All information on the Department of Public Works form is keypunched. The coordinates for the center line of a proposed highway are taken and also keypunched. The information from the punch cards is recorded on tape within the computer. The computer can then provided the information on any site within a specified distance of the highway center line.

A DEMONSTRATION: BOXFORD

One town can be used to illustrate how the Historic Sites Study is conducted, how it is used by planners, and what may be done with endangered sites. Boxford has been chosen because the inventory information which was collected conforms closely to the standards of reporting desired.

Boxford was originally part of a large tract of land occupied by the Agawam Indians. In 1683 the land was deeded to John Winthrop. In 1685, 48 families were living on the land called Rowley Village. At that time they applied for a separate town charter in order that they might settle a minister and build a meeting house, "wee being sensaball to the great need of having the publick word of God preached among us . . . . For the betor edication of our childern that cannot gooe fouer mieles to meeting." The charter was granted by the General Court, and the Town of Boxford, named for Boxford, England, was incorporated August 12, 1685.

Although the beginning of Boxford is similar to that of many New England towns, its evolution to the present is not. Two hundred eighty-five years after its incorporation, with a population slightly over 3,000, Boxford still has the atmosphere of a village.

Driving through the center of Boxford today one has the feeling of going back a hundred years. There is a sense of the past comingled with the present that evokes a total picture of the town's history. This feeling that Boxford is a historic town is not an accident. It is derived from the town's careful preservation of old houses as well as its pride in the new. Boxford's citizens have worked hard to sustain the past. Special zoning laws have preserved the integrity of groups of older houses. Private owners of old houses have tried to keep them in repair and as unaltered as is practical. There is an active Historical Society, headed by Loren M. Wood, who expressed Boxford's concern for history in a letter to the Massachusetts Historical Commission:

> Boxford is a unique town in Eastern Massachusetts surrounded by burgeoning suburbia. This town retains a quiet rural setting for its fine old homes, and its new ones alike. This happy situation is not happenstance. Rather, it is the result of diligent zoning and planning board administration. (Two acres, 250 ft. frontage minimum. Even the road shoulders have a minimum cutback to enhance the rural atmosphere, and signs have a maximum size

limit.) The result is a delightful settings of fields and woodlands with the houses and their settings well-matched examples of times as they were.

Introducing the Inventory

Loren Wood was sent a letter informing him of the desire for historical inventory of Boxford. (In all the cities and towns where it was possible, the aid of local historical societies and commissions or volunteers was solicited.) A folder of information was sent from the office of the Massachusetts Historical Commission. This folder included a letter stating the purpose for the inventory and requesting local assistance in completing it; a sample of the Massachusetts Historical Commission's inventory form; a sample of the Department of Public works inventory form; a sheet of criteria defining historic site; a booklet explaining how the Massachusetts Historical Commission forms should be completed, and how to recognize certain architectural styles and features; a sheet explaining how to fill out the Department of Public Works forms; and suggestions for methods of conducting the inventory. Mr. Wood was asked to form a committee to inventory the town and to set a date when a representative from the Department of Public Works or the Massachusetts Historical Commission could meet with the committee and review the procedures.

Mr. Wood found the folder self-explanatory, so no meeting was necessary in Boxford, although meetings were held in many of the other cities and towns. During these meetings the information supplied in the introductory letter was expanded, and questions were answered. Sometimes a brief lesson in architecture was included. These meetings served a dual purpose: they were informative and they fostered goodwill. Through these meetings we hoped to convey the state's interest in individual communities and to express appreciation for the time and effort these towns would expend on the project.

The Inventory

The actual inventory of Boxford's historic sites was carried on by the committee members. Boxford had previously drawn up a list of 113 historically and architecturally important houses. The committee selected 67 of these (and two areas) to be included in the inventory. Information on each site was recorded on both Massachusetts Historical Commission and Department of Public Works inventory forms (see samples shown in Figs. 2 and 3). The Massachusetts Historical Commission form is constructed for the recording of more detailed architectural and historic information; space is provided on the back of the form for details on the history and interior features of more important structures. The Department of Public Works form includes information that is most relevant to transportation planners and highway engineers. Since all the information from these forms is translated into codes for use on a computer, space is provided on the right for this purpose.

Mapping and Photographing

The one aspect of the inventory that was most stressed was mapping. As stated earlier, the objective was to establish an early warning system. In order to have an effective system two things must be known: first that there is a building of architectural or historic value, and second where it is located. It was requested that the volunteers hand-draw detailed maps in the space provided on the Massachusetts Historical Commission forms and also locate the sites on a United States Geological Survey Map, each inventoried house being given a number corresponding with the number on the map. It was also requested that each site, when possible, be photographed (Fig. 4). These photographs are an immeasurable aid to Architectural Heritage, in classifying the sites. After each of the sites had been inventoried and checked, forms and map were returned to the Massachusetts Historical Commission.

FORM B - STRUCTURE SURVEY
MASSACHUSETTS HISTORICAL COMMISSION
Office of the Secretary, State House, Boston

2. Town BOXFORD
Street (214)* IPSWICH RD
Name KIMBALL / ROWE / ALLEN
Original Use DWELLING
Present Use RESIDENCE
Present Owner MRS. ARTHUR W. ALLEN
Date 1780 Style 18TH CENTURY COLONIAL
Source of Date B.H.S.
Architect

1. Is this structure historically significant to: Town Commonwealth Nation

Structure has historical connection with the following themes: (See also reverse side)

Agriculture	Commerce/Industry
Architecture	Science/Invention
Art/Sculpture	Travel/Communication
Education	Military Affairs
Government	Religion/Philosophy
Literature	Indians
Music	Development of Town/City

3. CONDITION: Excellent Good Fair Deteriorated Moved Altered 1932

IMPORTANCE of site to area: Great Little None SITE endangered by

4. DESCRIPTION

FOUNDATION/BASEMENT: High Regular Low Material: STONE

WALL COVER: Wood CLAPBOARD Brick Stone Other

STORIES: 1 2 3 4 CHIMNEYS: 1 2 3 4 Center End Cluster Elaborate Irregular

ATTACHMENTS: Wings Ell Shed Dependency Simple/Complex

PORCHES: 1 2 3 4 Portico Balcony SCREENED Recessed

ROOF: Ridge Gambrel Flat Hip Mansard
Tower Cupola Dormer windows Balustrade Grillwork

FACADE: Gable End: Front/Side Symmetrical/Asymmetrical Simple/Complex Ornament

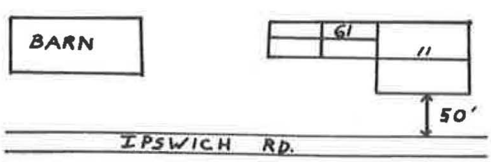
Entrance: Front/Side Centered Double Features: SIDE WINDOWS/OVERDOOR TRIANGULAR PED.

Windows: Spacing: Regular/Irregular Identical/Varied DOUBLE HUNG 9/6 6/6 (OLD)

Corners: Plain Pilasters Quoins Obscured

OUTBUILDINGS BARN LANDSCAPING UNUSUALLY FINE

5. Indicate location of structure on map below



6. Footage of structure from street 50
Property has 1900 feet frontage on street

Recorder I. M. WOOD
For BOXFORD HISTORICAL SOCIETY
Photo

E05.	038-1-09

NOTE: Recorder should obtain written permission from Commission or sponsoring organization before using this form. (See Reverse Side)

*NOT STREET NO.
NUMBER IS FROM PERLEY'S LISTINGS "DWELLINGS OF BOXFORD"

FORM - MHCB - 10M-6-66-943017

Figure 2. Form B—Structure Survey, Massachusetts Historical Commission.

FOR USE WITH IMPORTANT STRUCTURES (Indicate any interior features of note)

Fireplace 5 original fireplaces around center chimney still working

Stairway front stairs, clockwise, two landings

Other original barn (1780) still standing and in use- barn contains bellows and blacksmithing equipment from original Amos Kimball occupancy- wide pine board flooring throughout original house-one room retains original Indian shutters

GIVE A BRIEF DESCRIPTION OF HISTORIC IMPORTANCE OF SITE (Refer and elaborate on theme circled on front of form)

Why Important:

1. Because it was the home of Rev. Samuel Rowe, the first deaf mute ordained as a Congregational minister in the United States.

2. Because it was the home of Dr. Arthur Allen, noted surgeon in the Massachusetts General Hospital(now deceased)

3. Because of the integrity and excellent general condition of the structure, built 1780 by Amos Kimball, blacksmith. The property remained in the Kimball family until 1880. At that time Rev. Samuel Rowe and Mr. Isaac Wyatt came from New Gloucester, Me. and purchased the farm. Messrs. Rowe and Wyatt were deaf mutes. Rowe was an Evangelist of the Congregational Church to the deaf mutes of Maine. His ordination took place in the Second Church(West Boxford) in 1878- the service was all done by sign language

REFERENCE (Where was this information obtained? What book, records, etc.)

"Dwellings of Boxford" Perley, Published 1893 by Essex Institute

BIBLIOGRAPHY

Original Owner:____________________

Deed Information: Book Number______ Page_______, ______________ Registry of Deeds

(BACK OF FORM B)

Figure 2. Continued.

Form H-12

HISTORICAL SITE INVENTORY FORM—EMRPP

MASS. DEPT. OF PUBLIC WORKS

DO NOT WRITE IN THIS SPACE
CODE

CODE# County 05 Town 038 Type 1 Site # 009

Site ☒ Area ☐

I [1]
II [05]
III [038] [1]
IV [009]

Name KIMBALL/ROWE/ALLEN

X & Y Location X 719.240 Y 618.715 --- V [7 1 9 2 4 0 6 1 8 7 1 5]

Location S.W. X ____ Y ____

N.W. X ____ Y ____

N.E. X ____ Y ____

S.E. X ____ Y ____

Location: County ESSEX

City BOXFORD

Street(s) IPSWICH

Number(s) ____ VI [ ]

Kind: (Underline One) 1) [Home] 2) Museum

3) Monument 4) Park 5) Other VII [1]

Theme: (Underline One or Two if there are double themes. If two or more indicate first & second importance)

1) Agriculture 8) Commerce/Industry

2) [Architecture] 9) [Science]/Invention

3) Art/Sculpture 10) Travel/Communication

4) Education 11) Military Affairs VIII [02]

5) Government 12) [Religion]/Philosophy

6) Literature 13) Indians

7) Music 14) Devel. of Town/City

General Date
or Period 1780 IX [780]

Figure 3. Historical site inventory form—EMRPP.

HISTORIC SITE INVENTORY FORM - EMRPP PAGE 2 | 2 | 0 5 | 0 3 8 | 1 | 0 0 9 |
(9/16/66)

Size of Base of Bldg. (Approx. sq. ft.) 2400 X | 0 2 4 0 0 |

Size of Bldg. Lot (Approx. sq. ft.) 82 ACRES XI | 3 5 2 6 0 0 0 |

Distance of Bldg. from Existing Rd. 50' XII | 0 0 0 5 0 |

Ownership: (1) Public__________ Agency:__________

(2) Private [boxed]

(3) Certified

(4) 5A of Chap. 79

(5) Other (____________________) XIII | 2 |

Present Use:
1. Private Home [boxed]
2. Museum
3. Transportation
4. Entertainment
5. Commerce or Industry
6. Religion
7. Civic
8. Unoccupied
9. Other (Specify)____________________

XIV | 1 |

Number of Stories 2½ XV | 0 0 2 |

Wall Cover: (1) Wood [boxed] (2) Brick (3) Stone

(4) Stucco (5) Shingle

(6) Other (____________________) XVI | 1 |

Overall Condition: (1) Excellent [boxed] (2) Good

(3) Fair (4) Deteriorated

(5) Altered XVII | 1 |

If Area:

Number of Historic Bldgs.____________________ XVIII | | | | |

Historic District

(1) Yes______ (2) No______ (3) Pending______ XIX | |

Do Not Write Below This Line

Overall Rating 3/4 XX | 3 | 4 | — |

FOR ADDITIONAL INFORMATION SEE:

Figure 3. Continued.

Figure 4. Photograph of the Kimball-Rowe-Allen House.

Preliminary Classification

The forms were then sent to Architectural Heritage to be classified. Evaluating the importance of an historic site involves more than knowing facts such as the historic connection, the number of building stories, the wall cover, the date; it also involves a subjective measurement of the site's worth. A two-category classification system has therefore been developed to indicate a site's intangible worth. Each site has been classified numerically under history and architecture. (See Appendix B for classification system code and explanation.) A numerical designation has been used since it is most adaptable to the computer. The classification has been kept to two categories because all evaluations are made from information on the inventory forms and a more detailed classification could only be based on conjecture and hypothesis. The rations on each site are by no means final and were not devised to indicate that certain low-rated buildings are expendable. These ratings merely added to the information on a site. Detailed evaluation of a site for preservation purposes can be given by experts when the site is threatened.

Some of the factors influencing the ratings in Boxford were as follows: the distribution of houses recorded by 50-year periods; the relation of one site to others, in a group or alone (as seen from the map); and the relation of the house to its natural surroundings. There are probably some errors in these classifications, but they were made with the greatest accuracy possible from the quality of the information on the forms.

X and Y Coordinate Location

When all the Boxford sites had been classified, the inventory forms, lists, and maps were returned to the Department of Public Works office. Using the U.S. Geological Survey maps and the hand-drawn maps, each site was located on large aerial photos on which the coordinate system is marked. From these photos the X and Y coordinate of the center point of a building was measured, and this information was put in the space provided on the inventory form. In dealing with an area rather than a single site, four coordinate points were used.

The Computer Product

All information on the Boxford historic sites was coded on the inventory forms. When the forms had been coded and checked, the coded information was keypunched on cards and transferred to tapes for use in the computations.

Retrieval may be carried out in four ways: a printout of data on all the sites within a town; a printout of all the recorded sites within a 25-year period; a printout of all sites classified as 1 or 2; a printout of all sites within 1,000 yards and 1,000

* DPW HISTORIC SITE INVENTORY * BOXFORD * MARCH 9,1967 * TCA *

** SITES WITHIN 1,000 FEET OF IPSWICH ROAD CENTERLINE **

		L O C A T I O N		DISTANCE FROM
TOWN	SITE	X COOR.	Y COOR.	CENTERLINE #FEET<
038	009	719.240	618.715	77
038	014	721.530	618.630	152
038	015	723.510	619.000	97

Figure 5. Printout of all sites in Boxford within 1,000 feet of Ipswich Road centerline.

**** DPW HISTORIC SITE INVENTORY DATA TABULATION * BOXFORD * 1800-1825 * 3/2/67 * TCA ***

CO.TOWN	TYPE	SITE NO.	LOCATION X COOR.	LOCATION Y COOR.	SW X COOR.	SW Y COOR.	NW X COOR.	NW Y COOR.	NE X COOR.	NE Y COOR.	SE X COOR.	SE Y COOR.	LOC. KIND	THEME	DATE
05 038	1	010	719.690	620.505	.	.	.	.	.	.	.	.	1	14	1810
05 038	1	015	723.510	619.000	.	.	.	.	.	.	.	.	1	02	1812
05 038	1	025	728.580	608.580	.	.	.	.	.	.	.	.	1	12	1800
05 038	1	052	736.285	605.380	.	.	.	.	.	.	.	.	1	02	1825
05 038	1	060	738.470	597.340	.	.	.	.	.	.	.	.	1	14	1825
05 038	1	063	739.970	614.500	.	.	.	.	.	.	.	.	1	14	1810
05 038	2	071	717.000	622.670	716.935	622.205	716.640	622.840	717.235	622.805	717.320	622.415	5		1800

Figure 6. Printout of all sites in Boxford within a 25-year period, 1800-1825.

feet of the center line of a proposed highway. (Some printout samples for Boxford are shown in Figs. 5 and 6.) There is also the production of information on a data plotter. A data plotter can graphically display the line of the road and designate sites falling within certain distances of it.

The Computer Product in Boxford

To examine how information on historic sites and roadways may be obtained and used we will use two highway proposals in Boxford. The first is actual: the widening of I-95 to Boston; the second is hypothetical: the widening to four lanes of Ipswich Road east to Highland Road, and of Highland Road East to the Boxford town line. The first concern is to ascertain what sites may be encountered when the highway plan is in the early stages; the second is how to deal with these endangered sites.

In Boxford, two highway plans are contemplated for 1975. There are two ways that a planner can check his plans; by drawing his roadway to scale on U. S. G. S. maps where the historic sites for a town are recorded or by feeding to the computer the X and Y coordinates of his highway plan and having the information printed out showing all sites within a specified distance of the highway. For the widening of I-95 through Boxford the planner uses the first method and finds that the widening does not directly affect any of the sites enumerated on the U. S. G. S. maps. The second hypothetical highway plan is in an advance design stage. The planner marks the X and Y coordinates of this highway, feeds the information to the computer, and requests information on all sites within 1, 000 feet and 1, 000 yards of the highway's center line. The computer will return information on these sites, designating the site by code number. The lateral distance of the road (length) can be any number of miles and depends only on the center point coordinates that the planner has recorded and at what intervals. In the town of Boxford, the computer shows that sites 05-038-1-009, 05-038-1-014, and 05-038-1-015 are all at a 1, 000-foot interval (Fig. 5). Further information on these sites can be obtained by feeding their code numbers to the computer and getting a printout of all the recorded information on them.

Disposition of Endangered Sites

The planner now has three recorded sites that his plan endangers. The ways that these sites may be dealt with are, at this time, only proposals rather than settled policy. First, assume that the highway plan is not in an inalterable design stage. The planner or some other representative of the Department of Public Works should, upon discovery of the endangered sites, send notice of these sites and the highway proposal to the Massachusetts Historical Commission. The Commission would go to the Boxford files and pull out inventory forms on 05-038-1-009, the Kimball-Rowe-Allen House, 05-038-1-014, the Tyler-Wood Homestead, and 05-038-1-015, the Jonathan Foster House.

Each site should be checked in the field and an evaluation of its architectural and historical merits and its relation to its surroundings should be made by qualified historical surveyors. They would judge whether to move the structure to another location, to preserve it where it stands, or to destroy it.

These judgments and evaluations should be presented to a committee. This committee could be composed of qualified preservationists and members of the Massachusetts Historical Commission and the Department of Public Works. The committee would only act as a review board when the instance of an endangered site arises. Its decision on how to deal with the site would be based on the reports of the surveyors and the economic feasibility of various alternatives. With both planners and preservationists on the committee, weight will be given to both the value of the highway plan and of the historic site. If the state does not act to preserve the endangered site, preservation societies or private individuals would, with advance warning, find alternative measures for saving the structure. (The Massachusetts Historical Commission is now preparing a paper on the various methods of preservation and will make it available to private individuals on request.)

Value of the System

The system is valuable both to planners and preservationists, as well as to the transportation planner. It can anticipate legal entanglements and avoid them. It can avoid public anger by defining the value of certain sites to the state and to individual communities. It can permit the planner to comply with highway beautification requirements by offering him the alternative of integrating an historic site into his highway design. It offers communication and unity in local and state goals. The planner can now make communities aware of their local historic assets and can provide them with a comprehensive program by which they can recognize and record these assets. Through advance warning, communities and private individuals are given time to work out alternative preservation solutions for endangered historic sites. It also assures a closer union of purpose between planners and preservationists.

Application on a Local Level

Boxford's historic sites have been dealt with only as they are directly affected by the highway proposals. The development of a major highway through any community may bring increased population, housing, commerce and industry, and changes in access roads, which may threaten historic sites. These threats can only be dealt with by the town, for preservation is mainly the responsibility of the community and its residents. Many preservation alternatives are possible. It was proposed in the inventory stage that each community make copies of the inventory forms and file them with the historical commissions and societies of the town. These forms, as well as maps marking the sites, could also be given to the town planning board, which could inform the historical society when a site is threatened so that preservation can be made.

CONCLUSIONS

There are three major advantages to the Historic Sites Study. The first is community participation. Through coordination in the inventory process, both the town and the state benefit by better understanding each other's position, and there is uniformity of information and unity of purpose. Second, the information is computerized. When things must be done quickly and accurately the computer is of great assistance. The third advantage is that it is not a preservation program but an early warning system. It would be impossible, in a state as rich in historic assets as Massachusetts, to decide on a certain number of buildings deserving immediate preservation attention. It seems more practical to deal with each structure as it is threatened, with individual communities accepting the responsibility for preserving local structures, with the state stimulating local interest in historic assets, and with the Massachusetts Historical Commission continuing its program of certification and preservation.

Appendix A

SUMMARY OF RECENT FEDERAL LEGISLATION

Public Law 89-594 Sec. 137 Preservation of Parklands
Public Law 89-665 National Historic Preservation Act

In addition to giving explicit sanction to an accelerated Federal effort in historic preservation, this measure:

(a) gives strong official encouragement to the vital role of private efforts,
(b) authorizes matching grants to the states for comprehensive surveys and for programs of acquisition and development of significant properties appearing on a National Register to be expanded and maintained by the Secretary of the Interior,
(c) authorizes matching grants to the National Trust for Historic Preservation, and
(d) establishes a 17-member National Advisory Council on Historic Preservation (six Cabinet members, the Chairman of the National Trust and ten Presidential appointees) which, "inter alia," will receive and review reports about the effect on any property listed on the National Register, of any Federal or Federally assisted project from the responsible agency head.

To carry out the matching grant program, $2,000,000 is authorized for Fiscal Year 1967 and $10,000,000 for each of the three succeeding fiscal years. Most of the $2,000,000 authorized for Fiscal Year 1967 is expected to go to the National Trust.
PL 89-665 allows the Trust to spend matching funds received from the Federal Government to meet the traditional Trust responsibilities.

Public Law 89-754 The Demonstration Cities and Metropolitan Development Act of 1966

Title 1 - Comprehensive City Demonstration

Section 103. (b) In implementing this title, the Secretary shall . . . (3) encourage city demonstration agencies to (A) enhance neighborhoods by applying a high standard of design, (B) maintain, as appropriate, natural and historic sites and distinctive neighborhood characteristics. . . .

Title VI - Preservation of Historic Structures

Urban Renewal

Title VI amends the urban renewal law to provide recognition of historic and architectural preservation in urban renewal plans and to authorize preservation activities and planning therefor as eligible project costs.

A local public agency (LPA) could, as part of an urban renewal project, relocate historically or architecturally significant structures within or outside the project, whether or not the structures were owned by the LPA. An LPA could also acquire and restore properties of historic or architectural significance.
Title VI also amends the urban renewal law to authorize local grant-in-aid credit for certain expenditures by localities and other public bodies for historic and architectural preservation.

701 Program Expansion

Moreover, the Secretary of Housing and Urban Development is authorized to make up a two-thirds grant to assist a city with a population of 50,000 or more to make a survey of properties of historic or architectural value.

Grant Program

The Secretary would also be authorized to make matching grants to states and local public bodies for the acquisition, restoration, and improvement of areas, sites, and structures of historic or architectural value in urban areas. Properties will be judged eligible for inclusion in the program in accordance with the "criteria comparable" to those of the National Register. This requirement will take effect, however, only 3 years after the date of enactment.

Demonstration Grant Authority

Special 90 percent grants would be authorized for historic preservation demonstration projects which have special value in developing and demonstrating new and improved methods and materials.

Grants to the National Trust

A separate program of grants would be authorized to the National Trust for Historic Preservation for restoration of structures of historic or architectural value. These grants could not exceed $90, 000 per structure; they could provide help only for properties the Trust had accepted and would maintain for historic purposes. While not limited to 50 percent of project cost, the grants could not be used for acquisition or maintenance.

Appendix B

THE PRELIMINARY CLASSIFICATION SYSTEM

Architectural Heritage, Inc., is a nonprofit organization dedicated to the preservation of early architecture, by providing governmental agencies and other nonprofit organizations with professional assistance in evaluation, documentation, and preservation of significant architecture. The Department of Public Works contracted with Architectural Heritage to devise a system which would evaluate, rate, and screen the historic sites survey information gathered by volunteers in 40 communities in eastern Massachusetts.

Preliminary Classification System Objectives

The objective of the classification system is to provide highway engineers and transportation planners who are not familiar with architectural history with a measure of the relative architectural and historical worth of each structure or area. The system provides a preliminary classification to be used by planners and is not intended to be a final evaluation. It will first identify structures inventoried throughout the commonwealth that have value to the general public or to a community of interest broader than those of a particular town or city. Second, it will identify those structures or areas of greatest historical and/or architectural value to each town.

Classification System Methodology

Architectural Heritage reviews the inventory forms pertaining to one town to determine the quality and quantity of the information gathered by local historians. This information, in part, has been recorded on Massachusetts Historical Commission forms, one form for each area (Form A) or each structure (Form B). This architectural and historical information is supplemented by photographs and lists of previously inventoried sites, such as the Historic American Building Survey (H.A.B.S.).

The locations of all sites submitted by local historians or volunteers are mapped and show the spatial relation of one site to another. Often a related group of buildings, illustrative of an architectural period or development, are identifiable from these maps. If not already determined by local volunteers, these architectural or historical areas are carefully noted and identified on Massachusetts Historical Commission area forms.

When all available information is reviewed, a preliminary measurement is made of the relative worth of each inventoried area and site. Each one is rated twice, historically and architecturally.

Evolution of Classification System

Other surveys were examined and a preliminary classification list for Massachusetts was drawn up. The need was recognized for quality control of completeness and accuracy of submitted inventory forms and for a preliminary measurement within established definitions that would meet the requirements of transportation planners in the early stages of planning. After the practical application of this preliminary classification system to several towns, the need for revision became apparent. The preliminary system was incomplete and placed too little value upon areas. The final criteria as they evolved were comprehensive and also took greater recognition of the relatively rare occurrence of significant historical and architectural areas.

Explanation of Classifications

An area is considered a group of typical or related buildings, illustrative of an architectural period and maintaining an atmosphere of an earlier time, or a group of buildings with historic associative value. An area may also be a piece of land, cemetery, town common, pathway, etc., that cannot be defined as a single structure. A structure or site is an individual building or location of architectural or historical value.

Ratings range from 1 to 5 in descending magnitude of value to the nation, commonwealth, and town. Rating 6 indicates incomplete information. The first two ratings pertain to the value to the general public or to a community of interests broader than those of one town. The next two pertain to the interest of a particular town. The last is a tool to screen out the individual sites that are not significant to either commonwealth or town or are too incompletely documented for forming judgments. (See Rating Criteria at the end of this Appendix.)

The scope of judgment is limited to the number of inventoried sites which have been submitted for each town.

Rating 1 identifies sites that have historical associations known to and for the use of the general public and that are exempt from eminent domain.

Rating 2 identifies sites that are known beyond their community, in the commonwealth or nation.

Rating 3 identifies those sites that are of major importance to a particular town.

Rating 4 identifies the sites in a town that are significant but not of major significance in relation to the other inventoried sites.

Rating 5 identifies sites of no significance because of deterioration, major alterations, or recorded but insignificant history.

Rating 6 identifies those sites with inadequate historical or architectural information.

If a site does not receive the same rating both historically and architecturally, it is judged by the higher rating.

Application of Classifications

All ratings are reported on a standard form "Area and Structure Itemized Listing by Town" (see Fig. 7). Architectural and historical areas are the first to be rated. Areas are usually judged to be of major significance to a town. Each site and structure within the area usually is judged to have at least an equal rating to the area. A site is judged to have relatively greater value if it is a component of an architecturally or historically valuable area. This judgment is made in the belief that in the evaluation of architectural or historical assets, the grouping of related structures is an increasingly rare phenomenon.

AREA AND STRUCTURE ITEMIZED LISTING BY TOWN
TOWN: BOXFORD

DATE	HIST. AREA	HISTORIC STRUCTURE/AREA NAME	CODE *	CLASSIFICATION HIST.	CLASSIFICATION ARCH.
18th		East Boxford Village Area	05 038 1 072	3	3
19th		West Boxford Village Area	05 038 1 071	3	3
SITES 1790		Major John Robinson	05 038 1 001	3	4
1845		Stone House	05 038 1 002	4	4
1745		G. B. Austin	05 038 1 003	6	4
1763		Bradstreet Tyler	05 038 1 004	6	4
1788		Governor Andrew	05 038 1 005	2	2
1775		Nason House	05 038 1 006	4	4
1843	X	Second Congregational Church	05 038 1 007	3	3
1830	X	Ephraim Foster	05 038 1 008	3	3
1780		Kimball-Rowe-Allen	05 038 1 009	3	4
1810		Peter Pearl	05 038 1 010	4	4
		Site of Old Morse House	05 038 4 011	4	5
1793		Doherty House	05 038 1 012	4	4
1730		Col. Thomas Knolton	05 038 1 013	3	4
1690		Tyler Wood Homestead	05 038 1 014	2	3
1812		Jonathon Foster	05 038 1 015	4	4
1695		Eagle Nest Farm	05 038 1 016	4	4
~~1794~~		~~Israel Foster~~	~~05 038 1 017~~	~~6~~	~~6~~
1700		H. Berry	05 038 1 018	3	4
1702		Old Adams House	05 038 1 019	3	3
1810		Brookview Farm House	05 038 1 020	4	4
~~1805~~		~~Israel Spofford~~	~~05 038 1 021~~	~~6~~	~~6~~
1730		Connecticut Saltbox	05 038 1 022	4	4
1730		John Boardman	05 038 1 023	4	4
1831		D. Bremmer	05 038 1 024	4	4
1800		S. P. Peabody	05 038 1 025	2	4

Figure 7. Area and structure itemized listing by town for Boxford.

(Boxford Continued)

DATE	HIST. AREA	HISTORIC STRUCTURE/AREA NAME	CODE*	CLASSIFICATION HIST.	CLASSIFICATION ARCH.
1790		Match Factory House	05 038 1 026	3	4
1830	X	George Perley	05 038 1 027	3	3
1826	X	Captain John Peabody	05 038 1 028	3	3
1774	X	Alice Freeman Palmer	05 038 1 029	3	3
~~1812~~	~~X~~	~~Samuel Perley~~	~~05 038 1 030~~	~~6~~	~~6~~
1840		W. G. Mathews	05 038 1 031	4	4
~~1817~~		~~Eliphalet Perley~~	~~05 038 1 032~~	~~6~~	~~6~~
1760	X	Abraham Reddington	05 038 1 033	3	3
~~1856~~		~~G. K. Cole~~	~~05 038 1 034~~	~~5~~	~~5~~
early 19th		R. K. Foster	05 038 1 035	4	4
1750		Gould Sawyer	05 038 1 036	4	4
~~17th~~		~~Goodrige Gould~~	~~05 038 1 037~~	~~5~~	~~5~~
1842		Daniel Gould	05 038 1 038	5	4
~~1783~~		~~John Gould Farmhouse~~	~~05 038 1 039~~	~~6~~	~~5~~
~~1745~~		~~Solomon Wood~~	~~05 038 1 040~~	~~6~~	~~6~~
1828		Deacon Samuel Bixby	05 038 1 041	3	3
1817	X	Frederick D. Allen	05 038 1 042	3	3
late 17th	X	Wood - Peabody	05 038 1 043	3	3
1938	X	First Congregational Church	05 038 1 044	3	3
1840	X	Jefferson Kimball	05 038 1 045	3	3
1700	X	Thomas Reddington	05 038 1 046	3	3
1844	X	John Averill	05 038 1 047	3	3
1770	X	Rev. Wm. P. Alcott	05 038 1 048	3	3
1841	X	Wm. Howe	05 038 1 049	3	3
1842	X	Rev. Coggin	05 038 1 050	3	3
1760	X	Holyoke - French	05 038 1 051	1	1
1825	X	Dean Andrews	05 038 1 052	3	3
1835	X	Ancill Dorman	05 038 1 053	3	3

Figure 7. Continued.

(Boxford Continued)

DATE	HIST. AREA	HISTORIC STRUCTURE/AREA NAME	CODE	CLASSIFICATION HIST.	CLASSIFICATION ARCH.
1688	X	Moses Dorman	05 038 1 054	3	3
mid 18th	X	Nat Dorman	05 038 1 055	3	3
1842		Daniel Andrews	05 038 1 056	4	4
1773		Amos Perley	05 038 1 057	4	4
1687		Watson - Hale	05 038 1 058	3	4
1749		Old Barnes House	05 038 1 059	3	3
~~1721~~		~~Garob Gould~~	~~05 038 1 060~~	~~5~~	~~5~~
1765		Solomon Gould	05 038 1 061	4	4
mid 19th		Zaccheus Gould	05 038 1 062	6	4
1810		Chester Killman	05 038 1 063	3	4
early ~~18th~~		~~Dr. George W. Sawyer~~	~~05 038 1 064~~	~~5~~	~~5~~
1790		Janes House	05 038 1 065	4	4
1818		Aaron Perley	05 038 1 066	4	4
1749		Old Hale House	05 038 1 067	4	4
late 17th		Asa Perley	05 038 1 068	4	4
1890		Hale House	05 038 1 069	4	4

Notes: *County XX City XXX Single site or area X Site number in area XXX

——————Structures classifies with 5s or 6s.

Figure 7. Continued.

After areas and all the individual sites within the areas are identified and rated, the sites scattered throughout the town are rated. In most instances, these sites are rated to be of importance to a town. Occasionally a structure is found that has a community of interest broader than the town.

Application of Classification: Boxford

Boxford was used as a case study, and all submitted material was reviewed by Architectural Heritage. The information from the field was compiled by the Boxford Historical Society, directed by Loren Wood. From this material, consisting of forms, maps, and photographs, the overall measure of the inventoried sites and areas was taken: number and location of areas, identification of structures within these areas, and recognition of structures outside of areas. The inventory included 69 structures and two areas—East Boxford and West Boxford. Both areas were judged to be of major importance to Boxford and were rated as 3. All the 21 inventoried structures within the areas were also rated at least 3 historically and architecturally.

Structures not in areas were judged next. Ten inventory forms (in 5-6 rating category) were screened out because the structures were judged not significant or the information was too incomplete to make a judgment. This left a total of 61 inventory forms significant enough to be computerized. Four structures were judged to have a value and scope of interest beyond the town and were rated 1 or 2. Nine sites were judged to be of major significance to the town but not of major importance and were rated 4; none of the 25 is unique in Boxford, a town unusually fortunate in the number and quality of its historic houses (see Fig. 7).

Conclusion

This classification system is unique and is the first devised for transportation planning. Ratings provide an assessment of the relative value of each site, and are comprehensive, yet easy for a planner to use. The system is preliminary and will be followed, when needed, by an in-depth evaluation based on more precise location of transportation facilities. Though devised for the Commonwealth of Massachusetts, this system could be applied in any state.

PRELIMINARY HISTORICAL RATING CRITERIA FOR THE CLASSIFICATION OF MASSACHUSETTS HISTORICAL COMMISSION SURVEY FORMS

1—For Public Use, or Exempt from Eminent Domain

Area—historically significant

- Mass. Historic Landmark, designated by Mass. Historical Commission
- National Historic Landmark, designated by U.S. Department of Interior
- National Park or State Parkland (with historic Associations, buildings, sites)
- Town park or town common (excluding surrounding buildings)
- Preserved or maintained by a historical organization as an ancient landmark, or property of historical or antiquarian interest
- Burial ground or any tract of land used for more than one hundred years as a burial place

Structure or site—historically significant

- Mass. Historical Landmark, designated by Mass. Historical Commission
- National Historic Landmark, designated by U.S. Department of Interior
- Within National Park or State Parkland (with historic associations)
- Structure owned, preserved and maintained by any historical organization or society as an ancient landmark or as property of historical or antiquarian interest

2—Significant to Commonwealth/Nation

Area—historically significant to Commonwealth/Nation

- Historic District
- Group of buildings or sites related to historical development, person, or event significant in the history of Commonwealth/Nation
- Archaeological or geological area significant to Commonwealth/Nation

Structure or site—historically significant to Commonwealth/Nation

- Structure within an area historically significant to Commonwealth/Nation
- Structure or site related to historical development, person, or event significant in the history of Commonwealth/Nation
- Structure previously recorded in national surveys

3—Major Significance to Town

Area—historically significant to town

- Group of buildings or site related to historical development, person or event significant in the history of town
- Archaeological or geological area significant to town

Structure or site—historically significant to town

- Within an area historically important to town
- Related to an important historical development, person, or event significant in history of town

4—Minor Significance to Town

Area, structure, or site whose historical importance is not of major significance to town

5—Not Significant

Area or structure researched but not historically significant

6—Significance not Determined

Historical information not recorded

ARCHITECTURAL HERITAGE, INC.
March 31, 1967

PRELIMINARY ARCHITECTURAL RATING CRITERIA FOR THE CLASSIFICATION OF MASSACHUSETTS HISTORICAL COMMISSION SURVEY FORMS

1—For Public Use, or Exempt from Eminent Domain

Area—architecturally significant

- Mass. Historic Landmark, designated by Mass. Historical Commission
- National Historic Landmark, designated by U.S. Dept. of Interior

Structure—architecturally significant

- Mass. Historic Landmark, designated by Mass. Historical Commission
- National Historic Landmark, designated by U.S. Dept. of Interior
- Within an area designated as a National Park or State Parkland
- Owned, preserved, and maintained by any historical organization or society as an acient landmark or as property of historical or antiquarian interest

2—Significant to Commonwealth/Nation

Area—architecturally significant to Commonwealth/Nation

- Historic District
- Outstanding group of related buildings, illustrative of an architectural period or development
- Outstanding example of landscape architecture

Structure—architecturally significant to Commonwealth/Nation

- Within an area architecturally significant to Commonwealth/Nation
- Work of great architect or builder; great work of minor architect or builder
- Outstanding example or rare survivor of an architectural style
- Early example of an architectural detail or construction technique

- Noteworthy architectural curiosity
- Outstanding example of earlier commercial, industrial, or institutional building
- Recorded in an earlier national survey

3—Major Significance to Town

Area—architecturally significant to town
- Group of typical or related buildings in their original settings, preserving the atmosphere of an earlier time
- Outstanding landscape architecture important to town

Structure—architecturally significant to town
- Within an area architecturally significant to town
- Outstanding example or rare survivor of an architectural style (town)
- Outstanding example of an earlier commercial, industrial or institutional building (town)

4—Significant to Town but not Unique

Area not unique, but noteworthy because of maintaining atmosphere of earlier time

Structure not unique, but noteworthy because a survivor of an earlier architectural period

5—Not Significant

Area whose architectural integrity has deteriorated by numerous changes in design

Area not architecturally significant

Structure whose architectural significance has been destoryed by drastic alterations

Structure not architecturally noteworthy, and not within area of architectural significance to town

6—Significance not determined

Architectural information not recorded

ARCHITECTURAL HERITAGE, INC.

Management of Turfgrass Treated With Maleic Hydrazide

R. C. WAKEFIELD and A. J. CLAPHAM, Department of Agronomy and Mechanized Agriculture, University of Rhode Island

A field experiment was conducted for two seasons to study the effect of maleic hydrazide (MH) on a mixed stand of perennial grasses and to investigate the interrelationships of nitrogen fertilizer treatments, mowing schedules, and application rates of growth retardant.

MH limited the height and dry weight of clippings of all species including Kentucky bluegrass, orchardgrass, and quackgrass at both 4 and 8 lb/acre. The higher rate gave best results. MH reduced the number and height of orchardgrass and quackgrass seedheads and reduced the height of bluegrass seedheads so that their presence was not objectionable. It reduced growth of grasses throughout the period of normally heavy growth. A slight increase in growth of treated grass followed during the summer which was attributed to utilization of carbohydrates accumulated during growth suppression. MH caused thinning of the sod during the spring, which favored encroachment of weeds. Normal stand density returned during the summer, but weed problems remained. Low cutting increased the clipping weights but not the number of mowings necessary. Plots cut high had greater density of grass and better color.

Results of these studies indicate that MH will effectively retard growth of grasses when applied during early May in Rhode Island. The vigor of grass based on use of nitrogen fertilizer did not affect results with retardant although density and color of grass was improved when nitrogen was used. High cutting was superior to low cutting by maintaining density and good general appearance of the grass. Use of a herbicide to control broadleaf weeds seems imperative.

•A GOOD stand of turfgrass or other type of vegetation is important along highways to prevent erosion and improve the appearance of the landscape. Grasses are used extensively because a cover can be established easily in a short time. Maintaining the extensive acreages of turfgrass along modern highways presents a problem, particularly during the flush period of growth in late spring. At this time weather conditions are ideal for growth and seedheads are produced. Labor and equipment costs make mowing of highway turf an expensive process. As the miles of highways increase and as public acceptance of well-maintained roadside turf increases, maintenance costs can be expected to increase.

A synthetic growth retardant, maleic hydrazide (MH), is available for spraying on roadside turf (1, 10). It has been on the market for some time and has been used with varying degrees of success (2, 5, 6, 7, 8, 9). Highway departments have been interested in the retardant in order to control the growth of grass along highways. Perhaps the most frequent question asked is: How many mowings will it save? Specific answers have been difficult to formulate, since effectiveness is related largely to pre-

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Paper sponsored by Committee on Roadside Development and presented at the 47th Annual Meeting.

vailing conditions at the time of application. Temperature, relative humidity, amount of leaf area present, stage of grass development, whether the chemical is fully translocated or not—all have been cited (4, 12).

In general, MH has been found to be effective for about 6 weeks (1, 3) when used at 4 or 6 pounds per acre and applied to green grass in the early spring when the grass was 2 to 3 in. tall (12). As the use of MH spread it became evident that a herbicide program was necessary to control broadleaf weeds, otherwise continued mowing would be necessary. Application of 2, 4-D with MH was found to be advisable (2, 5, 6, 11).

Maintenance practices on treated areas appear to have a great deal of influence on the success and economy of "chemical mowing" with MH (4, 5). They include proper mowing height and use of fertilizer to maintain dense, weed-free, and attractive stands of grass. Several management practices that may influence the effectiveness of MH were explored.

EXPERIMENTAL METHODS

A field experiment was initiated at the Rhode Island Agricultural Experiment Station agronomy plots on well-established mixed stands of turfgrasses. These consisted of Kentucky bluegrass (75 percent), quackgrass (10 percent) and orchardgrass (5 percent), with small percentages of tall fescue, redtop and colonial bentgrass, and approximately 5 percent broadleaf weeds identified as red sorrel and Virginia copperleaf. Crabgrass was also present in the late summer.

The plot area was uniformly fertilized with 400 lb/acre of a 0-20-20 fertilizer and sprayed with 1 lb/acre (ai) 2, 4-D before the experiment was begun. Treatments consisted of two rates of MH* (4 and 8 lb/acre), three cutting treatments (low—5 cm, high—10 cm, and a late hay-type cut) and three times of nitrogen fertilizer (50 lb N/acre as ammonium nitrate) applied in the early spring—2 weeks before use of MH, midspring—at the time of MH application, and late spring—2 weeks after use of MH. Plots were cut when growth exceeded the desired height by 5 cm, or at 10 cm and 15 cm for the low and high cuts. A randomized complete block design with four replications was utilized to allow statistical interpretation of data. Plot size was 6 by 20 ft.

MH was applied with a bicycle-mounted compressed air sprayer fitted with four fan-type nozzles. Plots were cut with a rotary mower outfitted with a bag to catch clippings which were then dried and weights recorded.

Morphological data consisted of measurements of height and counts of seedheads. Observational data were taken on vigor of growth, color, vegetative cover, and the percentage of weed growth. Rhizome growth was measured on field plugs of sod 2 in. in diameter which were potted in sand and allowed to grow in the greenhouse for 8 weeks.

The experiment was continued for two years on the same plots. Weather conditions were cool with adequate rainfall during both spring periods for good growth of grass. Application of MH was on May 8, 1965, and May 11, 1966. Conditions were excellent for uniform application and no rainfall occurred during the 24-hr period following spraying. Rainfall during both summers was below normal.

RESULTS AND DISCUSSION

The field experiment, conducted for two years, included data on the height of growth, amount of growth as measured by clipping weights and number of mowing necessary, rhizome growth, and observational data on grass density, color, vigor, and on weed encroachment.

Height of Growth

MH substantially reduced the height of seedheads and vegetative culms of grasses during the spring period of most active growth (Fig. 1). Results were similar for all

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*Maleic hydrazide (MH), 6-hydroxy-3-(2H)-pyridazione. The formulation used was MH-30 (registered trademark of UniRoyal, Naugatuck Chemical Division).

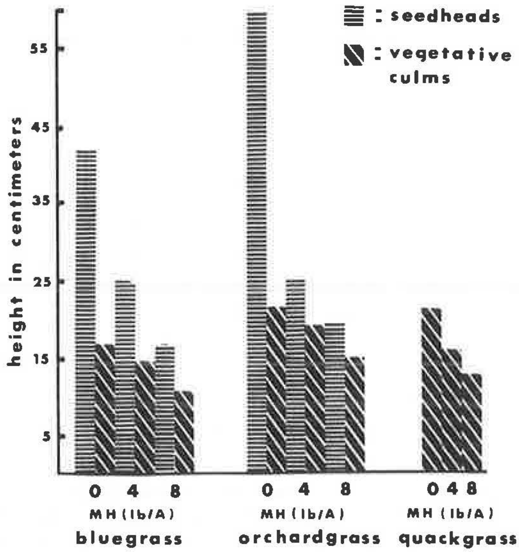

Figure 1. Average height of grass species on May 25, 1965, after treatment with maleic hydrazide.

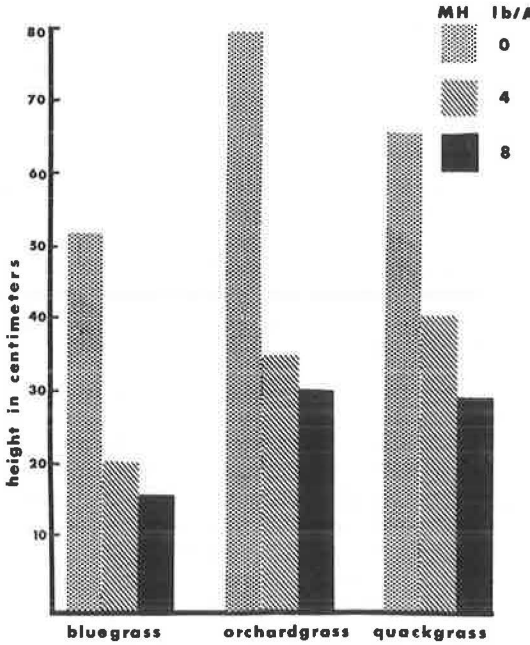

Figure 2. Average height of seedheads of individual grass species on July 21, 1965, after treatment with maleic hydrazide.

species, although quackgrass seedheads had not emerged as of May 25, 1965, when initial measurements were made. Continuing measurements of height revealed that the effectiveness of MH lasted for approximately 6 weeks in 1965. Height measurements of Kentucky bluegrass, orchardgrass, and quackgrass in late-cut plots on July 21 revealed effective suppression of seedhead elongation through this data (Fig. 2). For example, Kentucky bluegrass treated with 4 and 8 lb/acre of MH reached 20. 2 and 13. 2 cm compared to 51. 9 cm for untreated plots. Nitrogen applied early or in

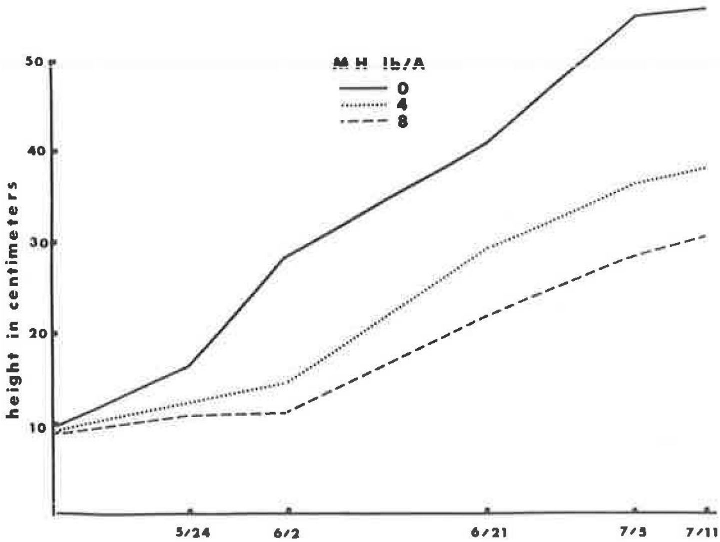

Figure 3. Average height of grass in 1966 after treatment with maleic hydrazide.

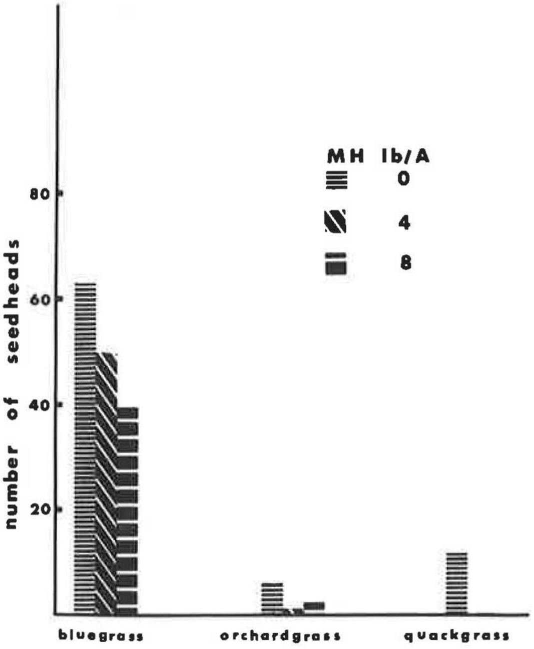

Figure 4. Number of seedheads per square foot, 1965.

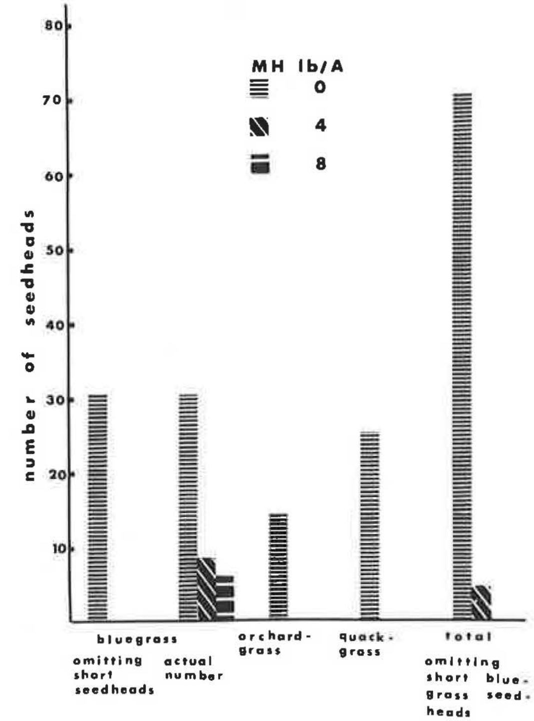

Figure 5. Number of seedheads per square foot, 1966.

midspring stimulated growth of grass, particularly Kentucky bluegrass. However MH was effective in retarding the height of nitrogen-fertilized grass.

In 1966, data were recorded on the average height of all grass species and results of 1965 were confirmed (Fig. 3). The average reduction in height was 32 percent for 4 lb and 45 percent for 8 lb of MH through July 11 (8 weeks). On this date grass treated with MH was relatively shorter from early and midspring nitrogen than late applications as shown in 1965. Height of regrowth was measured at the end of 1966 on late-cut plots and could not be related to spring MH treatments or nitrogen treatments, indicating that effects had largely dissipated prior to the initial mowing on July 11, 1966. Kentucky bluegrass seedheads per unit area were reduced but not eliminated by MH (Fig. 4). As noted previously, height of growth was greatly affected but very short seedheads were observed within the vegetation. The number of orchardgrass seedheads was reduced slightly, and quackgrass seedheads were completely eliminated by MH.

The vegetation clipped high (10 cm) contained the many shortened bluegrass seedheads. These were not objectionable since they were effectively screened by leaf growth and did not contribute to the mowing requirement. Seedhead counts in 1966 showed that no bluegrass seedheads emerged beyond 10 cm (Fig. 5). As in 1965 orchardgrass and quackgrass seedheads were greatly reduced in number, particularly at the 8-lb rate of MH. The number of seedheads was not affected by nitrogen fertilizer applications, although height was greater where no MH was used.

Clipping Weights

Regularly mowed plots were cut eight times at two heights while late-cut plots were mowed once in 1965. At each mowing 5 cm of growth were removed to reach the prescribed height (15 cm back to 10 cm, and 10 cm back to 5 cm). The time of cutting for all regular plots was determined by the height of growth when not treated with MH and

TABLE 1

SEASONAL TRENDS IN DRY MATTER YIELDS OF CLIPPING (GRAMS) 1965

Treatment	5/25	6/10	6/22	7/7	7/20	8/4	8/19	9/9	9/29
MH (lb/acre)									
0	368a*	215a	65b	35b	42b	41b	35b	34c	25b
4	202b	161b	77a	48a	54a	51a	44a	40b	31a
8	172b	68c	56b	49a	57a	55a	48a	45a	35a
Height of cut									
Low	347a	262a	103a	66a	76a	67a	56a	55a	41a
High	147b	58b	29b	23b	26b	31b	28b	24b	19b
N applied									
Early	411a	160a	56b	44a	53a	52a	47a	43a	31a
With MH	219b	163a	63b	46a	49a	48a	42ab	40a	31a
Late	11c	157a	80a	43a	51a	48a	37b	36b	29a

*Duncan's significance at 5 percent level.

where nitrogen was applied in early spring. Late-cut plots were mowed once on July 21, 1965, when seedheads were mature.

MH substantially reduced the amount of grass clippings on regularly mowed plots in 1965. The first three cuttings were made on May 25, June.10, and June 22. During this period of normally rapid growth, there was 30 percent less growth at 4 lb/acre and 54 percent less at 8 lb/acre (Table 1). The effect of MH did not extend beyond cuttings made on June 22. During the remainder of the growing season there was slightly more dry matter from plots that were treated with MH.

Yields of dry matter from plots cut back to 10 cm were significantly lower than yields from plots cut back to 5 cm for all cuttings during 1965. For example, the average yields from high-cut plots were 234 gm compared to 712 gm for low-cut plots for the first three mowings.

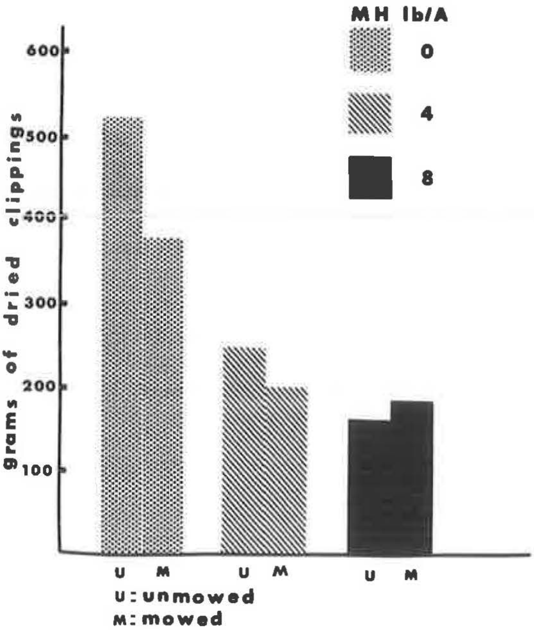

Figure 6. Dry weight of grass clippings from regularly mowed and "unmowed" plots, 1965.

Nitrogen fertilizer applied early stimulated growth considerably compared to applications at subsequent 2-week intervals. This was due to the fact that weather conditions were more favorable for growth in early May. In addition, grass was producing numerous flowering stems during the early period.

It should be noted that MH effectively retarded growth of grass regardless of time of nitrogen application. However, early use of nitrogen stimulated early growth of grass. Therefore, use of nitrogen was more satisfactory when applied at the same time as MH or 2 weeks following MH. Later use of nitrogen had a greater residual effect and improved color and density of grass well into the summer.

Dry matter yields of "unmowed" plots (cut once on July 21) followed a pattern similar to regularly mowed plots treated with MH (Fig. 6). Growth was greater for plots cut once, except where the high rate of MH (8 lb) was used. The volume of growth was considerably reduced with MH treatment on single-cut plots. Mowing and removal of growth were conse-

TABLE 2

NUMBER OF MOWINGS IN 1966

Treatment		Low Mowing		High Mowing	
MH (lb/acre)	N applied	Spring	Summer	Spring	Summer
0	Early	4	1	5	1
4		3	1	3	3
8		2	1	2	3
0	With MH	4	1	5	2
4		3	1	3	2
8		2	2	1	3
0	Late	3	1	4	2
4		1	2	2	3
8		1	2	2	3

quently much easier. The absence of seedheads on these plots also improved the appearance appreciably.

Number of Mowings

During 1966, individual field plots were mowed as required and dry weight yields evaluated for two growth periods (May 16 to 21 and June 21 to 26). Results were similar to those in 1965 but were expressed on the basis of number of mowings necessary for the various treatments (Table 2). MH reduced the number of mowings necessary during the early growth period at both low and high cutting. Three to five mowings were necessary where no MH was used, depending on time of nitrogen application and cutting height. No more than two mowings were necessary when 8 lb of MH was used. When late nitrogen was used in conjunction with low cutting, only one mowing was necessary. Similarly, plots cut high and fertilized in midspring at the time of MH application required only one cutting. No mowing was necessary until early June at either height of cut when nitrogen was deferred and MH used at 4 or 8 lb/acre.

During the second growth period extending from June 21 through the remainder of the growing season, one to three mowings were necessary. Low mowing generally required one less mowing. However, this may be attributed to the severity of the low cut in reducing the vigor of the grass. Low-cut plots appeared dry and brown during the summer period compared to the green and healthy appearance of high-cut plots.

TABLE 3

RHIZOME PRODUCTION OF KENTUCKY BLUEGRASS—1966
FIELD EXPERIMENT

Treatment	MH (lb/acre)			Averages
	0	4	8	
	Number of Rhizomes			
N applied				
Early	9.6a**	3.2b	1.5b	4.8a
With MH	8.1a	2.3b	0.7b	3.7a
None*	1.8b	1.4b	0.2b	1.1b
Averages	6.5a	2.3b	0.8c	
	Dry Weight (milligrams)			
N applied				
Early	177.7a	33.4b	25.4b	79.0a
With MH	139.0a	23.6b	6.9b	56.5a
None	31.4b	13.2b	3.0b	15.9b
Averages	116.1a	23.5b	11.8b	

*Late N had not been applied when the plugs were taken.
**Duncan's significance at the 5 percent level.

One additional mowing was generally necessary during this period where MH had been used. Clipping weights were greater following use of MH. This phenomenon may be attributed to a greater storage of carbohydrates by grass treated with MH which subsequently resulted in greater growth when effects of the chemical dissipated.

Rhizome Growth

In order to determine the effects of MH on underground rhizome growth of Kentucky bluegrass, 2-in. sod plugs were removed from the field 2 days after spraying and planted in glazed crocks filled with sand. Data taken 6 weeks later revealed that MH had severely inhibited the number and average length of rhizomes (Table 3). The dry weights of rhizomes treated with 0, 4, and 8 lb/acre of MH were 116. 1, 23. 5, and 11. 8 mg per pot, on the average. Lower weight of rhizomes was due in part to a substantial decrease in number that developed as a result of MH treatments. Application of nitrogen increased both the number and total weight of rhizomes but did not overcome the effect of MH.

Appearance of Grass Stands

Density—Use of MH resulted in a decrease in the density of turf during the early part of both the 1965 and 1966 growing seasons following application of MH. Density increased later in the season so that differences were small and not significant by early September.

In both years, low cutting decreased the density of the turf compared to high cutting. Plots cut once per season were lower in density than those cut regularly.

Weeds—Plots sprayed with MH were more weedy than check plots during both years. An application of 2, 4-D at 1 lb/acre in April 1965 effectively controlled weeds during the initial stages of the experiment. However weeds again encroached following use of MH. This indicates that MH improved conditions for weed growth by thinning the sod. This was shown by reduced density of sod and restricted rhizome growth of Kentucky bluegrass following treatment. The most troublesome weed was red sorrel which spreads vegetatively and became the dominant species in several plots treated with 8 lb/acre of MH.

Nitrogen applied at time of MH applications encouraged more weed growth than other combination treatments. The reduced nitrogen utilization by grass during growth suppression by MH apparently made it available for weed growth.

Vigor and Color—Observations during both seasons indicated that MH reduced the vigor of grass initially but increased the vigor as the season progressed. High-cut plots were consistently more vigorous than low-cut plots. Nitrogen increased the vigor of growth immediately following applications but growth decreased rapidly after two to three weeks.

MH changed the normal light green color of grass to a dark bluegreen color for approximately 6 weeks. Nitrogen influenced color and vigor similarly. High-cut plots were generally darker green during the entire season.

ACKNOWLEDGMENT

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The Need for Specifying Two- or Three-Step Seeding and Fertilization Practices for Establishing Sod on Highways

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There is a critical need for establishing plant cover quickly along newly constructed highways. Such a sod cover should be well established so as to require a minimum of maintenance after the road construction has been completed. Many miles of new seedings along highways turned over to the Virginia Department of Highways for maintenance have not developed a well-established turf ready to be turned over to maintenance crews.

The one-shot fertilization and seeding practices now specified often result in failures because one or more of the factors necessary for germination, emergence, and seedling growth is adverse. Also, many newly established seedings soon begin to degenerate because of low soil phosphorous and available nitrogen. It is strongly recommended that specifications be amended to include several-step seeding-fertilizer procedures to assure better stands and sod establishment and lower maintenance costs. Several-step seeding procedures, based on grass-legume sod establishment along highways and observations of present practices are recommended. Slowly available sources of nitrogen such as ureaformaldehyde should be included in initial seedings to provide available nitrogen to prolong plant growth, especially in one-step seedings. Research findings for obtaining effective grass stands along highways are summarized.

•PROVIDING plant cover along newly constructed highways for soil and water control must be directed toward obtaining quick and persistent sod cover requiring minimum maintenance. The cover should also blend in with the beautification program and aid in reducing driving monotony on highways.

Many miles of new seedings, made by contractors along highways and turned over to the Virginia Department of Highways for maintenance, do not have a suitable cover of established turf. Such new seedings must usually be refertilized and reseeded out of state funds, as the present "one-step" specifications of liming, fertilizing, and seeding cannot generally produce a sod ready for maintenance. The establishment of turf involves complex interrelationships in biological communities, since dense sods depend on many factors—temperature, moisture; soil characteristics, including liming and fertilizer balance; species, mixtures, and varieties of perennial grasses and legumes; companion grasses; date of seeding; inoculation; mulching; microclimates during establishment; and presence of weed, disease, and insect pests. If any one of these factors is unfavorable—a common occurrence—turf establishment is unsatisfactory. Seeding failures are common because such a biological complex cannot be manipulated and controlled as can the engineering pursuits in highway construction. By adding irrigation to specifications, the success with one-step seedings could be decidedly improved, but cost would be prohibitive.

Our research shows that an effective sod cover can be established in 60 to 100 days under favorable environmental conditions, but such a sod often degenerates because of the low content of organic matter in soils along most highways in the humid East. Lime,

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fertilizer nutrients, and organic matter are characteristically low in almost all soils of the various mineral geological formations in Eastern United States. A several-step seeding and fertilization procedure would assure good establishment and provide needed fertilizer nutrients for the development of rooted plants that would maintain themselves even under adverse conditions.

This paper summarizes some of the cooperative research with the Virginia Department of Highways that shows the need of using several-step seeding operations, including the use of nitrogen, to improve sod cover during the years after establishment.

TURF ESTABLISHMENT ALONG ROADSIDES

Soil Preparation

The initial grading should be done according to specifications so that areas may be seeded to aid in soil and water control before establishing roadbeds. It is common experience that the sod of seeded slopes is often destroyed by regrading because of initial grading errors. Seedings made early while highway construction is under way will allow for several-step seedings and assurance of good grass stands when the turf from newly developed highways is turned over to highway departments for maintenance. Soils should be firm at seeding time to encourage good moisture availability for the small grass and legume seedlings. This will stimulate growth rate and aid in avoiding "washouts." Better stands and maintenance are obtained with top-soiling, but very satisfactory results are being obtained in Virginia on steep slopes with subsoils using proper liming and several-step fertilization practices as outlined later.

Lime and Fertilization

Almost all the soil materials along newly constructed highways in Virginia and the humid East are low in nitrogen (organic matter) and phosphorus and are mildly to very strongly acid. Such acid soils must be limed for bluegrass, tall fescue, clovers, birdsfoot trefoil, crownvetch, and other species of cool and warm season origin. Liming at high rates may temporarily retard sericea lespedeza establishment. Many subsoil materials consist of a low calcium-low phosphorus-high aluminum complex that is often strongly acid. The addition of lime to soils that are strongly acid reduces soluble aluminum, improves phosphorus availability, and adds calcium as a nutrient. Initial liming is necessary for rapid seedling growth and development of a deep root system necessary for the maintenance of most of the desirable turf species. Short-lived species such as redtop thrive without lime. Ordinary finely ground limestone is very satisfactory and coarser particles are effective for a period of years. The lime gives best results when incorporated into the soil, but satisfactory stands have been established and maintained for more than ten years with surface applications.

Fertilizer experiments have been established on many cut and fill slopes on different geological formations in various locations in Virginia. Based on many soils with different seeding mixtures, excellent stands of sod have been obtained by applying 1, 000 to 2, 000 lb/acre of a 10-20-10 or 10-20-5 fertilizer for establishment. Based on many experiments, the Virginia Department of Highways recommends a 10-20-10 fertilizer or its equivalent at 1, 500 lb/acre. So-called turf fertilizers such as 10-6-4 have been unsatisfactory because of low phosphorus content. Low rates of low phosphorus fertilizers have caused very poor seedling growth and establishment.

Because of the low soil organic matter, low nitrogen availability is associated with sod degeneration that often occurs soon after establishment. It is desirable in one-step seedings to use fertilizer formulations containing 50 to 75 percent of the nitrogen as ureaformaldehyde (U-F). In one-step seedings on a wide variety of soil materials, including top and subsoils, the best turf cover four or more years after seeding occurred where 400 lb of U-F was added to the initial application of a 10-20-10 fertilizer. The effects of slowly available nitrogen from U-F are greener grass, denser soil cover, less weed encroachment, and taller but not overstimulated growth. When using all U-F nitrogen in a fertilizer for establishment, seedling growth was slow, yellowish, and nitrogen starved.

Mixtures and Species

It is very important to select grasses and legumes that are relatively easy to establish, but persistence and longevity for easy maintenance are also important. Ideally, the species in a mixture should vary with the slope exposure, soil formation, altitude, latitude, lime and fertilizer programs, and mowing management to be employed. The microclimate on warm, sunny slopes is decidedly different from that on cool, semishaded slopes. For example, excellent stands and sod maintenance are obtained in the southern part of Virginia with the cool season species on semishaded slopes, whereas stands and persistence are less satisfactory on the warm slopes. Conversely, with warm-season species such as bermudagrass, better stands, growth, and persistence occur on the warm slopes. Sericea lespedeza is widely adapted, but develops best on hot slopes; crownvetch is relatively better suited to shaded or semishaded slopes.

Kentucky 31 fescue is used in all latitudes, altitudes, and soil situations because of its extremely wide range of adaptation to soil, climatic, and biotic factors. It is easy to establish because of rapid germination and good seedling vigor and is a hardy perennial when limed and fertilized as mentioned before. Bluegrass is long lived and persistent; creeping red fescue and redtop, especially, are short lived. Redtop is used in small amounts as a component in mixtures becuase of its rapidity and ease of establishment and wide adaptation. Crownvetch does best on the cooler sites of higher altitudes, and especially on limestone and calcareous shale material when the soil pH is above 6.0.

If stands of sericea lespedeza are desired in new seedings, it should be seeded during the late-winter early-spring season at the rate of 30 to 40 lb/acre, with a grass associate such as Kentucky 31 fescue at about 30 lb/acre. In such cases, no more than 50 lb of nitrogen (N) per acre should be applied to reduce the seedling competition of aggressive grasses. When sericea lespedeza is seeded with full seeding rates of grasses and fertilized liberally, especially with nitrogen, the aggressive grass seedlings will crowd out the lespedeza seedlings during the first year. However, hard seeds will germinate in subsequent years and the species will become established.

The establishment of crownvetch demands high soil calcium, which generally accompanies a pH of 6.0 or higher, and liberal phosphorus applications or availability. Stands on shaley limestone soils and cooler sites have been best. Crownvetch seedlings emerge slowly and grow at a slow rate during establishment; thus, it is desirable to reduce light competition by using companion grasses and nitrogen fertilizer at low rates. Best results with crownvetch have been obtained by making seedings during the winter-to-spring season. It is necessary to inoculate liberally and stands that sometimes appear as failures during the first year often develop successfully in subsequent years.

Companion Grasses

Companion grasses such as small grains and annual and perennial ryegrasses are often harmful because their quickly emerging and aggressive seedlings crowd out desirable species. The cereals in unthrashed or partially thrashed straw cause exceptional competition. Seedlings from cereals grow many times faster than perennial grasses and legumes; thus, desirable perennials are frequently "shaded out." In mulch materials that are free from seeds, such as woodfiber celluloses, 5 to 10 lb/acre of annual ryegrass in the seed mixture is desirable.

It is usually not necessary to use the companion grasses with Kentucky 31 fescue since this grass emerges rapidly and has excellent seedling vigor. Kentucky bluegrass emerges slowly and has a slow seedling growth rate; thus, light seedings of companion grasses to stabilize soils while bluegrass gets established are desirable.

Mulches

Mulches used at light rates moderate soil temperatures and improve moisture to hasten germination and seedling emergency and encourage rapid seedling establishment. Mulches should be weed-free and are useless if they do not stay in place on the soil surface. In our work, organic mulches such as straw have given the best stands.

Season of Seeding

The best stands are obtained when seedings are made when the microclimate is most favorable for germination and seedling growth. The best seeding periods are during March through mid-May and mid-August to October.

Weed Control

It is often necessary to use weed herbicides to retard broadleaf competitive weeds. Weeds are usually a more serious problem with topsoiling as compared with seedings made on subsoil materials.

TWO- AND THREE-STEP SEEDINGS FOR ESTABLISHMENT

Experiments conducted since 1955 show that grass stands degenerate soon after seeding with the one-step application of lime, fertilizer, and seed. The changing of the specifications to high rates of fertilizer high in phosphorus, such as a 10-20-10 fertilizer at 1, 500 lb/acre has reduced sod degeneration, but it has not solved it. Such fertilizers improve the available phosphorus in soils for many years, but grass sods degenerate because of low soil N, especially because of low organic matter. Almost all topsoil materials are low in organic matter; hence, nitrogen for maintenance becomes a problem. Inspection of seedings made 10 years ago shows excellent sod cover for soil and water erosion control and also little weed encroachment where such original seedings were refertilized two or three times. These seedings were made in spring and were refertilized the following September or October. On steep and difficult sites, an additional third application of fertilizer was needed about one year after the two-step application.

For all seedings, the sod cover was decidedly improved by the second fertilization the next spring. A third application one year later was necessary to get a permanent sod cover. By comparison, sod cover on such areas with one-step seedings is very poor, exhibiting bare soil and much weedy growth.

Refertilizing only across the top 8 ft of slopes has added to the longevity of the sod, as such areas on slopes usually degenerate first.

It is especially necessary to use a two- or three-step method on sunny, hot slope sites as they require more fertilizer and plants are less persistent than for cool slopes. The following suggestions are based on experiments and observations on many slope and soil conditions.

For shallow, cool slope sites, with soils of better than average fertility and good physical properties, the preferred method is as follows:

1. Apply lime incorporated to a 3 to 5-in. depth at 1 to 2 tons/acre. (It would be desirable to base this on soil tests.)
2. Apply a 10-20-10 fertilizer at 800 lb/acre and seed. Six months later, add 400 lb/acre of a 10-20-10 fertilizer plus 300 lb/acre of U-F. Apply 75 percent across top half of slopes.

An alternate method is as follows:

1. Apply lime as above.
2. Apply 1, 000 lb of a 10-20-10 fertilizer or its equivalent, plus 300 lb of U-F per acre, plus normal seed rates.

For 2:1 slopes in more difficult soil environments with problem fertility or physical properties:

1. Apply lime as above.
2. Apply a 10-20-10 fertilizer or its equivalent at 800 lb/acre with a 75 percent normal seeding rate. Three to six months later, apply 10-20-10 or its equivalent at 500 lb/acre, 300 lb of U-F, and 25 percent of original seeding rate.

For 1:1 slopes in the more difficult soil and microclimatic environments the following procedure is recommended:

1. Apply 1 to 2 tons of lime. (Soil test is desirable.) Lime and fertilizers may be applied after mulching.
2. Apply 10-20-10 or its equivalent at 800 lb/acre with a 75 percent normal seeding rate.
3. Within three months apply 10-20-10 or its equivalent at 400 lb/acre with a 25 percent normal seed rate. Apply 75 percent of mixture across top 50 percent of slope.
4. Apply 10-20-10 or its equivalent at 400 lb/acre and U-F (152 lb N) at the same rate, with 75 percent on top half of slopes.

Use lateral furrows for all slopes 1:2 or steeper. A 10-20-5 fertilizer is preferred over a 10-20-10 because of less osmotic and burning effects on seedlings.

CONCLUSIONS

A 10-20-10 fertilizer or its equivalent at 1,500 lb/acre will give better results in a two- or three-step seeding on any soil or microclimate for the following reasons:

- Better grass and legume stands are produced as competition for water and/or injury from salts is reduced.
- Legume stands will be improved because of reduced competition from grass as less N is initially applied.
- There will be less competition from weeds. Fertilizer will be used more efficiently as grass seedlings will be more competitive with weeds by the time a second application of fertilizer is made.
- The need for specifying topsoiling is practically eliminated. Most topsoil is of poor quality and contaminated with weeds. However, good topsoil free of weeds will improve the initial stands and sod maintenance.
- There is invariably some soil, seed, and fertilizer movement down slopes, even on shallow ones due to torrential rains or channeling of accumulated water from rainfall. Thus, with one-step methods some soil areas will be left without seed and fertilizer. Such bare areas become enlarged in subsequent years and soil and water movement may become serious.
- Seeding rates could be reduced with several-step seedings. Also, a given amount of seed would be more effective.
- Sod degeneration of young seedlings often starts 6 months after seeding; hence, a two- or three-step method would improve size of plants, root depth, persistence, and longevity.

The use of U-F is desirable with a one-, two-, or three-step establishing method because nitrogen for grass maintenance then becomes available for at least four years after establishment.

The implementation of a several-step seeding and fertilizer program would assure good sod establishment and persistent long-lived sods. It would avoid the heavy expenses now encountered by the Virginia Department of Highways for reseeding and refertilizing along newly constructed highways to obtain a suitable cover.

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Control of Grasses and Weeds Growing in Asphalt Pavements

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Herbicides offer the engineer a means for controlling vegetation involving asphalt surfaces. The plants may arise from seeds or plant parts in the base material, by encroachment of plants from outside the pavement, or from seeds that become lodged in cracks or seams in the pavement.

Bermudagrass and many associated plants can be controlled with either presurface or postsurface application of herbicides. Presurface treatment just before the prime coat effectively prevents the penetration of the new surface by plants growing from the base material. Postsurface treatments are applied on a program basis beginning with the start of plant growth in the spring. Subsequent treatments are applied when the plants again become green, usually 30 days following the initial treatment. A TCA application at 200 lb/acre is used for each postsurface treatment.

Research is still seeking effective postsurface treatment for a mixture of annual and perennial broadleaf and grassy weeds in northwestern Texas. Materials recommended for open-soil treatment in agriculture are not as effective when applied to the same materials growing in asphalt surfaces.

•VEGETATION growing in asphalt pavement presents a problem for highway engineers. This unwanted vegetation greatly shortens pavement life, traps dirt and other trash, and creates an irregular border along the travelway. Asphalt surfaces on shoulders, especially those along the inside of divided highways, and on roads carrying low rates of traffic are most susceptible to weed invasion. Medians and islands paved with asphalt and used for channelization also become infested with weeds.

Problem plants range from bermudagrass, johnsongrass, and associated plants in eastern Texas, to bindweed, blueweed, carelessweed, and other species in northwestern Texas. Plants infesting pavements originate from seeds or other plant parts contained in the base material, encroachment or extension of plants rooted beyond the pavement, and seeds that lodge in the surface aggregate, cracks, or joints in the pavement.

The Texas Highway Department initiated a program in 1959 to compare various herbicides for controlling bermudagrass and other weedy plants in the eastern part of Texas. In 1960, a cooperative research program was initiated with the Texas Transportation Institute and the Texas Agricultural Experiment Station of Texas A&M University to develop treatments for controlling unwanted vegetation on highway rights-of-way. The U. S. Bureau of Public Roads joined in this cooperative effort in 1962.

An analysis of the problem suggested the research approach of preventing entry by weeds into asphalt pavements or developing treatments for vegetation invading pavements already in place. Preventive treatments would be applied to the surface of the base material just ahead of the first asphalt course (prepaving). Weeds in existing pavements would be treated as the need developed (postpaving). Tests were initiated

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TABLE 1

MATERIALS USED AND APPROXIMATE COST OF PREPAVING TREATMENTS FOR 1959 AND 1960 TESTS

Herbicide	United Price (est.)[a]	Rate per ft-mi	Cost per ft-mi
	1959		
Polyborchlorate	$ 0.11	212.5 lb	$23.37
Sodium TCA	0.35	12.5 lb	4.37
		25.0 lb	8.75
Dalapon	0.92	10.0 lb	9.20
Monuron	2.60	7.5 lb	19.50
Chlorax liquid	0.35	20.80 gal	7.28
		31.25 gal	10.94
Erbon	4.99	5.0 gal	24.95
	1960		
Polyborchlorade	$ 0.11	200.0 lb	$22.00
Sodium TCA	0.35	12.50 lb	4.37
		25.00 lb	8.75
Dalapon	0.92	10.0 lb	9.20
Monuron TCA (granules)	0.75	12.50 lb	9.37
Diuron	2.65	5.0 lb	13.25
Monuron	2.60	5.0 lb	13.00
Chlorax liquid	0.35	24.0 gal	8.40
		32.0 gal	11.20
Garlon	6.60	2.5 gal	16.50
Monuron TCA (liquid)	12.00	0.917 gal	11.00

[a]Estimated retail prices were provided by manufacturers in the winter of 1960-61 and may not coincide with current prices. The extended costs per ft-mi do not include mixing and applying the material.

TABLE 2

COMMON AND CHEMICAL NAMES OF HERBICIDES

Common Name	Chemical Name
Amitrole	3-amino-1, 2, 4-triazole
AMS	Ammonium sulfamate
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-s-triazine
Borascu	63% sodium borate, boron trioxide
Bromacil	5-bromo-3-sec-butyl-6-methyluracil
Chlorax liquid	A liquid combination of sodium chlorate and sodium metaborate
Dalapon	2, 2-dichloropropionic acid
Dicamba	2-methoxy-3, 6-dichlorobenzoic acid
Diuron	3, (3, 4-dichlorophenyl)-1, 1-dimethylurea
Erbon	2-(2, 4, 5-trichlorophenoxy) ethyl-2, 2-dichloropropinate
Fenac	2, 3, 6-trichlorophenylacetic acid
Garlon	Ester forms dalapon 50.8¢ and silvex 7.7¢
MCPA	2-methyl-4-chlorophenoxyacetic acid
Monuron	3-(p-chlorophenyl)-1, 1-dimethylurea
Monuron TCA	3-(p-chlorophenyl)-1, 1-dimethylurea trichloroacetate
MSMA	Monosodium acid methanearsonate
Paraquat	1, 1'-dimethyl-1-4, 4'-bipyridinium salt
PBA	Polychlorobenzoic acid
Picloram	4-amino-3, 5, 6-trichloropicloinic acid
Polyborchlorate	73¢ disodium octaborate tetrahydrate and 25¢ sodium chlorate
Prometone	2-methoxy-4, 6-bis (isopropylamino)-s-triazine
Pyriclor	2, 3, 5-trichloro-4-pyridinol
Silvex	2-(2, 4, 5-trichlorophenoxy) propionic acid
Sodium arsenite	Sodium arsenite
Sodium chlorate	Sodium chlorate
Sodium TCA	Sodium salt of trichloroacetic acid
Substituted ureas	Monuron, diuron or monuron TCA
Tritac	2, 3, 6-trichlorobenxyloxypropanol
2, 3, 6-TBA	2, 3, 6-trichlorobenzoic acid
2, 4-D	2, 4-dichlorophenoxyacetic acid

TABLE 3

MATERIALS AND RATES APPLIED AS POSTPAVING TREATMENTS IN 1960

Material	Rate per ft-mi
Dalapon	1.0 lb
	4.0 lb
Garlon	0.75 gal
	1.00 gal
2, 3, 6-TBA	0.75 lb
	1.50 lb
Sodium TCA	12.50 lb
	25.00 lb
Monuron TCA	2.75 lb
	4.125 lb
Diuron	6.25 lb
Polyborchlorate	200.00 lb

in 1960 to develop both pre- and postpaving controls for bermudagrass. Beginning in 1964, herbicides recommended for controlling bindweed and other species on cropland in northwestern Texas were applied postpaving to determine their suitability for controlling the same weeds in pavements.

Bermudagrass and Associated Plants

Both sterilant and systemic type herbicides, including granules as well as liquid sprays, were used in prepaving tests applied in 1959 and 1960 (Table 1). All herbicidal materials tested in prepaving treatments were effective in preventing penetration of the asphalt by plants originating in base material. The substituted ureas, erbon, "Polyborchlorate," "Chlorax liquid" (see Table 2 for chemical designations), damaged the vegetative cover between the edge of the pavement and the ditchline. Damage from herbicides containing substituted ureas was more severe and extended in some cases to the edge of the right-of-way. Application of herbicides in granular form was unsatisfactory because air turbulence caused by traffic whipped them away before they could be stabilized by watering.

Prepaving treatments have been effective for periods varying from one season along the pavement edge to as many as seven years in median areas. They are usually a contract item in new construction, and the contractor is given a choice of using 10 lb dalapon, 24 lb sodium TCA, 200 lb "Polyborchlorate," or 586 lb "Borascu" per ft-mi (8.25 ft-mi = 1 acre).

Postpaving treatments for bermudagrass control stressed the application of systemic herbicides, but some sterilants were included (Table 3). All postpaving treatments were applied as liquid sprays. Of the materials originally applied postpaving, dalapon, sodium TCA, and Polyborchlorate were selected for further comparison in 1961 on the basis of the bermuda control achieved together with the absence of undesirable side effects. A single application of a given material did not effectively control bermudagrass for the entire season, but a second treatment greatly improved the degree of control achieved with the original application.

Dalapon was more effective as a postpaving treatment in the humid eastern portion of Texas than in drier western areas. Polyborchlorate performed equally as well as TCA later in the season (Fig. 1). Each material was applied at three volumes, but no difference in effectiveness could be attributed to volume used.

Of the three materials compared in 1961, sodium TCA combined safety, effectiveness, and relatively low cost for controlling bermudagrass and some other plants infesting asphalt pavements. Consequently, it was tested further in three districts of the Texas Highway Department in 1962.

The ester, acid, and sodium salt forms of TCA were compared for relative effectiveness. The same degree of control was achieved with equivalent amounts of the acid form applied as a water spray; so selection of the form of TCA should be based on cost of TCA equivalent (Fig. 2).

Herbicide programs usually involve a relatively heavy initial application, followed by lighter applications at appropriate intervals. Consequently, the test sections were treated initially at the rate of 24 lb of sodium TCA per ft-mi, and re-treated with 12, 18, or 24 lb/ft-mi. These tests showed that sodium TCA used for controlling bermudagrass should be applied at a uniform rate of 24 lb/ft-mi each treatment date (Fig. 3).

Soil and other trash often accumulate on shoulder pavements infested with vegetation. Sweeping or blading to remove this accumulation prior to the initial application of sodium TCA improved the efficiency of this herbicide. Bermudagrass was controlled equally as well if the accumulated material was removed, and seedlings of many other plants were removed at the same time (Fig. 4).

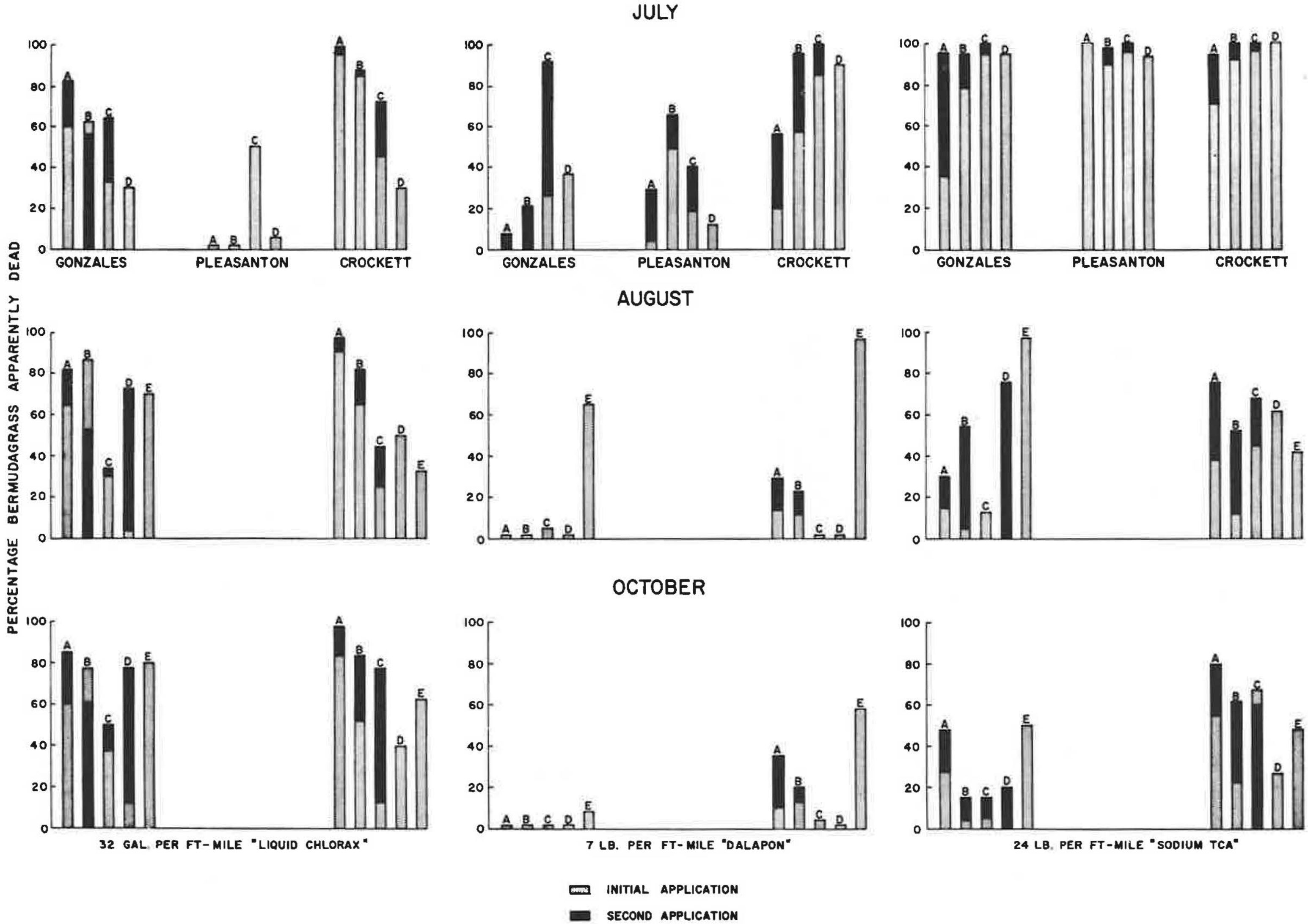

Figure 1. Percentage of bermudagrass apparently dead in July, August, and October, 1961, for one or two treatments of "Liquid Chlorax," dalapon, and sodium TCA applied initially in March (A), April (B), May (C), June (D), or July (E), 1961.

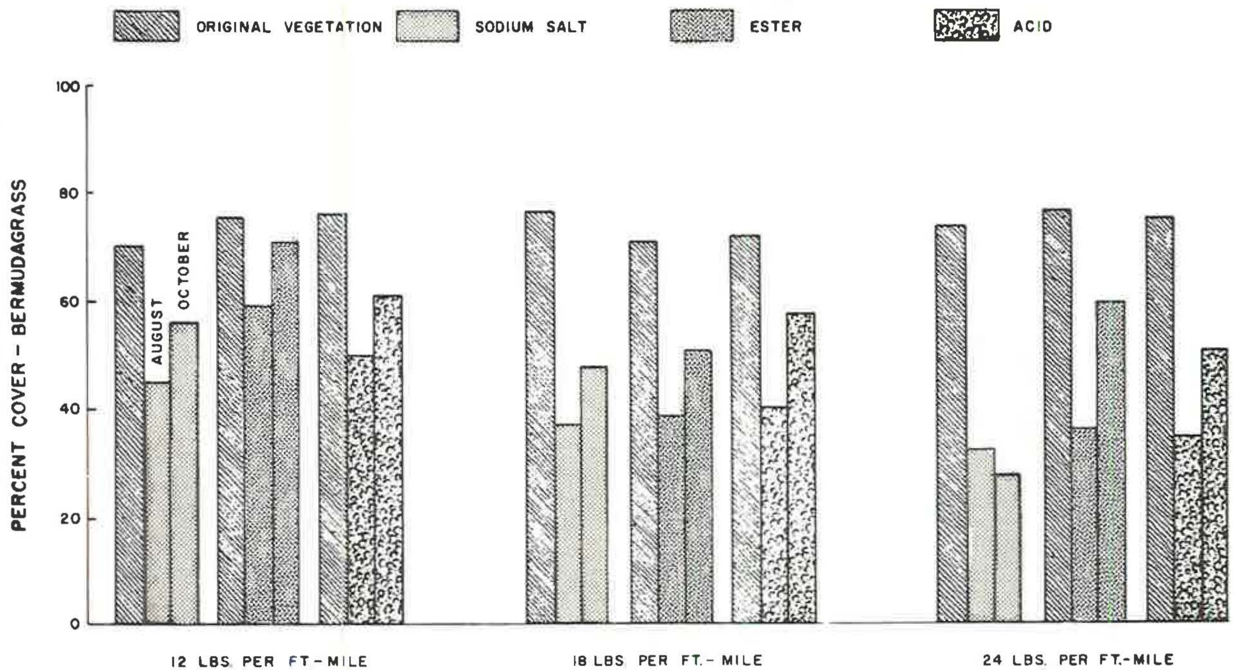

Figure 2. Percent of pavement surface covered with bermudagrass in August and October following treatment in June with TCA. Three formulations were applied at three rates.

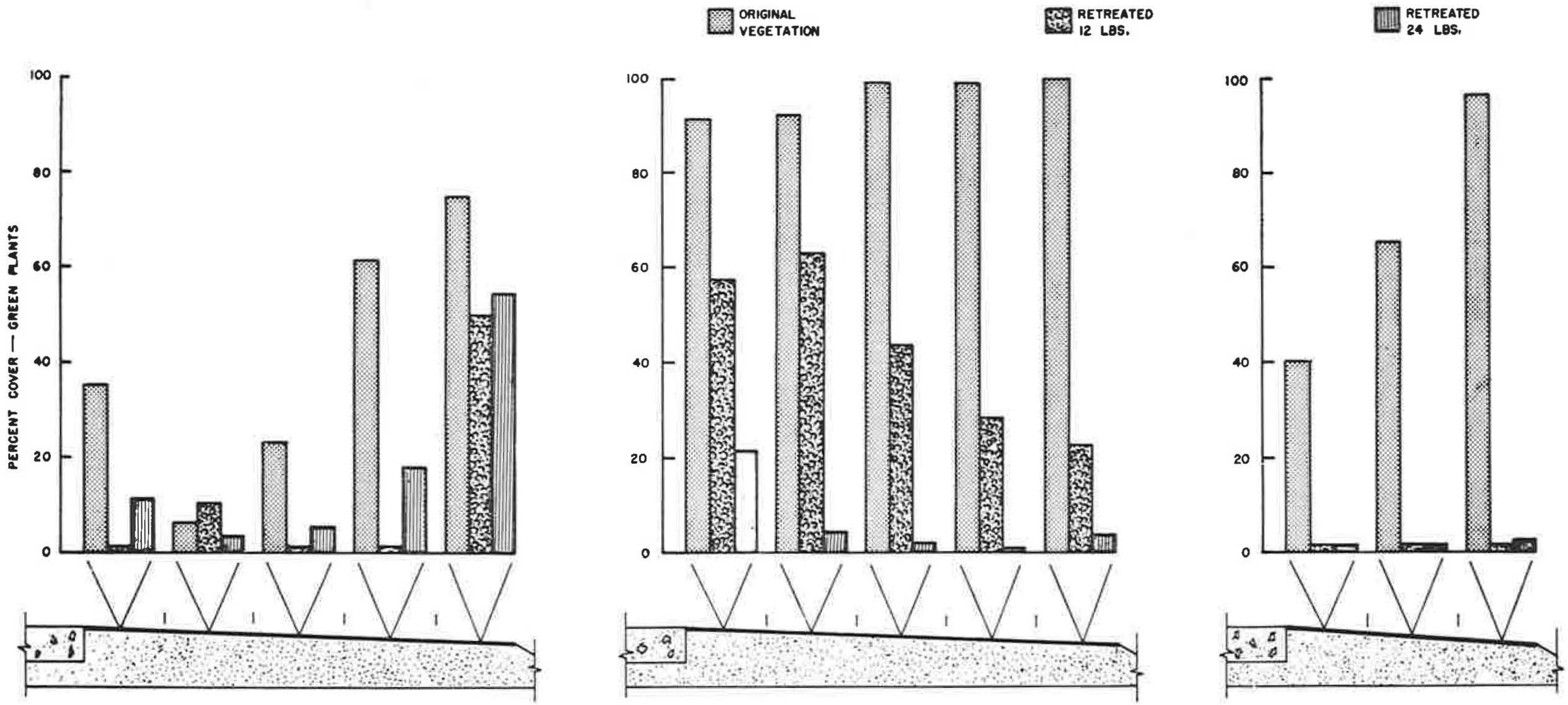

Figure 3. Response of bermudagrass to subsequent treatment with two rates of sodium TCA following initial uniform application of TCA at 24 lb/ft-mi. Measurements are shown for 1-ft segments of shoulder pavement 3 or 5 ft wide, beginning at the edge of the road surface on the left.

TABLE 4
POSTPAVING TREATMENTS

Treatment	Rate per Acre				
	1964	1965a	1965b	1966	1967
AMS		2475#			
Pyriclor		8# ox			
		16# ox			
Pyriclor/Dicamba					2#/4#
					4#/4#
Pyriclor/Picloram				1#/1#	
				2#/1# o	2#/1#
Pyriclor/Prometone					2#/3 gal
					4#/3 gal
Pyriclor/TCA				1#/100#	
				2#/100#	2#/200#
				4#/100# o	4#/200#
Dicamba		2#	1#		
		4# o	4#		
Dicamba/Amitrole					4#/4#
Dicamba/Dalapon			1#/20#	4#/10# x	
Dicamba/Fenac					5#/15#
		10#/30# o			10#/30#
		20#/60#			
		30#/90# x			
Dicamba/TCA				2#/100# x	
				4#/100#	
Erbon		40 gal o		40 gal ox	
				60 gal ox	
Erbon/Fenac/Dicamba					40#/5#/15#
Fenac/TCA	6#/150#				
	12#/150#				
	18#/150# o				
	6#/200#				
	12#/200#				
	18#/200# o	20#/200# x	20#/200# x		20#/200#
		30#/200# ox		30#/200# ox	30#/200#
				40#/200# ox	
Garlon				2 gal	
				4 gal	
				6 gal	
Bromacil (wetting agent added)					5#
MCPA/Pyriclor					2#/2#
MCPA/Picloram					2#/1#
MCPA/Prometone					2#/3 gal
Paraquat/Amitrole			10#/60#		
Paraquat/Atrazine			2#/5#		
Paraquat (surfactant added)			2#		
Picloram				1#	
			3# x	3# ox	
				5# o	
Picloram/Amitrole					1#/4#
Picloram/Prometone					2#/3 gal
Picloram/TCA				1#/100# x	2#/200#
			3#/200# x	3#/100# o	
Prometone				1 gal ox	
				2 gal ox	3 gal
					6 gal
Sodium arsenite		900# x			
2, 3, 6-TBA/TCA		20#/200# ox		20#/200# o	20#/200#
				40#/200# ox	40#/200#
TCA	100#				
	150#				
	200#		200#		
Tritac				20 gal x	
				40 gal x	
Tritac/TCA			20#/200# x		20#/200#
				40 gal/ 100# ox	40 gal/200#
Tritac/TCA/2, 4-D			20#/200#/1#		
2, 4-D/Amine			1#		
2, 4-D/Dalapon			1#/20# x	2#/10# x	
				4#/10# x	
2, 4-D/MSMA			1#/10#		
2, 4-D/TCA			1#/50# x		

NOTE: o = promising 3 months following application.
x = promising 12 months following application.

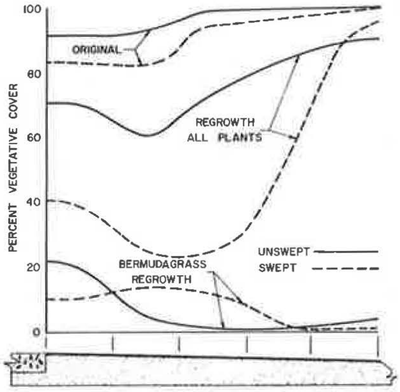

Figure 4. Effect of sweeping to remove soil accumulated on shoulder pavements prior to herbicidal treatment. Vegetative cover is charted for 1-ft segments of shoulder, with roadway on the left.

Bindweed and Associated Weedy Plants

A number of annual and perennial weeds infesting cropland in the Texas Panhandle also invade asphalt highway pavements in that area. They invade asphalt surfaces by means of seeds which become lodged in joints between the travel surface and the shoulder pavements or in "dry weather" cracks. Perennial weeds may persist for several years. Bindweed arises as shoots from roots and rhizomes, as well as from seeds.

Herbicide treatments to control bindweed growing in cropland have been recommended (2). Recommended materials include 2, 3, 6-TBA, PBA, fenac, tritac, picloram, and sodium chlorate. These herbicides are applied as soil sterilants, and persist for varying periods depending upon the materials used and subsequent rainfall.

Bindweed and many other broadleaf weeds found in highway pavement can be controlled reasonably well with repeat applications of 2,4-D. However, cotton and other susceptible crops growing in adjacent fields restrict the use of this or other growth-regulator herbicides. Uncertain plant growth conditions in this area of Texas result from sporadic control with 2,4-D (3).

The variety of weedy plants, together with the specificity of the different herbicides, suggested combinations of materials from the first. A combination of trichloracetic acid (TCA) and fenac in 1964 gave good knockdown of both grassy and broad-leaved weeds in existing pavement. All grassy weeds were controlled with this treatment. The treated broadleaf plants showed fenac symptoms throughout the year of treatment, but growth during the following spring appeared normal. A wider variety of materials was used beginning in 1965. These treatments used materials specific for the existing or combined materials for early knockdown with those known to have some persistence. Beginning in 1967, two applications per season were scheduled for comparison with single treatments.

The treatments showing effect on the majority of plants were noted 3 to 12 months after application (Table 4). Four of the materials recommended for control of bindweed and other weeds in agricultural lands have shown promise. These included picloram and tritac as well as combinations of fenac, 2,3,6-TBA, picloram, and tritac with TCA. Apparently these materials depended greatly on root uptake from open-soil treatments used in agriculture. An asphalt barrier between the point of application and the roots of these plants decreased the effectiveness of these recommended treatments.

In addition, pyriclor, erbon, and dicamba performed well when combined with one of several materials. The herbicide prometone also showed promise. Since these treatments failed to give season-long control, they are being programmed for early summer test applications to be oversprayed in late summer.

SUMMARY AND CONCLUSIONS

Vegetation often invades asphalt surfaces if the traffic volume is low. A number of herbicides will control a wide variety of plants, but no one material will solve all weed problems. The engineer, in selecting a particular material, should know which weedy plants are susceptible to a given material, as well as any possible hazards to crop or ornamental plants on adjacent properties. Most herbicides are not hazardous to personnel if used according to label directions.

A systematic spray program should begin as soon as weedy plants appear in the pavement. If the infestation becomes severe, the pavement probably will need replacing, even with a successful herbicide treatment. Brownup of vegetation on sprayed shoulder pavements is not objectionable, and traffic usually will use the sprayed area, thus aiding in control.

Observations concerning the control of bermudagrass are as follows:

1. TCA is relatively inexpensive and safe to use. Bermudagrass is controlled effectively with this material, but the number of treatments depends on growth conditions and traffic load.

2. Prepaving treatment with one of several materials should be applied just ahead of the first asphalt course. After the herbicide has been placed the base surface should not be bladed or broomed. Prepaving application will prevent penetration of the new surface from underneath, but maintenance treatments will be needed for encroachments from beyond the pavement or those which arise from seed in surface cracks or joints.

3. The initial postpaving treatment should be made with the beginning of growth in the spring. The TCA should be applied at the rate of 24 lb/ft-mi, and subsequent applications made as needed. The treatment interval is about 30 days.

4. Soil and other trash accumulated on the surface should be removed and the bermudagrass permitted to begin growth before the herbicide is applied.

5. The Texas Highway Department has designed and furnished to individual maintenance sections a sprayer that uses existing water tanks as a spray reservoir.

Research is continuing in its efforts to identify herbicide treatments for controlling other weedy plants growing in asphalt surface. Although treatments recommended for use in agricultural situations may be effective under highway conditions, they should be tested thoroughly before adoption and widespread use in highway maintenance.

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