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Kress and Dornbusch discuss the feasibility of including commercial services in rest areas and describe a lease arrangement to incorporate private enterprise in a traveler services rest area in California. Byrne used data from three existing rest areas to develop a model for estimating usage of a welcome center in Vermont.

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Commercialization of Rest Areas in California

EDWARD N. KRESS AND DAVID M. DORNBUSCH

The California Department of Transportation (Caltrans) is studying the feasibility of establishing private commercial services in rest areas. A lease was signed in late 1990 for the first traveler services rest area (TSRA), which provides such commercial services. Under the agreement, a private partnership will build, operate, and maintain the rest area for 35 years, after which all improvements will become the state's property. Caltrans will contribute the land and $500,000 in exchange for an operating rest area and revenues from the commercial operations, estimated to be at least $9 million over the life of the agreement. TSRAs are still in an experimental stage, and two main obstacles impede further developments: federal law prohibiting commercial services on Interstates and opposition from local business operators who fear additional competition. However, during development of the first TSRA, ways were found to avoid these obstacles. Procedures being used in the investigations and implementation of the first TSRA development effort are discussed here, including the importance of community relations, dealing with local opposition, and approaches to the division of responsibility between the private sector and state. It is concluded that the approaches used to develop commercial services in new and existing rest areas in California hold great promise. State officials are encouraged that the new federal attitude toward privatization and the willingness of the state to work with local interests will engender greater latitude in implementing future projects.

For the past 5 years, the California Department of Transportation (Caltrans) has been studying the feasibility of incorporating private commercial services into as many as 6 new rest areas and 4 existing rest areas. The procedures being used in the investigations and the results of California's first effort to implement such a development are discussed here.

BACKGROUND

During the 1960s and 1970s, a portion of Federal-aid for highways was available for rest areas, but priorities and policies have since changed. Rest areas now compete with other transportation needs for available federal money. Compounding the funding issue, California had to give programs such as financing of rest areas low priority because of burgeoning demands to fix deteriorating roads, relieve traffic congestion, and improve overall highway safety. The state still wants to maintain its existing 88 rest areas and even add as many as 14 new units to its system. To do that, it is clear that funding, to a large extent, will have to come from sources other than the gasoline tax or other public funds.

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The cost of building a new rest area that serves both directions of freeway travel to Caltrans' standards is about $5 million plus the expense of land, which varies considerably from site to site. A standard full-size rest area, located adjacent to the freeway and accessible from an existing interchange, provides parking spaces for 240 vehicles and modern comfort stations, fully supported by utilities and site amenities.

In addition, annual maintenance costs are between $75,000 and $125,000, not including the hidden costs of insurance (California self-insures) and security (provided by the California Highway Patrol and local law enforcement agencies). Of course, future costs must be considered for major repairs and rehabilitation of facilities as they wear out.

Another reason that Caltrans would like to include commercial services in rest areas is that crime has become a significant and growing problem in many areas. Despite the best efforts of the California Highway Patrol and local police, the nature and frequency of crimes (including violent crimes) in a number of rest areas have caused many potential users to avoid the facilities entirely. Crime is considered to be a significant problem in 20 percent of the state's rest areas.

Furthermore, commercial services are being provided quasi-legally and even illegally adjacent to and at a number of rest areas. Food and beverages, vehicle repairs, and other goods and services are being offered in rest areas and "through the fence." Law enforcement authorities have only limited abilities to control these enterprises, and some vendors are able to use First Amendment protection to legally "sell" their products for a "contribution." The contention is that rest areas are public forums open to anyone who wants to express his or her beliefs. Legal precedents have enforced the position of nonprofit organizations that the provision of services to travelers is an extension of their right to free speech.

The provision of permanent commercial services within a rest area could provide Caltrans with rental income that it does not currently have. Also, this provides an opportunity to eliminate quasi-legal and illegal activities.

To pursue the idea of including commercial services in rest areas, Caltrans broadened its authority because such facilities within freeway right-of-way were prohibited by law. Federal regulations and state law permit only vending machines, the sale of newspapers, and space for commercial traveler information in Interstate rest areas. One of the first actions then was to secure authorization to at least test the concept of joint private-public projects.

Efforts to gain approval for a federal joint development demonstration have not been successful. However, California

legislation authorizing a rest area joint economic development demonstration project became effective January 1, 1985. It requires that joint development contracts be awarded on the basis of competitive bidding. The sale of alcoholic beverages is prohibited within the rest area. Other provisions are as follows: there must be at least the opportunity for a public hearing for each unit; law enforcement responsibilities are to be the same as on the highway system; revenue received by the state is to be deposited in the State Highway Account; and the legislature is to be kept informed annually on the actual operations.

The California authorization is for commercial facilities in as many as six new rest areas. To deal with the Interstate restriction, Caltrans adjusted siting criteria to require the locations to be outside controlled access rights-of-way. Until federal sanction is received, such locations accessible from existing interchanges are the most likely places for joint private-public facilities on Interstates.

FIRST CALIFORNIA REST AREA TO INCLUDE COMMERCIAL SERVICES

Caltrans signed the lease late in 1990 for its first rest area to include private commercial services. The new traveler services rest area (TSRA) will be located near the I-15/Route 395 Interchange in San Bernardino County, south of Victorville. Average traffic flow past the site is about 68,000 vehicles a day. The new TSRA will include all of the usual services available at the state's other rest areas, such as rest rooms, parking, landscaped areas with walkways for people to stroll and walk pets, and picnic tables.

Most of the 14 acres of the San Bernardino TSRA will be devoted to free public uses. A total of 250 parking spaces will be provided, with 68 percent dedicated to automobiles. Large-vehicle parking will be separate. Only a small portion of the site will contain commercial services, which will include a restaurant, a fuel service facility, and a convenience store.

The restaurant/store building is to be 16,400 ft^2 in size. The main comfort station of about 2,500 ft^2 is to be set in the "green" area occupying some 30 percent of the site. In addition, a uniformed security guard will patrol the picnic area, and call buttons throughout the site will allow motorists to summon emergency help.

To develop the TSRA, Caltrans is contributing the land and $500,000. In exchange, the private developer/operator (TSRA operator) will build, operate, maintain, and be responsible for the security of the entire facility for 35 years, after which all the improvements will become the state's property. In addition, the developer/operator will pay Caltrans annual rent and a percentage of the sale of all goods and services at the rest area, which are estimated to be at least $9 million over the life of the agreement.

Although Caltrans initiated the project, performed the feasibility study, and identified the site to be developed, the TSRA operator was responsible for the engineering and architectural design and for obtaining permits and environmental approvals. The on- and off-site improvements were designed to Caltrans' standards, and Caltrans reviewed and approved the plans before they were submitted to the county for permits.

The agreement between Caltrans and the TSRA operator puts full responsibility for all mishaps, such as fuel tank leaks, on the operator. Caltrans was particularly careful about insisting on full insurance coverage by the operator because of concern about the effects of other unfortunate occurrences, which might affect the public's perception and use of the rest area. Among these was Caltrans' responsibility for correcting problems, even to the extent of the operator going bankrupt or abandoning the project. To the degree that it was possible to use the agreement to protect against the negative effects of these occurrences, Caltrans attempted to do so.

However, Caltrans officials felt that one of the best ways to avoid such problems would be to implement a project with a high probability of financial success, for both the operator and Caltrans. Such a project would serve as a good example for future TSRAs. This reasoning led to the decision to use the I-15/Route 395 site because it is expected to generate high commercial sales revenues.

OTHER PROJECTS

Joint Development

Based on its experience with the San Bernardino TSRA, Caltrans has pursued a second project in response to legislative direction to try the joint private-public concept in another area. A feasibility study showed that expected revenues from commercial services would justify soliciting proposals for a similar type of facility on I-8 in Imperial County, west of the California-Arizona border. Although this TSRA would be developed at an entirely new site, it would replace an existing rest area that has a number of safety problems and which Caltrans has wanted to remove for some time. The department will soon solicit proposals from prospective developers for this second project.

Privatization

Projecting the concept further, the feasibility of privatizing four existing rest areas, including additional commercial services, is being studied. As with the two new projects, these four existing rest areas are accessed from interchanges. Caltrans reasons that the access control line is located so that the rest areas are outside the zone in which the federal restriction against commercial services would preclude such activities.

Authority from the state's standpoint is based on established airspace procedures to maximize benefits from the department's holdings. Although never applied to rest area right-of-way before, the concept seems sufficiently broad to permit such consideration. Airspace is any property within the right of way limits of an existing operating highway that is capable of other uses without undue interference with the operation and foreseeable future expansion of the transportation corridor for highway or other transportation uses.

METHOD FOR EVALUATING FEASIBILITY

Approach

The studies for evaluating the feasibility of including commercial services at a new or existing rest area generally address the following questions.

- What are the physical limitations and advantages of the site? What types and sizes of commercial services are feasible?
- What additional or expanded public services would enhance the use of the commercial services? How can the commercial services be physically incorporated within or in relation to the rest area?
- What utilities need to be developed or expanded?
- To what degree would the commercial services enhance the use of the public services?
- What is the sales revenue potential of the commercial services?
- How can the joint development be achieved at minimum cost and maximum revenue generation for the transportation department?
- How much land is required, and is it desirable to purchase or option land not owned by the state?
- How can procurement be structured to obtain the broadest competition among proposers and most advantageous proposals for the state?

Estimation of Commercial Development and Sales Potential

Commercial development potential is estimated based on analysis of the following information:

- Average annual daily traffic passing the rest area.
- Traffic seasonality and peak hours.
- Mixture of automobiles, trucks, and recreational vehicles.
- Primary trip purposes and locations of principal origins and destinations.
- Percentage of traffic stopping at the rest area, and available surveys reporting characteristics of rest area use.
- Existing and planned commercial enterprises in the region that may complement or compete with services at the rest area.
- Sizes and proximity of nearest population centers.
- Visibility and accessibility of the site.
- Signing (special opportunities and restrictions).
- Site parking and circulation potential and limitations.
- Site capacity for public facilities.
- Site ability to accommodate private commercial services at desirable locations.
- Availability, capacity, and quality of utilities.
- Special use and maintenance issues or problems (such as recreation staging area, traveler information service center, illegal use or undesirable activities, etc.)
- Public agency jurisdiction, land use restrictions, and compatibility with other land uses in the area.
- Special environmental and archaeological constraints.
- Land ownership issues, including possible federal or private control and restrictions on use.

After thorough examination of this local information, it is wise to review experiences from a broad range of sources before reaching conclusions. Available data and studies on commercial patronage and sales from elsewhere in the state and country (including toll road commercial service plazas) assist in estimating the following factors:

- The additional stopping traffic percentages induced by the presence of candidate commercial enterprises in the TSRA, by vehicle type;
- The expected number of persons per vehicle, by vehicle type;
- The percent of patrons who will purchase various goods and services;
- The expenditure per person by type of goods and services; and
- The total annual sales by enterprise type.

The most lucrative commercial operations were found to be restaurants, fuel services, and convenience stores. Motels would also normally be profitable ventures. However, they were excluded for three reasons. In the particular case studies, motels would require expansion of utilities and parking to a degree that would make it expensive to serve them as well as the other services. Second, it was felt that TSRAs should be primarily for travelers who would not spend long periods of time there. This reasoning excluded destination-type entertainment services. Third, local opposition, a factor at a number of the sites, could be reduced by excluding motels from consideration.

Cost Versus Revenue Potential

The purpose of the cost-revenue analysis was to determine whether it made sense for Caltrans to seek development proposals for a TSRA development at a particular site or sites. The state specified two objectives to be met for it to consider implementation of a TSRA project. First, the state desired to contribute no more than half the cost to develop a project. Second, the state desired to obtain at least a 10 percent rate of return on its investment. When the financial analysis showed that both objectives stood a reasonable chance of being met, Caltrans proceeded to solicit proposals.

LOCAL OPPOSITION AND COMMUNITY RELATIONS

Where opposition to a project was encountered, it generally came from the existing local business community and tended to relate to the number and proximity of service businesses to the proposed TSRA and the economic viability of those services. The most significant opposition was encountered where the economy of the region was weak, where the local businesses' dependence on highway users was high, and where

those businesses believed that the TSRA's enterprises would take a significant share of their revenues.

In areas of high traffic volumes, numerous commercial services exist already, and the economic base is broad. Caltrans has encountered little opposition in those areas. In fact, strong support has been expressed by local business and political leaders for locating one TSRA near two communities where those leaders expect the TSRA to attract large numbers of highway users to their downtown commercial district.

Caltrans developed a number of approaches for working with community and business leaders who expressed opposition to locating TSRAs near their commercial services. Of primary importance is to open lines of communication early to achieve the following objectives.

- Provide local jurisdictions with complete information on the proposed project, including a summary of why the state is undertaking private-public sector joint development, the proposed nature and scope of the project, maintenance and operation issues, the potential benefits to various constituencies, the process by which the state would identify and select a private developer, project timing, and specific opportunities for public input and comment.
- Gather information concerning local and regional planning and economic development goals, local market conditions, and other considerations that might influence the type and scale of the project.
- Solicit community input regarding special project components such as tourist information centers, interpretive centers, or other services that relate directly to local concerns.
- Identify key areas of support and opposition within the community and attempt to build consensus in support of the project.
- Explore the possibilities for financial participation in the project from local jurisdictions. It is also important to proceed slowly and not attempt to ram the project through the opposition, but to seek to work with their concerns and attempt to find methods for overcoming their objections. The key here is to find out what the local community wants and try to find a way to achieve its objectives.

Caltrans representatives have met with local business people, staff of local chambers of commerce, tourism promotion organizations (such as convention and visitors bureaus), elected officials, and other interested parties. This has helped to show how the TSRA might satisfy their needs and served to identify what types of private commercial services at the TSRA might be acceptable to them.

Ultimately, a good strategy is to locate groups within the community that favor the TSRA and to support those groups in their efforts to counter the opposition. Local "ownership" of the concept is critical to achieving community support. Caltrans' experience shows the developer/operator can play an important role in achieving this through interaction with local groups during the process of obtaining necessary approvals and permits.

Local business people favor including a staffed traveler information center within the TSRA. Such a center can help to generate a considerable amount of tourism and business sales in the region, but as a separate facility, it can cost at least $250,000 to build and $50,000 a year to operate.

California has elected not to finance such centers on its own, and the development and operation costs are generally well beyond the reach of most communities, even where a region's private and public sectors work together to sponsor such centers. However, by incorporating the center within one of the TSRA's commercial buildings, its construction and operation costs can be reduced significantly, and if the state chooses, a portion of the rental revenues obtained from the private TSRA operator can be used to offset a portion of the center's operating costs.

Inclusion of a traveler information center is certainly not a compelling reason for the operators of existing nearby competing services to support a TSRA, but it does generate support from the owners of other businesses who stand to gain from the promotion it offers. Whether sufficient support can be generated to make the TSRA possible ultimately depends upon the strength of the backers. A key influence is the degree to which the local economy is driven by groups on either side of the issue and the ability of each group to mobilize political support.

ALTERNATIVE METHODS FOR DIVIDING RESPONSIBILITY

Before the first TSRA was developed, it was not clear what division of responsibilities between Caltrans and the private developer/operator would be most effective toward accomplishing the state's objectives. Two primary alternatives were considered: turnkey and project packaging.

Under the first alternative, turnkey, the private sector would be responsible for the entire project, including land assembly (if necessary), development planning, design, environmental documentation and permits, construction, operation, and maintenance.

Under the second alternative, project packaging, the state would acquire the land, lease portions to private operators (controlling and managing the private construction and operation), and develop and maintain a portion of the site for the public facilities.

A third option, coordination, was briefly considered. Under this option, both the state and private businesses would acquire adjacent sites, with each entity developing and constructing its own facilities. This alternative was rejected because of problems associated with the state maintaining sufficient legal and administrative control over the private development.

Other alternatives consisted mainly of variations on the first two options, with the state participating to varying degrees in the following aspects:

- Development planning;
- Design;
- Obtaining permits;
- Financing;
- On- and off-site improvements (especially roadway improvements and signalization), signing, promotion, specifying and monitoring operation and maintenance standards, pricing control, and inspections;
- Auditing; and
- Possibly, the provision of special services, such as security and liability insurance.

Primarily to attract the widest possible response from proposers, and therefore presumably the most potentially attractive proposal, the San Bernardino TSRA request for proposals allowed for either a turnkey or project packaging approach. At that time, research indicated that a number of large national corporations were reluctant to join forces with one another to provide a mix of food, fuel, and convenience store services as well as bear responsibility for developing the entire site.

The primary reasons for trying to attract large national corporations as tenants in the TSRA development are their demonstrated operating experience at similar sites, proven financial ability to support operations through potential lean years, managerial capability, and the ability of their name to attract a high volume of users and other tenants to the rest area. However, smaller organizations that may be well qualified, though less well known, may offer higher rents to compete with larger national corporations. In fact, Caltrans chose a local organization to develop and operate the San Bernardino TSRA.

Although the proposals indicated that many of the large national corporations preferred not to combine into a joint development/operation venture, it appears that they are now prepared to do so. For this reason, the fact that large national corporations are not considered to be necessary to make a TSRA successful, and because the state's administrative responsibilities are much less for a turnkey project, Caltrans has elected to solicit only turnkey proposals for its future TSRAs.

MONITORING

Following development, Caltrans will monitor these projects to achieve three purposes. The first is to ensure that Caltrans' policies and standards for maintenance, operation, and security are followed throughout the contractual period. Second, Caltrans wants to ensure that the contract terms are met during all phases of development and operation. Third, the department needs to gather information on TSRA use and operations that will be useful in performing feasibility analyses on future TSRA developments.

CONCLUSION

It appears that the approaches used to develop commercial services in new and existing rest areas in California hold great promise. Caltrans has succeeded in obtaining a new operating rest area at a low investment cost and simultaneously gained an asset with the potential for generating significant amounts of surplus revenues that can be used to finance other transportation facilities and services. However, TSRAs are still in an experimental stage.

Caltrans found that relying on a private developer to take responsibility for implementing the development worked well in the first project. Although it is still too early to report on the administrative problems encountered during the project's implementation, so far they have proven to be not much greater than for airspace leases.

The two main obstacles to further development of TSRAs are the federal law prohibiting commercial services on Interstate rights-of-way and local opposition from business operators who fear the effects of additional competition. California has found ways to avoid these obstacles in developing its first TSRA. Given the new federal attitude toward privatization of transportation projects, and the state's willingness to work with local interests to reduce the negative impacts, Caltrans is hopeful that it will gain greater latitude in implementing such projects in the future.

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Abridgment

Usage of Three Rest Areas in Vermont

BERNARD F. BYRNE

The purpose of the research reported here was to discover, or formulate, models for estimating usage of a welcome center and to estimate the parameters for such a model. The literature review revealed that each rest area should be modeled separately by a simple proportion of the traffic passing by the rest area. Examination of three rest areas in Vermont for which extensive data collection was undertaken revealed peaking patterns and model parameters. In general, the greatest peaks occur on summer and fall holiday weekends. On Fridays, traffic peaks from noon to 8:00 p.m. On Saturdays, a sharp, high peak occurs between 10:00 a.m. and noon. The proportion of vehicles stopping at each rest area studied is reasonably consistent. A further study of peak Saturday proportion stopping confirmed the model as formulated and estimated parameters for the model.

Design of a rest area or welcome center depends on accurate estimates of the usage of the facility. The purpose of the research reported here was to discover or formulate models for estimating usage of a welcome center and to estimate the parameters for such a model. An understanding of the peaking pattern of usage and its relationship with travel on the highway facility served by the rest area or welcome center is also necessary for accurate forecasting. Particular elements for which forecasts of future usage are necessary include sizes of automobile and truck parking lots and rest facilities. The overall design of the facility is also affected by the amount of expected usage.

LITERATURE REVIEW

Estimating welcome center and rest area usage has been the subject of several reports and papers. The earliest design guidelines are reported in *NCHRP Synthesis of Highway Practice 20* (*1*) and are based on a design procedure originated by the state of Oregon. Parking is based on design hourly traffic, which is found from average daily traffic using a K factor of 0.135 and a D factor of 0.6, which is a standard procedure with more or less standard values for K and D. From this, the number of vehicles stopping in the peak hour is estimated based on the proportion of vehicles stopping, which ranges from 5 percent to 13 percent of traffic.

Essentially the same procedure for estimating usage is used in the report *Safety Rest Area Planning, Location and Design*, prepared by the Minnesota Department of Transportation (*2*). Two factors further recognized in this report were that some peaking occurs during the summer and that the percentage of vehicles that stop varies by distance between rest areas.

DuBois and King, Inc., P.O. Box 339, Randolph, Vt. 05060.

Two recent studies, one in Virginia and one in Washington, have estimated values of design parameters for rest areas and welcome centers. In the Virginia study (*3*) seven rest areas and four welcome centers were studied.

In Washington (*4*), a study of rest area design criteria was undertaken. Reported were values of the proportion of traffic entering rest area, description of vehicle types, vehicle occupancy, and vehicle lengths of stay. The proportion of traffic entering the site on average days varied from 6 to 21.5 percent. During peak periods, the values ranged from 7.5 to 44 percent.

The most comprehensive and recent report on rest areas was prepared under NCHRP Project 2-15 by KLD Associates (*5*). In this study, individual studies from 12 states and a 1971 nationwide study were examined. Also included in this study was an examination of models for predicting the percentage of mainline traffic using a rest area based on distance between rest areas. Reported was a model using an FHWA formulation, which was tested using data collected in the study, that was found to underrepresent the percentage stopping. Several models were developed in the study, but were not thought to have wide applicability. This study recommended that usage be based on stopping percentage calculated from existing rest areas.

On the basis of time studies, the general model can be formulated as follows:

$$V = A\,pk \tag{1}$$

where

V = peak hour entering volume,
A = mainline daily volume in direction served by rest area,
p = proportion of traffic entering rest area, and
k = proportion of daily traffic in peak hour.

The problem then becomes one of estimating the factors p and k.

REST AREA DATA ANALYSIS

To estimate the stopping percentage, an extensive data collection effort was undertaken as part of a study of welcome centers in Vermont. The locations studied were Guilford, Derby, and Sharon. Guilford is a welcome center on I-91 approximately 0.1 mi north of the Massachusetts border. Derby is a rest area used as a part-year welcome center on I-91 approximately 3 mi south of the Canadian border. Sharon is a rest area on I-89, approximately 9 mi north of the New Hampshire border.

Near each of the rest area sites to be studied, and within each site's Interstate segment, Vermont has maintained a per-

manent counting station. Each station has a record of counts going back at least 20 years.

At each of the rest areas studied, hourly entering volumes were collected from mid-May to the end of October. Also collected were directional hourly volumes at each of the permanent counting stations. From these data, the percentage entering the rest area and peaking characteristics were studied. The overall percentage entering the rest area was 14.4 percent for Guilford, 10.7 percent for Derby, and 7.7 percent for Sharon.

The data for each of the rest areas were accumulated and summarized. Only the summary for Guilford is shown; data for the other rest areas are similar. Table 1 illustrates entering traffic, total mainline traffic in the counting direction, and percentage entering by month and day of the week for Guilford. The highest months are July and August; October and May are lower but do not include the entire month. By day of the week, Friday and Saturday show the highest traffic levels and numbers using the rest area. The percentage entering remains remarkably consistent by both month and by day of the week.

Peaking characteristics were also examined. In general, for these months, the peak days of travel were Fridays and Saturdays for the directions serving the rest area (i.e., northbound in Guilford and Sharon, southbound in Derby).

For Guilford, Figure 1 shows total daily entering traffic for Fridays and Saturdays from May 19 to October 28, 1989. As illustrated in the figure, the peak weekends are Memorial Day, the weekend preceding the Fourth of July, Labor Day, and fall foliage season. The highest peak was experienced June 30 through July 1, the weekend preceding the Fourth of July. Weekends in July and August were also high but not as high as the peak weekends. For the most part, total daily traffic on Fridays and Saturdays was approximately equal, although peak Saturday traffic on July 1 far exceeds June 30 Friday traffic. The pattern of mainline daily traffic closely follows the entering traffic pattern in Figure 1, although total daily Saturday traffic tends to be lower than total Friday traffic volumes. In general, Saturday peak hours tend to be much higher, a fact borne out by the hourly variation patterns, which will be discussed later. A similar set of graphs was plotted for Derby and Sharon.

For each rest area, the hourly variation of traffic for the peak weekends described above was examined to ascertain peaking characteristics. The hourly variation in entering traffic for Fridays for Guilford is shown in Figure 2. In general traffic volumes reached a peak by 10:00 a.m. and remained at that level until 8:00 p.m. They decline to their minimum level by midnight. The highest volume on a Friday was observed on June 30. Volumes, except for two instances, did not exceed 200 vehicles per hour. The hourly variation in mainline traffic for Fridays shows a consistent pattern for all the peak Fridays, which varies from the pattern for entering traffic. The hourly volumes increase steadily throughout the day and peak between 6:00 and 8:00 p.m., then decline precipitously toward midnight. The implication is that during the earlier part of the day, a higher percentage of vehicles stop than during the peak hours of 6:00 to 8:00 p.m. Figure 3 shows the hourly variation in entering traffic for Saturdays. This illustrates a sharper peak, and a higher peak, than that shown for Fridays. The peak occurs generally at 10:00 a.m. and remains high until noon, then declines through the rest of the day. This

TABLE 1 DAY OF WEEK SUMMARY SHOWING MAINLINE TRAFFIC, ENTERING TRAFFIC, AND PERCENTAGE ENTERING FOR GUILFORD

MONTH	MON.	TUES.	WED.	THURS.	FRI.	SAT.	SUN.	MONTHLY TOTALS
May	1,603	1,330	1,220	889	3,306	3,306	2,056	13,710
	10,368	9,502	10,084	6,211	22,466	20,887	14,482	94,000
	15.5	14.0	12.1	14.3	14.7	15.8	14.2	14.6
June	3,315	2,780	2,938	4,166	8,289	5,104	4,323	30,915
	20,559	20,272	22,416	30,478	57,613	32,952	28,490	212,780
	16.1	13.7	13.1	13.7	14.4	15.5	15.2	14.5
July	5,490	3,490	3,489	3,122	7,114	10,623	7,116	40,444
	35,154	23,823	26,598	28,782	51,620	63,296	46,369	275,642
	15.6	14.6	13.1	10.8	13.8	16.8	15.3	14.7
August	4,415	5,001	5,183	5,785	8,099	7,401	5,461	41,345
	28,478	33,936	35,770	41,343	56,044	46,343	36,563	278,477
	15.5	14.7	14.5	14.0	14.5	16.0	14.9	14.8
September	3,971	2,977	3,024	3,376	8,916	8,115	4,695	35,074
	24,940	22,421	23,538	26,021	66,073	54,275	32,813	250,071
	15.9	13.3	12.9	13.0	13.5	15.0	14.3	14.0
October	3,526	1,673	1,276	1,322	2,486	4,685	4,895	19,863
	22,035	15,568	11,387	12,410	21,939	31,385	33,740	148,464
	16.0	10.7	11.2	10.7	11.3	14.9	14.5	13.4
TOTAL	22,320	17,251	17,130	18,660	38,210	39,234	28,546	181,351
	141,534	125,522	129,783	145,245	275,755	249,138	192,457	1,259,434
	15.8	13.7	13.2	12.8	13.9	15.7	14.8	14.4

Legend:

Line 1	Rest Area Entering Traffic
Line 2	Northbound Mainline Traffic
Line 3	Percentage Entering

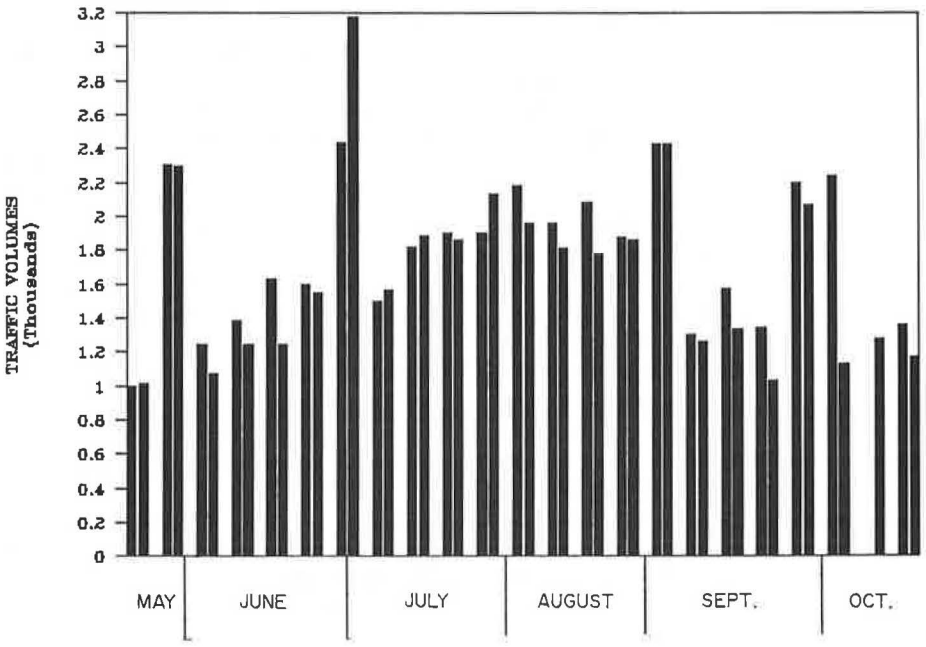

FIGURE 1 Total daily entering traffic for Guilford for Fridays and Saturdays, summer through fall 1989.

peaking phenomenon mirrors the peaking illustrated for the mainline traffic.

For Derby, the peak for Fridays and Saturdays tends to be less prominent, and the variation in hourly volumes tends to be greater. Volumes tend to be much less than for Guilford.

The Sharon rest area shows a pattern similar to that of Guilford. Volumes build in the morning, remain high through the afternoon, and decline after about 8:00 p.m. The hourly variation on Fridays for mainline traffic tends to peak in the afternoon, somewhat earlier than Guilford. Entering Saturday traffic volumes tend to peak at about noon, whereas the mainline volumes tend to remain constant from 10:00 a.m. to 2:00 p.m. and then decline gradually through the afternoon.

To summarize, in general, on Fridays, peak hourly volumes are reached by noon and continue, more or less level, to 8:00 p.m. On Saturdays, peak hours occur between 10:00 a.m. and noon. These hourly volumes were greater than the Friday peak hour volumes, but other hourly volumes tended to be

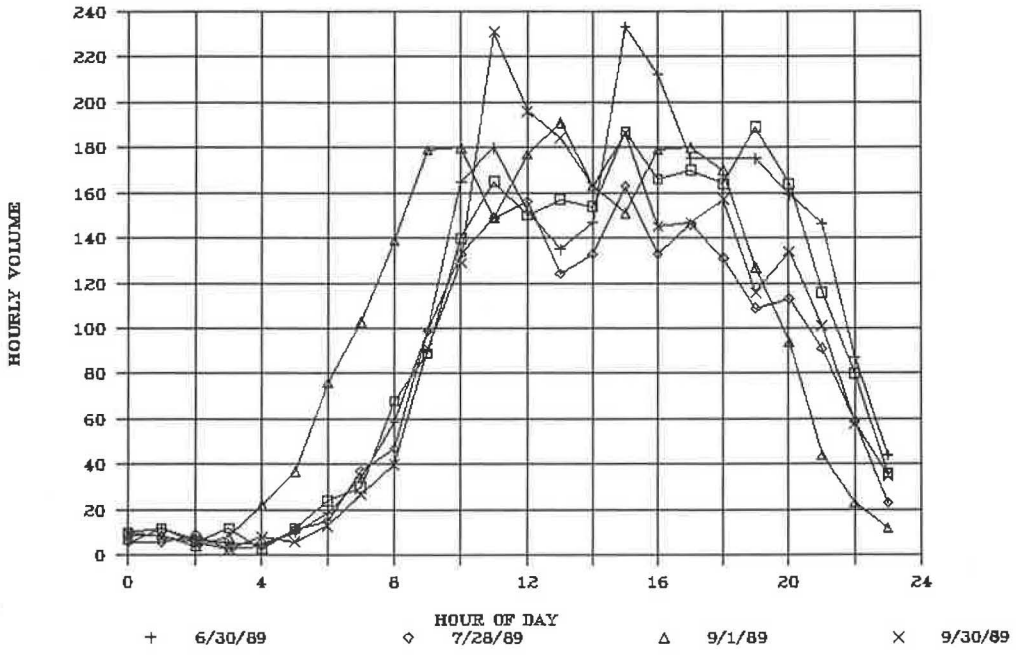

FIGURE 2 Hourly variation in entering traffic on peak Fridays for Guilford.

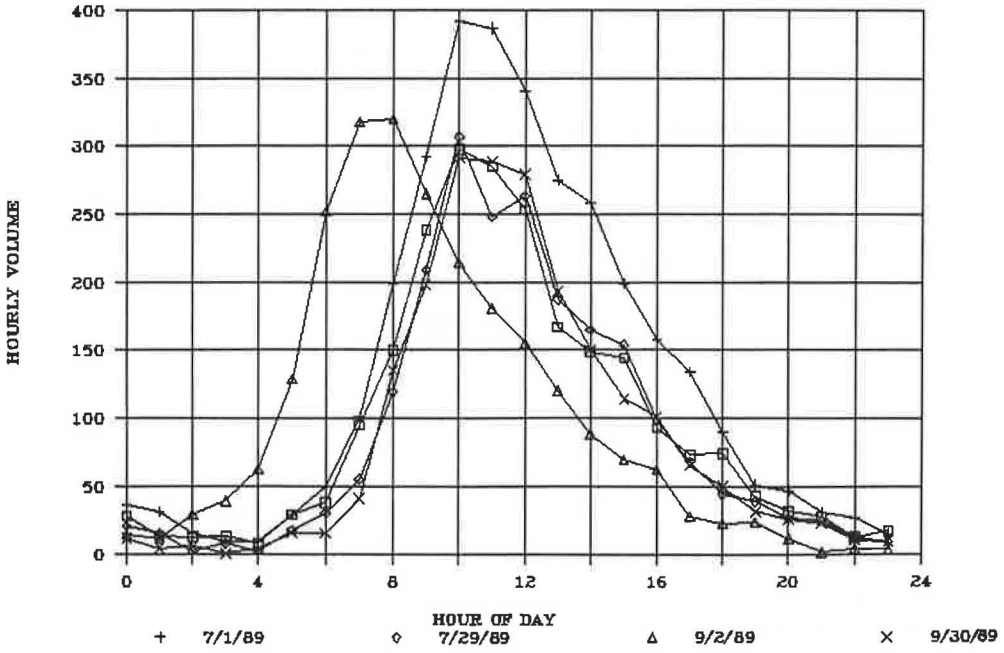

FIGURE 3 Hourly variation in entering traffic on peak Saturdays for Guilford.

lower, thus making Friday and Saturday daily volumes nearly equal in all cases.

Because Saturday peak hourly volumes were the highest in almost all cases, a further analysis of Saturday peak hour volumes was undertaken for each of the following set of dependent and independent variables.

Dependent Variables	*Independent Variables*
Rest area peak hour volume (k factor)	Rest area daily volumes
Rest area peak hour volume	Mainline volume at rest area peak hour
Rest area peak hour volume	Mainline daily volume
Rest area daily volume (p factor)	Mainline daily volume
Mainline volume at rest area peak hour	Mainline daily volume

A preliminary examination of the data suggested that a linear model may be applicable to describe rest area stopping behavior.

Regression analyses for each rest area were conducted to ascertain prediction equations for the several sets of possible variables. The equations are of the form

$$y = a + bx$$

where

y = dependent variable,
x = independent variable,
a = constant, and
b = coefficient.

The analyses were conducted to predict the values of a and b based on multiple sets of x and y values.

For each model developed, the a value was tested to determine if it was significantly different from zero. In nearly every case this did not prove to be true, so the model to be used was changed to the following:

$$y = bx$$

This model is the one that would normally be experienced because a zero volume on the mainline should lead to a zero volume in the rest area and confirms the original model formulation. These models may be interpreted as the proportion of independent variable that the dependent variable represents (Table 2). Along with each coefficient is shown, in parenthesis, the R^2 value, which indicates the strength of the relationship. The closer R^2 is to 1, the stronger the relationship between independent and dependent variables. As can be seen from the table, strong relationships are established for Guilford. Those established for Derby were somewhat less strong. Those for Sharon were weaker but not entirely valueless. These relationships were used for predicting peak usage in future years.

CONCLUSION

The traffic at these rest areas can be regarded as largely recreational in nature because of its peaking nature in summers, on holidays, and in the fall foliage season. In general, the higher peaks occurred on summer holiday weekends, and the highest peak on the Fourth of July weekend. On peak weekends, daily volumes on Friday and Saturday tend to be similar; however, the nature of the peaking differs. On Fridays, volumes remain high from noon to 8:00 p.m., but on Saturdays, a much sharper peak occurs around noon, so the highest hour of volume on a weekend tends to occur on a Saturday.

TABLE 2 RESULTS OF PEAK SATURDAY ANALYSES

Dependent Variable	Rest Area Peak Hour Volume	Rest Area Peak Hour Volume	Rest Area Peak Hour Volume
Independent Variable	Rest Area Daily Volume	Mainline Volume at Rest Area Peak Hour	Mainline Daily Volume
Coefficient			
Guilford	0.1355 (0.94)	0.2211 (0.76)	0.0217 (0.85)
Derby	0.1112 (0.83)	0.1552 (0.52)	0.0130 (0.72)
Sharon	0.1120 (0.93)	0.1219 (0.54)	0.0102 (0.27)
Dependent Variable	Rest Area Daily Volume	Mainline Volume at Rest Area Peak Hour	
Independent Variable	Mainline Daily Volume	Mainline Daily Volume	
Coefficient			
Guilford	0.1599 (0.91)	0.0964 (0.66)	
Derby	0.1168 (0.85)	0.0806 (0.58)	
Sharon	0.0912 (0.33)	0.0843 (0.84)	

NOTE: Figure in parenthesis following coefficient is R^2 value.

Using the basic approach reached by the KLD reports (i.e., preparing an individual model for each rest area), the basic model formulation in the literature, as shown in Equation 1, has been confirmed by the research reported herein. Additionally, values for p and k parameters were estimated. Later these were applied to estimating traffic at the rest area.

ACKNOWLEDGMENTS

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Pilot Study of the Influence of Vegetation and Other Factors on Pavement Condition

DAVID W. DUNLAP

Historically, the extent to which nonrhizomatous and nonstoloniferous vegetation, particularly grasses, on the road shoulder contributes to the premature deterioration of road pavement by impeding the off-surface flow of water has proven, in the absence of empirical evidence, to be controversial. Anecdotal evidence has been used to support the need to remove such vegetation. A pilot study was conducted to determine the relationship, if any, between the presence and abundance of road-shoulder vegetation and pavement condition ratings through an attempt to reveal the existence and strength of any correlation between the variables. Besides vegetation and pavement condition factors such as cracking and raveling, a number of other variables were investigated, including average daily traffic counts at the nearest road intersection, soil factors, roadway and shoulder grade, ditch condition, and canopy cover over the roadway. Whereas the purpose of the study was to collect and analyze data testing the null hypothesis that nonrhizomatous, nonstoloniferous vegetation does not cause premature pavement deterioration by impeding the off-surface flow of water, the purpose of this paper is to stimulate further research. The results of the pilot study indicate an apparent lack of association between the presence and abundance of shoulder vegetation and pavement condition because the correlation coefficient was not statistically significant. Other factors, however, are shown to be significantly correlated with pavement condition. Therefore, the study should be expanded to account for the influence of factors not considered in the pilot study because of data gaps.

The Lane County, Oregon, Department of Public Works recently adopted an integrated vegetation management (IVM) program. The IVM approach requires that a problem, actual or potential, be identified before vegetation management is conducted. Historically, the extent to which nonrhizomatous and nonstoloniferous vegetation, particularly grasses, on the road shoulder contributes to the premature deterioration of road pavement by impeding the off-surface flow of water has proven, in the absence of empirical evidence, to be controversial. Anecdotal evidence has been used to support the need to remove such vegetation.

A pilot study was conducted to determine the relationship, if any, between the presence and abundance of road-shoulder vegetation and pavement condition ratings through an attempt to reveal the existence and strength of any correlation between the variables. Besides vegetation and pavement condition factors such as cracking and raveling, a number of other variables were investigated, including average daily traffic (ADT) counts at the nearest road intersection, soil factors, roadway and shoulder grade, ditch condition, and canopy cover over the roadway.

Whereas the purpose of the study was to collect and analyze data testing the null hypothesis that nonrhizomatous, nonstoloniferous vegetation does not cause premature pavement deterioration by impeding the off-surface flow of water, the purpose of this paper is to stimulate further research. The results of the pilot study indicate an apparent lack of association between the presence and abundance of shoulder vegetation and pavement condition because the correlation coefficient was not statistically significant. Other factors, however, are shown to be significantly correlated with pavement condition. Therefore, the study should be expanded to account for the influence of factors not considered in the pilot study because of data gaps for parameters such as thickness of road base, point-specific pavement ratings, and pavement age, design, and loadings.

Lane County Department of Public Works, 3040 North Delta Highway, Eugene, Oreg. 97401-1696.

PROCEDURES

The parameters listed below were sampled, either from existing data or by in-the-field sampling, for 61 sites around the county. For those shown with an asterisk (*), the data were collected in the field.

- ADT,
- Soil pH*,
- Liquid limit of the soil*,
- Plastic limit of the soil*,
- Soil plasticity index*,
- Roadway grade*,
- Shoulder grade*,
- Ditch condition*,
- Alligator cracking of the pavement, hairline,
- Alligator cracking of the pavement, spalling,
- Longitudinal cracking of the pavement, less than 0.25 in.,
- Longitudinal cracking of the pavement, greater than 0.25 in.,
- Transverse cracking of the pavement, less than 0.25 in.,
- Transverse cracking of the pavement, greater than 0.25 in.,
- Patching, 0.1 to 0.5 in.,
- Patching, 0.5 to 1.0 in.,
- Edge raveling,

- Edge patching,
- Edge, lane less than 10 ft,
- Percent canopy cover (from trees over the lane at the sampling point)*,
- Percent bare ground*,
- Total percent aboveground vegetative cover*, and
- Composite pavement condition score (a score generated from measures of alligator cracking, longitudinal cracking, transverse cracking, and patching).

The sites were selected in a stratified random manner with at least 10 sites in each of 6 geographically distributed road maintenance zones. Sites were excluded from roads for which the paved surface or the shoulder had been rehabilitated within 2 years before sampling or since the date of the last pavement evaluation. Sites were determined to be the mid-point of randomly computer-selected road segments taken from the county's maintenance management data base. Soil samples were taken from the road shoulder material with a soil auger (except where the material was too rocky to allow the auger to penetrate), stored on ice in zip-lock plastic bags, and returned to the department's materials lab for analysis. Roadway and shoulder grades were determined with an abney. Ditch condition was subjectively determined by assigning the condition of the ditch at the sampling site to one of four condition classes; the higher the class ranking the poorer the condition of the ditch in terms of the ability of the ditch to convey water. Factors contributing to the ranking included ditch cross-sectional area and the presence or absence of congesting vegetation or other obstructions. Percent canopy cover over the road at the site was also subjectively determined. Total percent aboveground vegetative cover, and its near converse, percent bare ground and litter, were determined using a 0.1 m^2 circular quadrat placed at the pavement edge.

ANALYSIS

A correlation analysis was run on the variables listed previously. Shown in Table 1 are the correlation coefficients for the sampled variables.

The critical values for the correlation coefficients, with 59 degrees of freedom, were determined by interpolation to be 0.252 for alpha = 0.05, and 0.328 for alpha = 0.01.

RESULTS

Correlations (indicated as "variable/variable") significant at the alpha = 0.05 level include the following:

- Soil pH/liquid limit of the soil,
- Liquid limit of the soil/ditch condition,
- Liquid limit of the soil/patching, 0.5 to 1.0 in.,
- Liquid limit of the soil/composite pavement condition score,
- Plastic limit of the soil/edge patching,
- Soil plasticity index/ditch condition,
- Soil plasticity index/patching, 0.5 to 1.0 in.,
- Ditch condition/edge raveling,
- Ditch condition/edge patching,
- Longitudinal cracking, less than 0.25 in./transverse cracking, less than 0.25 in.,
- Transverse cracking, less than 0.25 in./percent canopy cover,
- Patching, 0.5 to 1.0 in./composite pavement condition score, and
- Edge patching/edge, lane less than 10 ft.

Correlations (indicated as "variable/variable") significant at the alpha = 0.01 level include the following:

- Soil pH/soil plasticity index,
- Liquid limit of the soil/plastic limit of the soil,
- Liquid limit of the soil/soil plasticity index,
- Liquid limit of the soil/longitudinal cracking, greater than 0.25 in.,
- Liquid limit of the soil/edge raveling,
- Liquid limit of the soil/edge patching,
- Plastic limit of the soil/soil plasticity index,
- Plastic limit of soil/longitudinal cracking, greater than 0.25 in.,
- Plastic limit of the soil/edge raveling,
- Soil plasticity index/alligator cracking, spalling,
- Soil plasticity index/longitudinal cracking, greater than 0.25 in.,
- Soil plasticity index/edge raveling,
- Soil plasticity index/edge patching,
- Soil plasticity index/composite pavement condition score,
- Roadway grade/edge patching,
- Roadway grade/edge, lane less than 10 ft,
- Roadway grade/percent canopy cover,
- Alligator cracking, hairline/longitudinal cracking, less than 0.25 in.,
- Alligator cracking, hairline/composite pavement condition score,
- Alligator cracking, spalling/composite pavement condition score,
- Longitudinal cracking, less than 0.25 in./composite pavement condition score,
- Longitudinal cracking, greater than 0.25 in./edge patching,
- Patching, 0.5 to 1.0 in./edge patching,
- Patching, 0.5 to 1.0 in./patching, 0.5 to 1.0 in.,
- Edge raveling/edge patching,
- Edge raveling/edge, lane less than 10 ft,
- Edge patching/composite pavement condition score, and
- Percent bare ground/total percent aboveground vegetative cover.

DISCUSSION OF RESULTS

If it is true that vegetation plays a significant role in the premature deterioration of pavement by creating a barrier to the free flow of water off the paved surface, then as vegetation abundance (measured as percent aboveground cover) increases, pavement condition scores should decrease. If this were to occur in every case, this perfect inverse relationship would produce a correlation coefficient (r) of -1. Such an inverse association is well illustrated by the nearly perfect (i.e., nearly equal to -1) correlation between vegetative cover

TABLE 1 MATRIX OF CORRELATION COEFFICIENTS

	ADT	Soil pH	Liq. Limit	Plast. Limit	Plast. Index	Road Grade	Shldr. Grade	Ditch Cond.
ADT	1							
Soil pH	-.128	1						
Liquid Limit	-.123	-.327	1					
Plastic Limit	-.159	-.224	.913	1				
Plasticity Index	-.066	-.372	.913	.688	1			
Road Grade	.032	.092	-.037	-.056	-.011	1		
Shoulder Grade	.180	-.120	.010	.084	-.065	-.038	1	
Ditch Condition	.037	2.052E-4	.272	.241	.257	.040	-.240	1
Allig. Cr. Hairline	.188	-.025	-.004	.020	-.027	-.118	.042	-.012
Allig. Cr. Spalling	-.103	-.056	.225	.083	.328	-.143	.038	-.210
Long. Cr. <0.25 in.	.213	-.002	-.144	-.107	-.158	-.171	.247	-.070
Long. Cr. >0.25 in.	-.068	-.120	.485	.350	.535	.128	.024	.014
Trans. Cr. <0.25 in	-.006	-.168	-.107	-.118	-.077	-.130	-.121	-.096
Trans. Cr. >0.25 in	-.003	-.050	-.061	-.067	-.043	.084	-.082	-.178
Patching 0.1-0.5 in	-.033	.022	-.052	-.067	-.028	.147	.012	-.073
Patching 0.5-1.0 in	-.073	-.030	.248	.177	.276	.135	.085	.189
Edge Raveling	-.150	-.099	.547	.526	.474	.223	-.033	.271
Edge Patching	-.065	-.132	.524	.306	.653	.353	-.073	.252
Edge, lane <10 ft	-.101	.092	.019	.038	-.002	.447	.005	.179
% Canopy Cover	-.133	-.148	-.096	-.077	-.099	.336	-.024	-.101
% Bareground	.081	-.147	-.020	-.093	.056	-.127	-.170	-.114
% Total Veg. Cover	-.086	.122	.057	.132	-.027	.144	.159	.148
Comp. Pvmt. Score	-.008	.051	-.286	-.145	-.377	-.022	-.107	.053

TABLE 1 (*continued*)

	Allig. Crack. Hairline	Allig. Crack. Spall.	Long. Crack. <0.25"	Long. Crack. >0.25"	Trans. Crack. <0.25"	Trans. Crack. >0.25"	Patch. 0.1-0.5"	Patch. 0.5-1.0"
Allig.Cr.Hairline	1							
Allig.Cr.Spalling	-.178	1						
Long.Cr.<0.25 in	.381	.144	1					
Long.Cr.>0.25 in	-.131	.112	-.206	1				
Trans.Cr.<0.25 in	.078	-.082	.292	-.060	1			
Trans.Cr.>0.25 in	-.064	-.046	-.100	-.034	-.029	1		
Patching 0.1-0.5"	-.011	-.022	.047	-.078	-.067	-.038	1	
Patching 0.5-1.0"	.178	.210	.068	.043	-.097	-.055	-.125	1
Edge Raveling	.224	-.141	.049	.145	-.027	.034	-.014	.155
Edge Patching	-.042	.168	-.151	.459	-.071	-.040	-.092	.499
Edge,lane <10 ft	.024	-.074	-.022	.170	-.124	-.070	.030	.135
% Canopy Cover	.128	-.162	-.011	-.004	.278	-.058	.147	.213
% Bareground	-.025	-.068	.058	.027	.109	.169	.110	-.189
% Total Veg. Cover	.007	.051	-.079	-.030	-.105	-.167	-.115	.195
Comp. Pvmt. Score	-.452	-.522	-.387	-.179	.003	.013	-.281	-.596

	Edge Raveling	Edge Patching	Edge lane <10 ft.	Percent Canopy Cover	Percent Bare-ground	% Tot. Veg. Cover	Comp. Pvmt. Score
Edge Raveling	1						
Edge Patching	.388	1					
Edge, lane<10 ft	.366	.255	1				
% Canopy Cover	.098	.005	.222	1			
% Bareground	-.056	.005	-.099	-.102	1		
% Total Veg. Cover	.092	.055	.125	.105	-.989	1	
Comp. Pvmt. Score	-.161	-.350	-.108	-.125	.106	-.083	1

and bare ground ($r = -0.989$). Likewise, a perfect positive association would give a coefficient of $+1$, and a correlation coefficient of 0 would indicate a total lack of association between the variables.

The results of this pilot study are interesting in that the analysis of the data collected shows no statistically significant correlations between the presence or absence of vegetation adjacent to the pavement edge and scores indicating poor pavement conditions. However, there were some potentially influential limitations on the study.

- A number of potentially significant variables, such as pavement age, thickness of base material, and equivalent single axle loadings, were not included. (This information was not available at the time of the study.)
- Pavement condition scores are for road segments and are not specific for the point at which the vegetation and soil data were collected.
- ADT counts were for the nearest road intersection and were not available for all of the roads on which samples were taken. Where data were missing, the mean value for the variable was used.
- Sampling was conducted during July and August 1989. Therefore, temporal changes in the pavement's condition and changes in the soil moisture regime are not taken into account, nor is it known at what point in the life of the pavement the sampling was done. Furthermore, because the study was short term, the potential effects of the root structure of shoulder vegetation on subsurface drainage were not analyzed.

Therefore, the results do not support the traditionally held engineering theory that herbaceous, nonrhizomatous, nonstoloniferous vegetation is a major factor in the premature deterioration of pavement. No apparent association was found between pavement condition and vegetation on the road shoulder. However, the factors influencing the premature deterioration of pavement may well be acting in concert with one another, and the influence of a single factor may go unnoticed in a simple descriptive study as this because of the confounding influences of other factors. A review of the correlation coefficients presented in Table 1 reveals strong associations between pavement condition factors, the composite pavement condition score, and a number of variables, most notably soil plasticity.

The results are inconclusive and indicate the value of a more in-depth study. Therefore, the study should be expanded to address the caveats already mentioned, especially the influence of vegetation through time, and to provide a solid foundation of information on which to base long-range vegetation management decisions. If the results of this pilot study are supported by subsequent analyses, it may be possible to reallocate maintenance resources with potentially great cost savings and improved maintenance effectiveness.

Publication of this paper sponsored by Committee on Roadside Maintenance.

Using Fine Fescues to Reduce Roadside Maintenance Costs

LARRY J. KUHNS

In Pennsylvania the two predominant roadside vegetative covers have been Kentucky 31 tall fescue and crownvetch. The tall fescue has been planted in areas that can be mowed, and the crownvetch has been planted on slopes and rocky areas. The primary disadvantages of these materials are that the tall fescue requires frequent mowing, and the crownvetch becomes infested with broad-leaved weeds and brush that are difficult to remove. Fine fescues are effective, low-maintenance grasses, but they have been little known and used. They will grow under a wide variety of soil texture, fertility, and moisture conditions. They develop a deep, extensive root system and a dense sod that will provide support for vehicles that leave the road. They tolerate shade and grow well in full sun. They survive and thrive better than any other cool-season grass under low-maintenance conditions, including little or no mowing, irrigation, fertilization, or pesticide use. Once established, they are extremely competitive with weeds and brush species, and they may have alleleopathic effects on other vegetation. They also are tolerant of many selective broad-leaved weed killers. This means that brush and weeds of all types can be removed from fine fescue plantings without damaging the fescues. They require little or no mowing. Sheeps and hard fescue grow slowly, and the leaf blades of the taller red and chewings fescue lay over and mat as they grow. The only reason to mow fine fescues along roadsides is to cut weeds or their seedheads, of which hard and red fescues produce few.

In Pennsylvania the two predominant roadside vegetative covers have been Kentucky 31 tall fescue (Festuca arundinacea Schreb.) and crownvetch (Coronilla varia L.). The tall fescue has been planted in areas that are mowed regularly, and the crownvetch has been planted on slopes, rocky areas, and areas that are mowed infrequently.

Kentucky 31 tall fescue has been widely planted because it forms a dense, deep-rooted turf under a wide range of soil texture and moisture conditions. It holds its quality through many years, tolerating periodic flooding and the salt sprays and runoff that can be quite heavy along Pennsylvania roadsides.

The disadvantages of Kentucky 31 tall fescue are its relatively fast growth rate and heavy production of tall seedheads. Most roadside managers and their constituents have found that it must be mowed frequently. When not mowed, or mowed infrequently, it develops a coarse, unkempt appearance.

Crownvetch has been widely planted because it produces a dense root system and cover of attractive fine-textured foliage and beautiful pink flowers. It grows over a wide range of soil textures and fertility levels and has proven to be especially useful on steep slopes. It does not need to be mowed but tolerates infrequent mowing.

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Crownvetch has one major disadvantage. When it is used on areas that cannot be mowed, perennial broad-leaved weeds and brush species eventually invade it. This occurs to a greater extent on high-fertility soils. Although this may not occur until many years after planting, it is difficult to control the weeds and brush once they are established without killing or injuring the crownvetch. A particularly troublesome weed problem in crownvetch in Pennsylvania is Canada thistle (Cirsium arvense (L.)Scop.). Legally it has been declared a noxious weed that must be controlled. However, when controlled with herbicides along roadsides, large patches of crownvetch are severely damaged or killed. These patches usually end up filled with weeds, predominantly Canada thistle, a year or so after application.

In 1983 a comprehensive research project was initiated at Pennsylvania State University (Penn State) to evaluate low-maintenance cover crops for use between rows of nursery stock and Christmas trees. On the basis of the results of those studies (*1*), in 1987 it was decided that fine fescues had considerable potential for use along Pennsylvania roadsides. At this point Pennsylvania's roadsides were observed more carefully and large areas of red fescue were found growing in all parts of the state. Red fescue has been a component of the grass mixtures that were predominantly tall fescue (Table 1, Formula D), and in some areas they developed into the dominant cover. The seeding mixes used by other state departments of transportation were also examined. It was discovered that Rhode Island had been using fine fescues as the dominant component in their seeding operations for more than 20 years (Table 2).

FINE FESCUES

What are fine fescues? As opposed to tall fescues, which have relatively broad, flat leaves that are as wide as 10 mm, fine fescues have leaves that are tightly folded and about 1 mm wide. The four major fine fescue species are creeping red (Festuca rubra L. subsp. trichophylla Gaud.), chewings (F. rubra L. subsp. commutata Gaud.), sheeps (F. tenifolia Sibth.), and hard (F. longifolia Thuill.). Creeping red fescue has been divided into two separate species, slender creeping fescue and spreading fescue, but they are grouped together here.

Common Characteristics

Several characteristics, common to all fine fescues, make them well suited for roadside use.

TABLE 1 SEED MIXTURES USED ALONG ROADSIDES IN PENNSYLVANIA (*9*)

Mixture	Percent
Formula B (for high visibility, use, and maintenance areas)	
Perennial ryegrass mixture (a combination of improved certified varieties with no one variety exceeding 50% of the total)	20
Creeping red fescue or chewings fescue	30
Kentucky bluegrass (a combination of improved certified varieties with no one variety exceeding 25% of the total)	50
Seeded at about 100 lb/acre	
Formula C (for slopes or infrequently mowed areas)	
Crownvetch	45
Annual ryegrass	55
Seeded at about 45 lb/acre	
Formula D (for mowed roadsides)	
Tall fescue 'Kentucky 31'	70
Creeping red fescue or chewings fescue	30
Seeded at about 100 lb/acre	
Formula E (for temporary soil stabilization)	
Annual ryegrass	100
Seeded at about 50 lb/acre	
Formula L (for low maintenance)	
Hard fescue (a combination of improved certified varieties with no one variety exceeding 50% of the total)	60
Creeping red fescue	40
Seeded at about 100 lb/acre	
Formula W (for wet areas)	
Tall fescue 'Kentucky 31'	70
Birdsfoot trefoil (a mixture of 50% Viking and 50% Empire, Leo, or Noreen)	20
Redtop	10
Seeded at about 50 lb/acre	

NOTE: Percentages are based on weight.

1. They will grow under a wide variety of soil texture, fertility, and moisture conditions. They are drought tolerant; well adapted to acidic, infertile soils; and will grow in clay soils or soils with a high sand content. They grow from coast to coast in the temperate regions of the United States and Canada.

2. They develop a deep, extensive root system and a dense sod that will prevent erosion and provide support for vehicles that leave the road.

3. They tolerate shade and grow well in full sun.

4. They survive and thrive better than any other cool-season grass under low-maintenance conditions, which include little or no mowing, irrigation, fertilization, or pesticide use (*2*). The following ranking of persistence of turfgrass species under low maintenance is based on observations in areas of the United States where cool-season species are well adapted (*2*):

   a. Hard fescue,
   b. Sheep fescue,
   c. Chewings fescue,
   d. Creeping red fescue,
   e. Tall fescue,
   f. Common Kentucky bluegrass,
   g. Improved Kentucky bluegrass, and
   h. Perennial ryegrass.

5. Once established, they are extremely competitive with weeds and brush (*3*). They may have alleleopathic effects on other vegetation, totally excluding it or severely stunting it. They are tolerant of many selective broad-leaved weed killers and are even resistant to Fusilade (fluazifop-p-butyl) and Poast (sethoxydim), two selective grass killers (*4*,*5*). This means that brush and weeds of all types can selectively be removed from fine fescue plantings without damaging the fescues.

6. They require little or no mowing. Sheeps and hard fescue grow slowly, and the leaf blades of the taller red and chewings fescue lay over and mat as they grow. The only reason to mow fine fescues along roadsides is to cut weeds or their seedheads, of which hard and red fescues produce few.

TABLE 2 SEED MIXTURES USED ALONG ROADSIDES IN RHODE ISLAND (*10*)

Species	Mowed Areas (%)	Unmowed Areas (%)
Red fescue	75	75
Kentucky bluegrass	15	–
Colonial bentgrass Exeter	5	5
Perennial ryegrass	5	5
Birdsfoot trefoil Empire	–	15

NOTE: Seeding rate of 100 lb per acre is recommended.

Distinctions Among Species

There are some distinctions among the fine fescue species.

Creeping red fescue is distinct from the other fine fescues in that it spreads by small, short rhizomes. Improved varieties develop a stronger rhizome system and can spread faster. It has a medium establishment rate and will provide a cover faster than hard or sheeps fescue. However, it does not compete excessively with them during establishment. Although leaf blade lengths of 20 in. are common for many of the turf varieties of red fescue, canopy height of an unmowed area will be considerably less because the leaves lay over. Other varieties have been developed that produce leaf blades of only 12 to 14 in. It typically produces few seedheads and would not require mowing for seedhead control. Red fescue is not as tolerant of wet soils and salt as hard fescue.

Chewings fescue is similar to creeping red fescue except that it lacks rhizomes. It is a bunch-type grass with a rate of establishment and vertical shoot growth comparable with that of red fescue. As with red fescue, shorter varieties are available. The climatic adaptations of chewings fescue are similar to those of red fescue. However, it does produce more seedheads, and they would need to be mowed once a year to maintain a neat appearance.

Hard fescue has a bunch-type growth habit, excellent drought and heat tolerance, and will survive higher soil moisture and salt levels than red fescue. Its germination and establishment rate is distinctly slower than that of red and chewings fescues. It produces few seedheads and would not need to be mowed for seedhead removal. Hard fescues have reasonably good winter color, but they are slower to become green in the spring than some chewings and red fescue varieties, especially under low fertility.

Sheeps fescue is a bunch-type grass that germinates and establishes at about the same rate as hard fescue, but grows slower and remains lower. It is extremely drought resistant,

but its heat tolerance is lower than the other fine fescues. It produces more seedheads than hard fescue and would need to be mowed.

Although they are well adapted for roadside use, the fine fescues have several limitations. They are usually weedy during establishment because they have a slow (hard and sheeps) to medium (red and chewings) germination and establishment rate (*5*). Establishment is especially poor during hot summer months. Also, their lateral spread is slow, even for creeping red fescue. This could be a problem on unevenly prepared sites or areas in which the seeding pattern was not uniform.

HISTORY AND RECOMMENDATIONS FOR USE

If fine fescues are so good, why have they not been used more along roadsides? Until the mid-1900s, lawns were seldom irrigated or fertilized (*6*). Under these conditions the fine fescues were the prevalent species in turf stands in many areas of the United States, particularly in the temperate regions and where the soil was acidic, infertile, or light textured. With the increase of fertilization and irrigation, these grasses decreased in popularity and ceased to be a major component of turf stands. Improved Kentucky bluegrasses, perennial ryegrasses, and tall fescue have dominated the turf market since then, and fine fescues have been used primarily for their shade tolerance. They have been a small part of the market because few were aware of their desirable characteristics. Most people were totally unfamiliar with any fine fescue except red fescue.

However, researchers in the turfgrass industry rediscovered the fine fescues. In an article summarizing a presentation at the TRB Annual Meeting in January 1989, Robert Duell of Rutgers University described why he thought grasses made the best vegetative covers along highways (*7*). He also discussed the grasses being used at that time and the potential for selecting grasses that would be better suited for roadside use.

> The brightest development presently available for roadside mixtures is that of the hard fescues. . . . Of all the cool-season grasses, the hard fescues are the densest growing and have the best summer green color, particularly under low maintenance. Their dense turf effectively excludes most weeds once the turf is established. The weed-free aspect, low growth, plus rich green summer color, provides quality roadside turf. They also require minimum mowing and tolerate low fertility and low soil moisture.

Research is continuing on fine fescues, and industry and university personnel are conducting active selection and breeding programs to develop new varieties. The improved varieties are not only extremely adaptable to a variety of sites, but they receive turf quality ratings as high or higher than those of Kentucky bluegrass and perennial ryegrass (*6,8*). At this time many varieties of the fine fescue species are available and more are being developed, tested, and introduced. This creates a major problem for anyone writing specifications for seed mixes, especially because almost all the testing is done under more typical turf conditions—annual fertilizer applications and close mowing. Differences between varieties include texture, growth rate, color, seedhead development, disease and insect resistance, and the presence of endophyte (a beneficial fungus associated with the grass that makes it resistant to some common insect problems). To further complicate the issue, the relative performance of two particular varieties may be reversed in different parts of the country. Improved varieties should be specified, however, because they are superior to the common, old varieties.

Other grasses may be combined with fine fescues to aid in establishment or provide some other characteristics that may be important in the long term.

Colonial bentgrass (Agrostis tenuis Sibth.) is a fine-textured, sod-forming grass that is adapted to northern, humid climates and will tolerate acid, infertile, and droughty soils. This grass has fine seeds and should not exceed 5 percent by weight in a seed mixture. The improved variety Exeter is recommended.

Kentucky bluegrass (Poa pratensis L.) is a sod-forming grass that is adapted to northern climates and better soils in the roadside environment or areas that receive some fertilizer, such as urban zones.

Perennial ryegrass (Lolium perenne L.) is a bunchgrass that establishes rapidly and is useful for initial stabilization. It is short-lived under roadside conditions and, because it is highly competitive during establishment, should be a minor component of roadside seed mixes. No more than 15 lb per acre should be included in a mix with fine fescues.

Establishing and maintaining a low-maintenance fine fescue turf is no more difficult than for any other turf. However, a few more steps can be added to speed the establishment of a weed-free stand.

1. Select a seed mix. Formula L in Table 1 was designed for Pennsylvania roadsides. The textures of the hard fescues and red fescues are compatible. Both are well adapted to a variety of roadside conditions, and neither produces enough seedheads to require mowing. If immediate soil stabilization is needed, add 5 to 10 percent improved perennial ryegrass. However, in preliminary trials on Pennsylvania roadsides, red fescue germination and establishment was not far behind that of perennial ryegrass.
2. Eliminate all weeds from the area. If the site is new construction, the soil will be bare after grading. If the site is being renovated or converted from a high-maintenance cover, spray the area with a translocated, postemergence, nonselective, nonresidual herbicide such as Roundup (glyphosate) to kill all perennial weeds and grasses.
3. Run over the soil with a disk to form shallow (1 in. or less) grooves. This should be done on bare ground or after sprayed vegetation has had time to absorb and translocate the herbicide to its roots.
4. The seed can be broadcast, dropped, or hydroseeded. Research conducted at Penn State showed that rolling or dragging following seeding was not necessary (*5*). Steps 3 and 4 can be combined with seeding equipment that is currently available.
5. Apply 40 lb of nitrogen per acre to increase the rate of growth during establishment.
6. When the grass reaches a height of 2 in., apply selective herbicides to control competing vegetation. Mowing will also work, but will not be quite as effective.
7. A broadcast application of selective herbicides every 2 to 5 years should be sufficient to prevent the establishment

of perennial broad-leaved weeds or brush species. Little or no mowing should be needed. If mowed, the grass should not be cut closer than 4 in.; there is really no need to cut lower than 6 in. because it does not regrow quickly.

Although a well-established fine-fescue planting would present a neat and attractive appearance along a roadside, it could become monotonous. Some of the money saved on maintenance costs should be spent on landscape plantings. These plantings should be groups of trees and shrubs instead of individual plants. The growth and development of individual trees and shrubs surrounded by fine fescue will be stunted by their competitive and alleleopathic nature. The trunks of trees planted individually are also often damaged by mowers. By planting the trees and shrubs in groups they can provide a canopy dense enough to keep the grass and mowers away from them.

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Survey of Landscape Use of Native Vegetation on Midwest Highway Rights-of-Way

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The transportation departments of 14 Midwestern states that occupy the region of the tallgrass prairie were surveyed on the management and use of prairie species on highway rights-of-way (ROW). A total of 128 surveys was mailed to state and district division offices; the response rate was 70 percent. The survey was divided into two sections: the first on the extent that prairie and other native vegetation are used on ROW and how well prairie meets the requirements of vegetation for ROW landscaping, the second on the establishment and management techniques used by highway departments and problems associated with these techniques. Ten of the 14 states are involved in the establishment of prairie vegetation; the remaining 4 are active in managing prairie on portions of roadsides. All states plant native grasses, wildflowers, and trees, as well as wildflower mixes of native and exotic plants. Drilling was rated higher in satisfaction and success than no-till seeding, hydroseeding, and transplanting. Four states reported the use of fire as a roadside management tool. Respondents reported that information on the management of prairie was inadequate and that department research on the topic was not widely disseminated.

This study of the use of native vegetation on rights-of-way (ROW) began after the Wisconsin Department of Transportation (DOT) initiated planting of native grasses, wildflowers, and trees for 42 mi of a newly reconstructed highway in the central sand plains of that state. The landscape goal was to create a corridor containing facsimiles of some of the plant communities that would have occurred in the area at the time of European settlement. Those communities were (a) prairie, a community dominated by grasses and largely devoid of trees, and (b) oak savanna, is a grassland community with a canopy cover of less than 50 percent (*1*). Searches for information on prairie establishment and management found relatively abundant material on natural plantings in arboreta and institutional grounds, but this information is not necessarily applicable to the planting of prairie on highway ROW because of the unique environmental characteristics and functional needs of the corridors. Highway departments that had tried prairie plantings, however, have published little information on the details of the planting process or on the extent and success of these plantings. The survey was an attempt to gain a better understanding of the use of prairie along roads and highways.

On the basis of discussions with transportation personnel and recent conference topics on the subject, it appears that interest in native plantings is increasing, but the levels of experience with native plants and the reasons for the interest in them vary. Many individuals appear to view native plantings as a low-cost alternative to turf grasses, whereas others view them as an aesthetic or ecological approach to ROW planning.

The use of prairie, native grasses, and wildflowers on roadsides, however, is not new. As early as the 1920s, Texas was experimenting on a small scale with wildflowers on roadsides. During the 1960s, Texas advocated the planting of wildflowers as a tool to encourage tourism. Nebraska, along with other states on the western fringe of the tallgrass prairie, has experimented for several decades with planting native grasses and wildflowers—partially for their beauty but with strong interest in their erosion controlling capabilities, water conservation properties, and abilities to increase soil fertility (*2*). Michigan began a program called Operation Wildflower in 1975 to promote the planting and establishment of roadside wildflowers. Prairie plantings have also been established along a number of expressways in the Chicago area. Both Minnesota and Wisconsin have established committees to review current landscape and roadside vegetation policies. *Roads and Bridges*, *Wildflower*, and conference proceedings, including the North American Prairie Conferences, National Roadside Vegetation Managers Association meetings, and Environmental Concern for Right-of-Way Management, have included articles or special issues examining the use of native plantings on roadsides as a means to ease management costs and enhance aesthetics. A paper on planting prairie in ROW was published in a 1981 *Transportation Research Record* on vegetation management (*3*).

The potential value of prairie for roadside planting is due in part to its evolution under the Midwest's climate. The prairie is a product of the interaction of microclimate, topography, and soils (*4–6*). Tolerant of extreme temperatures, drought resistant, and adaptable to a wide range of soils and soil characteristics, the prairie appears to be suited to less hospitable roadside environments than many agronomic or ornamental groundcovers. The prairie is also long-lived and has a deep, fibrous root system that benefits the development of organic matter in soils and aids erosion control (*7*).

PURPOSE OF SURVEY

The survey described here was distributed in April 1988. The first half of the survey was designed to determine the extent to which state transportation agencies plant native vegetation,

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FIGURE 1 Tallgrass prairie and survey regions.

particularly prairie, and how well this vegetation meets the demands and requirements of roadsides. The following questions were addressed.

1. Which Midwestern state transportation departments and their districts plant prairie or other native plant forms?
2. Are there regional trends in the use of native plant materials on roadsides?
3. How well does prairie, in particular, meet the demands and requirements that planners and managers have for roadside vegetation?

The second half of the survey was used to examine prairie establishment and management techniques used by transportation departments and their success. The following three main questions were addressed.

4. What techniques are used by transportation departments to plant prairie? How successful are they?
5. How are prairie plantings on ROW managed? Which techniques have been successful?
6. Is knowledge on prairie installation and management sufficient?

METHODS

A predominantly closed-ended questionnaire was mailed to state and district transportation offices in April 1988. Respondents were asked to rate or rank variables for 134 of the 170 questions. The remaining questions were either multiple choice or open-ended. Respondents were asked to include comments with their responses.

The sample was confined to 14 states in the original range of tallgrass prairie (Figure 1). This area extends from the Canadian border into Texas and from Ohio to the eastern third of North Dakota. Iowa is the only state that resides completely in the original tallgrass prairie range.

All surveys (n = 128) were addressed to state and district highway employees in charge of plantings and roadside maintenance. Employees were selected randomly from lists acquired previously from state offices. Comparisons between responses of state and district employees showed no significant differences; therefore, all responses were grouped together for analysis. Administration of the survey followed work by Dillman (*8*). Postcards containing a survey reminder and thank you were sent to all addresses one week after the original survey was sent. Those who did not respond were sent a letter three weeks later that stressed the importance of their participation in the survey. After another three weeks, they received a new survey form and a letter.

Landscape architects represented 42 percent of the respondents, engineers 23 percent, and specialists, including foresters and agronomists, 20 percent. A catch-all category for maintenance personnel represented an additional 15 percent. The final response rate was 70 percent (n = 90). Some states returned only one survey from a central office, claiming that it represented policies and actions followed by all department employees.

Questions were analyzed by tabulating responses and calculating frequencies. Not all questions were applicable to all respondents. For instance, some questions were to be answered by participants of a defined group (e.g., those who have planted prairie). Therefore, the number of responses to each question varied.

Written comments were provided by 74 percent of the respondents. These comments are reported when appropriate. However, comment summaries do not necessarily represent an unbiased or representative sample of roadside personnel, and in most cases, are based on the views of a few individuals.

The definition of a prairie was given to survey respondents—native tallgrass, mixedgrass, and shortgrass landscapes that were once common in the Midwest and Plains States. Prairie was considered to be the simultaneous planting of forbs and grasses. It is assumed that no department is actually restoring prairie in the sense of a scientific community. Questions were also asked about separate plantings of native grasses and forbs.

RESULTS

Which Midwestern DOTs Plant Prairie or Other Native Plant Forms?

Despite whether a respondent was actively engaged in using native plantings (prairie, native grasses, native wildflowers, wetland plants, or native trees and shrubs), respondents in all states liked the idea of using native vegetation on roadsides. Ten states—Illinois, Indiana, Iowa, Michigan, Missouri, Minnesota, North Dakota, Ohio, Texas, and Wisconsin—are planting prairie as part of their roadside landscape program.

Although prairie plantings have been conducted by states for the past 20 years, the most planting has occurred during the past 8 years. Many respondents were engaged in planting and experimenting with prairie plants but remarked that they lacked sufficient time and experience to judge their effectiveness and that of other native materials. Most of these plantings occur along limited access highways, primary highways, and in rural areas. Less than one-third of the respondents reported having prairie plantings in urban and suburban areas.

Plantings of native trees and shrubs, grasses, and wildflowers have been conducted by the vast majority of respondents in all surveyed states (Table 1). Respondents have been highly satisfied with plantings of native trees and shrubs and grasses and moderately satisfied with native wildflowers (Table 2).

TABLE 1 RESPONDENTS INVOLVED WITH PLANTING NATURAL VEGETATION ON ROW

STATE	N=	PRAIRIE	NATIVE GRASSES	NATIVE WILDFLOWERS	WILDFLOWER MIXES	NATIVE TREES
ILLINOIS	8	7	8	7	4	8
INDIANA	6	3	3	4	4	3
IOWA	5	4	5	5	2	4
KANSAS	2	0	2	2	1	2
MICHIGAN	7	4	6	7	3	6
MINNESOTA	14	11	12	13	4	14
MISSOURI	2	2	2	2	1	2
NEBRASKA	1	0	1	1	1	1
NORTH DAKOTA	4	2	4	2	0	4
OHIO	8	5	6	8	7	8
OKLAHOMA	1	0	1	1	1	0
SOUTH DAKOTA	3	0	2	2	0	3
TEXAS	19	5	17	18	11	18
WISCONSIN	5	4	4	5	1	5
TOTAL	85	47	73	77	40	78

Wildflower mixes, composed of native and exotic species and developed for broad regions of the country, are used frequently by some states (Indiana, Ohio, Oklahoma, and Texas) and infrequently by others. Although both wildflower and wildflower mixes have widespread support, nearly 24 percent of the respondents were dissatisfied with them. Weeds were viewed as highly competitive with wildflowers, and wildflowers were perceived as requiring much "tender loving care" in their establishment. Therefore, they were considered costly to establish and maintain, and for some, "a lot of fuss and bother for the short term."

Less than one-third of the respondents are engaged in wetland plantings; however, the variation between states planting wetlands is great. Two-thirds or more of the respondents from Wisconsin, Illinois, Michigan, and South Dakota reported attempts at wetland establishment. Less than one-quarter of the respondents from Minnesota, Texas, Ohio, Oklahoma, and Indiana reported establishing wetlands on roadsides. Wetland plantings had the greatest dissatisfaction (29 percent) of any planting type.

Do Regional Trends Occur in Use of Native Plant Materials?

Survey data were also tabulated by grouping respondents and states into regions because geographic location was expected to significantly influence a response. Region 1 consisted of

TABLE 2 PERCENT OF RESPONDENTS SATISFIED WITH NATURAL PLANTINGS

VEGETATION TYPE	N=	VERY SATISFIED	SOMEWHAT SATISFIED	SOMEWHAT DISSATISFIED	VERY DISSATISFIED
PRAIRIE	58	32.8	51.7	12.1	3.4
NATIVE GRASSES	76	46.1	43.4	10.5	0.0
NATIVE WILDFLOWERS	77	40.3	36.4	16.9	6.5
WILDFLOWER MIXES	47	27.7	51.1	21.3	2.1
WETLAND	34	14.7	58.8	26.5	2.9
NATIVE TREES	78	47.4	46.2	5.3	1.3

the northern and central tallgrass prairie states of Minnesota, Wisconsin, Illinois, Iowa, and Missouri (Figure 1). Region 2 consisted of Ohio, Indiana, and Michigan, which lie along the eastern edge of the prairie peninsula where prairie is found in pockets interspersed among hardwood forests. Oklahoma, Kansas, Nebraska, South Dakota, and North Dakota constituted Region 3, an area that includes the transition area from tallgrass prairie to mixed and shortgrass prairie. Region 3 has a significant amount of open land that is devoid of trees and still contains substantial acres of grasslands. Region 4 consisted of a single state, Texas, into which the southern edge of the tallgrass prairie extends. The number of respondents from each area are as follows: Region 1, $n = 36$; Region 2, $n = 21$; Region 3, $n = 11$; and Region 4, $n = 21$.

The majority of prairie planting attempts would appear to be occurring in the north central and eastern zones of the survey area. Illinois, Wisconsin, Iowa, and Minnesota of Region 1 had the greatest percent of respondents who reported that their departments have planted prairie (Table 3). In Region 2, nearly two-thirds of the respondents reported prairie plantings, whereas in Region 3, 20 percent reported planting prairie vegetation. South Dakota, Oklahoma, Kansas, and Nebraska of Region 3 each reported that they were not establishing prairie on roadsides, although prairie species were planted in rest areas in some states. Each of these states, however, manages naturally occurring prairie on roadsides and reported that they are active in planting large areas of native grasses. Approximately one-fourth of the respondents in Region 4 at the southern border of the tallgrass prairie reported conducting prairie plantings; others reported that they considered themselves outside the tallgrass prairie region.

All regions plant native trees, shrubs, grasses, and native wildflowers. A distinct difference between the percent of respondents planting wildflowers and wildflower mixes occurred in both regions 1 and 3, where 41 percent and 30 percent of the respondents plant wildflower mixes, and 94 percent and 73 percent plant native wildflowers, respectively. Species origin and stability are major differences between the plants composing these two types of wildflowers. Native wildflowers are local to the area of planting, and plantings often become dominated with perennials. Mixes are composed for broad regions, and not all species included are adapted to any one locale. Many of the species included in the mixes are annuals or biennials and therefore are present for only one to two years.

One aspect of measuring the perceived value of a vegetation type is how willing one is to go out of the way to preserve and manage it. As prairie has been removed from the landscape, the restoration and preservation of the remnants that are left has become an important issue in the scientific community. Some of these remnants may occur on roadsides as original prairie patches; more likely they have recolonized the right-of-way after road construction.

Two-thirds of the respondents stated that they were involved in preserving prairie remnants, most with citizen groups. Slightly more than half of the respondents reported that management plans or practices were developed to protect endangered species and remnant native vegetation located in ROW.

However, nearly two-thirds of the respondents also reported that their departments seldom kept records on remnant locations or compiled lists of species within these remnants. One might expect then that the majority of remnants and endangered species on roadsides are unknown to most departmental personnel and therefore receive no special treatment.

Responses vary considerably among regions. Regions 1 and 2 keep records on locations of native vegetation remnants "always" to "most of the time." Twenty-five percent of the respondents in Region 3 keep records "most of the time," and less than ten percent in Region 4 do. No regions regularly keep species lists at remnant sites.

How Well Does Prairie Meet the Demands of Planners and Managers?

The use of different vegetation types in a landscape setting depends on how well a planner perceives that the vegetation type will function in meeting the site's goals and objectives. Therefore, if any native vegetation is to become a common element along roads it must be perceived as being capable of meeting common ROW landscape objectives. Snow (*9*), for example, listed the following functions of plants along highways: (a) control erosion, (b) lower maintenance costs, (c) provide aesthetic beauty, (d) control snow drifting, (e) reduce headlight glare, (f) reinforce road alignment, and (g) serve as crash barriers. To determine how respondents per-

TABLE 3 PERCENT OF RESPONDENTS IN GEOGRAPHIC REGIONS THAT ARE PLANTING NATIVE VEGETATION ON ROW

REGION	N=	PRAIRIE	NATIVE GRASSES	NATIVE WILDFLOWERS	WILDFLOWER MIXES	WETLANDS	NATIVE TREES
1	34	82.4	94.1	94.1	40.6	37.5	97.1
2	21	60.0	71.4	90.5	70.0	23.8	81.0
3	11	20.0	90.9	72.7	30.0	30.0	87.5
4	21	26.3	89.5	95.0	57.9	94.4	95.0

ceived the function of vegetation in ROW and whether prairie meets their criteria, three questions were asked: (a) What are the responsibilities of roadside managers and planners? (b) What are the criteria used in selecting vegetation for landscape cover? and (c) Does prairie successfully meet these criteria and responsibilities?

Responsibilities of Roadside Managers and Planners

The primary responsibilities of roadside managers were perceived by the survey respondents to be weed control (99 percent), woody plant control (95.5 percent), maintenance of visual quality (94.5 percent), and erosion control (95.5 percent). Creation and maintenance of wildlife habitat (60 percent) and reduction of glare (62.9 percent) had less support as responsibilities, but even these were supported by more than one-half of the respondents. Management for wind and snow control was considered an important responsibility by 80 percent of the respondents.

Criteria Used in Selecting Vegetation for Landscape Cover

Ease in establishment received the highest score (Table 4) when respondents were asked to rank the top 10 criteria of a list of 22 that they would use to select plants. Rankings were summed for each criteria, and the relative percent that each was used in plant selection was computed. Seven of the top 10 criteria dealt with the ability of a species to establish and sustain itself in highway environments. Attractiveness, previous experience in dealing with a plant, and its response to mowing also ranked in the top 10. Respondents strongly agreed on the importance of the criteria, listing a total of only 12 of the 22 given criteria in the top 10. Respondents listed

TABLE 4 RELATIVE FREQUENCY OF AGREEMENT FOR ROW PLANT SELECTION CRITERIA BY RESPONDENTS ASSIGNED TO GEOGRAPHIC REGIONS

CRITERIA	REGION 1	REGION 2	REGION 3	REGION 4
ESTABLISHMENT EASE	14.23	10.93	14.95	13.84
ABILITY TO NATURALIZE	8.75	8.25	12.02	11.75
DROUGHT RESISTANT	8.70	10.70	8.63	11.38
IS A NATIVE SPECIES	10.47	6.58	9.86	12.48
ATTRACTIVE	10.06	9.48	9.40	9.38
DISEASE RESISTANT	9.54	10.47	7.40	9.11
PRIOR EXPERIENCE WITH SPECIES	8.34	4.91	3.38	5.28
TOLERANT OF POLLUTANTS/SALT	6.88	8.92	1.39	2.64
RESPONDS TO MOWING	2.29	4.79	6.16	5.10
RESPONDS TO CHEMICAL TREATMENT	2.39	5.46	2.77	5.28
COMPETES WELL	4.38	2.23	3.54	4.28
CREATES WILDLIFE HABITAT	3.13	1.23	7.24	0.82
WILL ACT AS SNOW FENCE	2.81	3.90	3.24	0.18
EVERGREEN	0.47	2.68	3.24	2.00
RECOMMENDED BY EXPERTS	1.88	1.90	1.54	2.00
LIMITED MATURE TRUNK DIAMETER	1.09	1.68	0.31	2.00
EFFECTIVE AS GLARE SCREEN	1.20	2.01	0.62	1.09
LIMITED MAXIMUM HEIGHT	1.20	2.56	0.00	0.00
DECIDUOUS	0.52	0.67	2.47	0.09
INVASIVE	0.05	0.00	1.08	1.37
USDA RECOMMENDATION	0.21	0.45	0.77	0.73

TABLE 5 PERCENT AGREEMENT FOR PRAIRIE PLANTING SELECTION CRITERIA

CRITERIA	HAVE PLANTED (N=38)			HAVE NOT PLANTED (N=19)		
	AGREE	UNSURE	DISAGREE	AGREE	UNSURE	DISAGREE
LESS COSTLY TO MAINTAIN	84.2	10.5	5.3	31.6	57.9	10.6
VISUALLY ATTRACTIVE	91.8	5.4	2.7	73.7	10.5	15.8
EFFECTIVE FOR EROSION CONTROL	71.0	23.7	5.3	63.2	36.8	0.0
PLANTED DUE TO PUBLIC RESPONSE	39.5	31.6	28.9	42.1	36.8	21.1
PART OF MITIGATION	37.8	24.3	37.8	31.6	52.6	15.8
REQUIRES LITTLE MOWING	94.8	5.3	0.0	73.7	21.1	5.3
REQUIRES LITTLE SPRAYING	84.2	7.9	7.9	57.9	36.8	5.3
COMPETES WELL	71.1	21.1	7.9	47.4	47.4	5.3
DROUGHT RESISTANT	94.6	5.4	0.0	79.0	21.1	0.0
GROWS IN LOW FERTILITY SOILS	73.7	18.4	7.9	52.6	42.1	5.3
INFO ON ESTABLISHMENT AVAILABLE	47.4	23.7	28.9	15.8	63.2	21.0
INFO ON MANAGEMENT AVAILABLE	39.4	26.3	34.2	10.6	63.2	26.3
SEEDS AND PLANTS AVAILABLE	42.1	13.2	44.7	10.6	42.1	47.3

additional criteria, two related to plant survival (tolerance to compacted soils and winter hardiness) and two practical ones (cost and availability of material) as concerns.

Ability of Prairie to Satisfy Plant Selection Criteria

The respondents were given 14 different criteria taken from the previous list and the literature (Tables 5 and 6) that are often cited as reasons for using prairie. Respondents were asked to rate the criteria using one of the following responses: strongly agree, agree, unsure, disagree, and strongly disagree. Respondents were also asked to compare prairie with vegetative covers of bluegrass and bromes on a number of similar criteria (Table 7).

Establishment Ease Respondents did not consider prairie an easy vegetation type to establish relative to traditional herbaceous plantings. They commented that prairie plants are

TABLE 6 ESTABLISHMENT EASE OF ROW PRAIRIE PLANTINGS

		% OF RESPONDENTS THAT FIND PRAIRIE ESTABLISHMENT:			
REGION	N=	QUITE EASY	SOMEWHAT EASY	SOMEWHAT DIFFICULT	EXTREMELY DIFFICULT
1	29	0.0	24.1	72.4	3.4
2	7	28.6	42.9	14.3	14.3
3	8	25.0	25.0	37.5	12.5
4	8	0.0	50.0	37.5	12.5
TOTAL	52	7.7	30.8	53.8	7.7

TABLE 7 COMPARISON OF PRAIRIE WITH BLUEGRASS AND BROME IN ROW PLANTINGS

		PERCENT RESPONDING THAT PRAIRIE IS:		
CRITERIA	N=	SUPERIOR	EQUAL	INFERIOR
EROSION CONTROL	33	24.2	57.6	18.2
LOWER MAINTENANCE COSTS	39	61.5	30.8	7.7
VISUAL ATTRACTIVENESS	44	59.1	31.8	9.1
PUBLIC APPEAL	30	33.3	42.4	20.0
LESS EQUIPMENT COSTS	36	44.4	47.2	8.3
LESS HERBICIDE APPLICATION	38	65.8	31.6	2.6
LESS MOWING	41	73.2	22.0	4.9
WITHSTANDS ROADSIDE POLLUTANTS	28	50.0	35.7	14.3

slow to germinate. Less than one-half of those who plant prairie believed that information on the establishment and management of prairie was readily available, and more than one-third believed it was not. Because of seed size and structure, many native grasses and wildflowers also require special planting equipment. Prairie establishment and management requires techniques that are different from those common to the more traditional cool-season turfgrass mixtures, and some techniques, such as burning, are considered inappropriate for highway settings.

Attractiveness Respondents agreed that attractiveness was important to landscaping and plant selections for ROW and that prairie was as attractive or more attractive than brome or bluegrass sods. Even so, only 40 percent of the respondents reported a large public demand to plant prairie.

Adaptability Nearly all respondents agreed that prairie was drought resistant. Past studies suggest that mature prairie plantings are capable of surviving and recovering after an extended drought but that newly planted prairies are not (*7*). The majority of respondents in each region also agreed that prairie grows well in low-fertility soils. Low fertility needs translate into cost savings in initial bed preparation and in less weed competition during establishment. Prairie species were not considered to have greater tolerance to salts or pollutants than brome or bluegrass sods, and research on this topic appears limited.

Maintenance Maintenance techniques and the timing of their applications vary between the cool-season plants of fescue and bluegrass and the warm-season plants of prairie. Respondents agreed that prairie requires less mowing and herbicide application than bluegrass or brome.

Ability to Compete Nearly two-thirds of respondents agreed that prairie competes well with established weeds. The dense rooting system of established prairies prohibits growth of late arrivals. Although this is a benefit in reducing weed competition, it also reduces the establishment of late germinating prairie species. Established prairie plantings that are burned occasionally show little evidence of weed invasion except for occasional persistent perennial weeds from the initial plantings. Burning, however, was a safety concern of the majority of respondents.

Erosion Control Prairie was considered to be effective for erosion control. However, it was not considered to be superior to brome or bluegrass sods. Concern was expressed that the slowness of germination and seedling growth kept the land open to erosion for the first year or two after a prairie planting was initiated. Temporary companion, or nurse, crops, which establish quickly but offer little permanent competition to the native species, are often recommended where wind and water erosion are problems. Sixty-seven percent of respondents (n = 49) said they used companion crops, particularly oats, ryegrass, sudan grass, and sprangletop.

Costs Respondents earlier in the survey stated that costs were a landscape planning concern. When asked if native plantings such as prairie are cost-effective, 4 respondents said no, 20 said yes, and the remaining 64 said that it was too soon to tell. Those who said yes cited that once the prairie was established, little replacement and maintenance was required. Although long-term costs of prairie plantings have not been documented, 84 percent of those who have planted prairie believe that prairie will be less costly to maintain than traditional or standard grass-dominated mixes of bluegrass, fescues, ryes, and bromes.

Several respondents were skeptical about the cost-effectiveness of prairie because of the "extras of planting and

managing," such as different equipment than that used for seeding turf grasses, the need for a different management schedule, and seed costs. Although survey results show that prairie is typically planted at 10 to 15 lb per acre, compared with 80 lb or more per acre for bluegrass and ryegrass plantings, prairie seed can cost up to 10 times as much as bluegrass seed. In a recent Wisconsin planting where the pure live seed ratio of grasses to wildflowers was 60:40 for 4 grasses and 16 wildflowers, seed and establishment costs were $1,600 to $1,800 per acre. When states add in maintenance costs, however, some respondents stated that prairie plantings become quite competitive with those of bluegrass-dominated mixes. Specific cost comparisons between prairie maintenance and traditional grass mixes have been too infrequent to draw any general conclusions.

Seed Availability In addition to its often high cost, the availability of prairie seed is perceived to be limited. Seeds of prairie plants (except range grasses) have had limited commercial production, and frequently production is inadequate to support the acreages that transportation departments are involved with. Seeds of prairie plants also tend to lack the high germination and vigor of many traditional turf grasses and cool-season weeds.

What Techniques Are Used to Plant Prairie and How Successful Are They?

Applying seed with a drill after plowing and disking the seedbed to eliminate weed growth is a common method of implementing a prairie (*3*). Other methods of establishing prairie include no-till seeding (*10,11*), hydroseeding, and transplanting (*12*). Drilling ensures even seed dispersal at a predetermined depth and establishes a firm seedbed but has limited use on highway slopes of 3:1 or greater. Drilling also requires a relatively long site preparation time and opens slopes to potential erosion.

No-till operations have the advantage of requiring little seedbed preparation, thus reducing soil disturbance. Sites that have minimal competition and sparse groundcover can often be seeded directly with a no-till drill. Hydroseeding has been used on steeper slopes, on which drills and no-till machinery are difficult to operate. Transplants have been used to supplement existing vegetation and to shorten establishment periods (*12*).

Respondents (n = 60) who have planted prairie or have been involved in related department actions were asked to indicate the methods of planting prairie in which they have had experience and the relative success or failure of each. Drilling, no-till seeding, and hydroseeding have been used by the majority of respondents, with drilling having the greatest percent of respondent use (67 percent) and satisfaction (48 percent). Drilling also had the lowest percent of respondents (7.5 percent) that believe it has a high rate of failure.

Both no-till seeding and hydroseeding have been tried by 60 percent of the respondents and appear to be equally successful, with 28 percent rating them as "working well" and 23 percent and 16 percent of the respondents reporting failed attempts, respectively. Hydroseeding received some of the following comments; "wind erosion often blew the seed away," "the seed did not germinate possibly due to a lack of moisture," and "the seedlings of those seeds that did germinate died during the first growing season." Others reported that hydroseeding required three times the amount of seed that drilling does.

Approximately 26 percent of the respondents also found transplants satisfactory; however, fewer of the respondents (35 percent) have actually tried this method. Transplant problems included the need for irrigation, a high rate of failure, and high expense.

How Are Prairie Plantings Managed?

The prairie is a plant community that evolved under both climate and disturbance regimes of fire and grazing (*13*). Fire provides many benefits to the viability and stability of these communities including the ability to reduce invasion from woody plants and cool-season grasses and the ability to stimulate growth in prairie plants (*14–16*). For these reasons, prescribed burns are a recommended management tool for prairie (*14,17*).

Because fire has limitations in modern-day settings, alternative mechanisms have been tried with varying degrees of success to replace the role of fire in the prairie ecosystem. Mowing has generally been considered a possible management tool but has limited effectiveness in eliminating aggressive cool-season grasses (*18*) and requires additional thatch removal equipment. Mowing in areas where prairie or native grasses are planted is best done in early spring or late fall to correspond with the growth of cool-season plants and the dormancy of warm-season grasses; however, these time periods do not fit the maintenance schedules of many departments.

Respondents were asked which of a variety of management methods were used on agronomic grasses (bromes, fescues, ryes, etc.) and which were used on native grasses. Comparisons were done among mowing, plant growth regulators, herbicides, controlled burning, and no treatment (Figure 2).

Although mowing was by far the main tool used to manage agronomic grasses and turf, it was rated as having the shortest length of effectiveness—only 30 to 60 days (Figure 3). Mowing was also the main management tool used on native grasses, although fewer respondents reported it as a normal practice. Respondents also agreed that prairie required less frequent

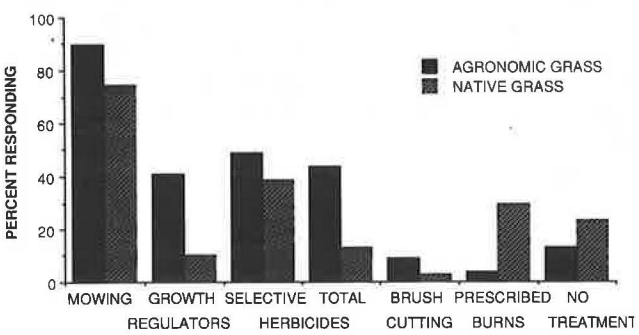

FIGURE 2 Management treatments applied to agronomic and native grasses.

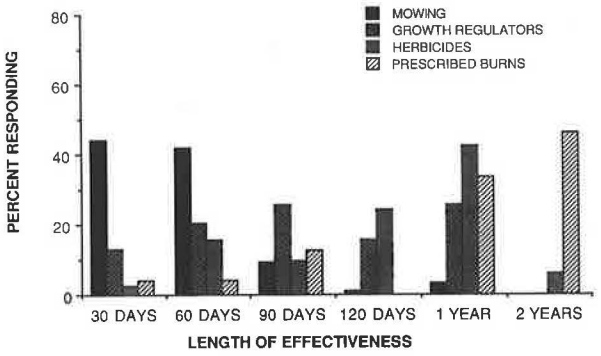

FIGURE 3 Length of effectiveness of management treatments.

mowing than did turf grasses. Herbicides, which were rated as lasting longer than mowing, (generally 120 days to 1 year) were reported as being used on agronomic grasses by approximately 45 percent of the respondents. Thirty-eight percent reported using herbicides in areas with native grasses but with less frequent applications than areas consisting of agronomic grasses. Plant growth regulators were used by 41 percent of the respondents on agronomic grasses and by 10 percent on native grasses. Even though controlled burning was rated as having the longest period of effectiveness (1 or more years), less than 4 percent use burning on agronomic grasses. On the other hand, 29 percent used burning on native grasses. Native grasses were also put on a no-management policy by 23 percent of the respondents. Less than 13 percent provided no treatment to agronomic grasses.

Survey questions were asked to find out which states were using prescribed burns as a management tool. One-fourth of the respondents, from four states located in the northern and eastern portions of the survey area, stated that they have used burning in treatment of prairie on roadsides. Of those states that do burn, 90 percent of the respondents remarked that they do so on fewer than 10 mi per year. Approximately 5 percent of the respondents remarked that their states burn between 10 and 100 mi per year.

The frequency of natural fires for any one area of prairie at the time of European settlement has been estimated at 1 for every 3 to 10 years (*14*). Rhizomes show greater growth and spread where burning is more frequent. Sites of native warm-season grasses that are burned at intervals greater than 5 years begin to show decline as a result of litter buildup (*16,19*). Prairie plantings on roadsides are currently burned on an irregular basis or every third year according to those respondents [32 percent, (n = 25)] who burn. Twenty-eight percent burn such plantings every other year, and 8 percent do so annually.

Burning can be labor intensive. However, most departments do not burn prairie on a yearly schedule. On the other hand, departments tend to mow areas two to three times a year. Respondents were asked to compare the costs of burning with mowing prairies. Of those who have had experience in burning prairies, 17 stated that mowing is more expensive (n = 22). Two believed that mowing was less costly than burning, and three believed that the two treatments were similar in costs. No department supplied actual cost comparisons.

Respondents who do not burn were asked to respond to a series of variables on why they do not. Safety concerns for motorists (78 percent), agency policy (65 percent), and potential threats to adjacent properties (60 percent) were the most frequently cited reasons for not burning. Gaper's block (the slowing or stoppage of vehicles by distracted drivers) and smoke drifting across traffic lanes were also considered by respondents to be major safety problems. Less than 24 percent of the respondents agreed that a lack of trained personnel, a lack of equipment, or an inability to receive permits from local authorities were reasons that they did not burn.

Is Knowledge on Prairie Installation and Management Available and Sufficient?

Perhaps one of the major impediments to the use of prairie is lack of knowledge and information. More than half of all respondents agreed that technical information on managing prairie was not readily available. Those who planted prairie reported information to be more available than those who had not (Table 5). The lack of access to information may contribute to the fact that more than 40 percent find prairie difficult to establish. Information on species selection, seed sources, propagation, and site preparation was accessible for most and was adequate in its coverage of the subject (Table 8).

Who is Conducting Research

Although states permit research on vegetation management within ROW, few individuals appear to be aware of the research results. Research on roadside vegetation is being conducted by departments, according to 77 percent of the respondents; however, only 16 percent of the respondents acknowledged that research results have been published in a form that would be available to other ROW managers, and 44 percent did not know if or when research results were published. The survey responses indicate that not all respondents are familiar with their state's research activities.

Sources of Information for Vegetation Management

The majority of respondents found nearly all sources listed in Table 9—industry, related occupations, agencies, and trade journals—to at least be somewhat helpful in providing information on the management of natural roadside vegetation. The greatest help came from state DOTs, chemical representatives, ROW managers, and landscape architects, with landscape architects and state DOTs having the highest annual frequency of use (Table 10). Plant ecologists, wildlife ecologists, and departments of natural resources were rated as helpful by one-half of the respondents but were never used by approximately 42 percent of the respondents. Other sources of information found to be valuable by several respondents included the Soil Conservation Service, Association for the Use of Native Vegetation in Landscape Through Education, and the National Roadside Vegetation Managers Association.

TABLE 8 ADEQUACY OF INFORMATION ON PRAIRIE ESTABLISHMENT AND MANAGEMENT

INFORMATION CATEGORIES	N=	% OF RESPONDENTS FINDING INFORMATION TO BE: MORE THAN ADEQUATE	ADEQUATE	LESS THAN ADEQUATE	NOT AVAILABLE
SPECIES SELECTION	84	8.3	58.3	28.6	4.8
SEED AND PLANT SOURCES	84	11.9	48.8	36.9	2.4
PROPAGATION METHODS	84	7.1	48.8	35.7	8.3
SITE PREPARATION METHODS	83	8.4	62.7	26.5	2.4
INSTALLATION METHODS	83	10.5	59.3	25.6	4.7
LANDSCAPE PLANNING	84	3.6	54.8	33.3	8.3
INITIAL MANAGEMENT	84	2.4	45.2	46.4	6.0
LONG TERM MANAGEMENT	84	4.8	44.0	42.9	8.3
VALUES OF NATIVES	84	7.1	52.4	36.9	3.6

TABLE 9 HELPFULNESS OF INFORMATION SOURCES ON NATIVE PLANTINGS

SOURCES OF INFORMATION	N=	% OF RESPONDENTS FINDING INFORMATION TO BE: VERY HELPFUL	SOMEWHAT HELPFUL	NOT HELPFUL	NOT USED
ROW MANAGERS	85	49.4	42.4	1.2	7.1
CHEMICAL INDUSTRY	85	36.5	54.1	3.5	5.9
MACHINERY INDUSTRY	84	6.0	50.0	13.1	31.0
LANDSCAPE ARCHITECTS	85	47.1	41.2	3.5	8.2
PLANT ECOLOGISTS	82	26.8	31.7	3.7	37.8
WILDLIFE MANAGERS	81	11.1	38.3	13.6	37.0
UNIVERSITY EXTENSION	85	34.1	41.2	9.4	15.3
DEPT NAT. RESOURCES	81	22.2	27.2	9.9	40.7
FED. TRANSPORTATION DEPT.	82	4.9	18.3	15.8	61.0
STATE TRANSPORTATION DEPT.	75	65.3	28.0	0.0	6.7
CONTRACTORS	84	25.0	47.6	3.6	23.8
TRADE JOURNALS	84	23.8	58.3	2.4	15.5

TABLE 10 INFORMATION SOURCES AND FREQUENCY OF USE

SOURCES OF INFORMATION	N=	% OF RESPONDENTS USING SOURCES: 1 TO 5 TIMES	6 TO 10 TIMES	MORE THAN 10 TIMES	NOT USED
ROW MANAGERS	84	71.4	16.7	4.8	7.1
CHEMICAL INDUSTRY	84	53.6	3.6	1.2	41.7
MACHINERY INDUSTRY	82	46.3	25.6	14.6	13.4
LANDSCAPE ARCHITECTS	80	42.5	7.5	5.0	45.0
PLANT ECOLOGISTS	81	45.7	8.6	2.5	43.2
WILDLIFE MANAGERS	84	51.2	6.0	1.2	41.7
UNIVERSITY EXTENSION	84	59.5	14.3	6.0	20.2
DEPT NAT. RESOURCES	79	44.3	3.8	7.6	44.3
FED. TRANSPORTATION DEPT.	78	24.4	2.6	1.3	71.8
STATE TRANSPORTATION DEPT.	72	40.3	29.2	23.6	6.9
CONTRACTORS	81	49.4	16.0	9.9	24.7
TRADE JOURNALS	82	51.2	19.5	9.8	19.5

CONCLUSIONS

Comments that prairie plantings are being used as a "replacement (for traditional plant materials) in weedy areas, eroded or droughty rocky slopes, and large mowed areas" are indicative of survey responses that prairie is competitive, effective as an erosion control cover, tolerant of droughty conditions, and requires minimal mowing. Respondents also considered prairie to be visually attractive. Prairie plantings were rated superior to bluegrass and brome sods for all the above characteristics except erosion control effectiveness for which they were considered equal.

If prairie is equal to or superior to more traditional planting types in terms of management costs, attractiveness, and environmental tolerances, why is it not planted more? There are several possible explanations based on what roadside planners and managers know and require of roadside plantings, including the following.

1. Previous experience with a particular species. Planners stated that previous experience with plants was important in designating them for use. As prairie plants are fairly recent ROW planting material, a planner's experience and familiarity with them is likely to be limited. In addition, prairie species and other native ground flora are not common in the traditional nursery industry and until recently have not been highly advertised or "visible."

2. Material Availability. Low seed availability and costs may restrict transportation departments from participating in more prairie plantings. Recent government set-aside programs for agricultural lands have made the growing of native grasses a much more profitable enterprise and have reduced already limited stocks in many agricultural areas. Several states in the eastern regions of the study area are currently engaged in developing state-administered seed farms to supplement highway plantings.

3. Establishment ease. Respondents selected establishment ease as the top criteria for selecting plantings to place in ROW, a criteria for which prairie plantings rated poorly. Ironically, the states who reported the greatest amount of prairie plantings also contained the highest number of respondents who believed it was difficult to establish, suggesting that criteria other than establishment ease are important to its use. The slow development of prairie may also concern managers, particularly where immediate erosion control is needed. At least one state is considering conducting research to determine the germination and seedling needs of species that are difficult to grow.

4. Management Techniques. Infrequent mowing appears to be the management tool roadside managers are using on native vegetation. Prescribed burns and a "hands-off" management policy are also used by only a few respondents. Mowing has proven useful in the initial stages of development, but research suggests that without the removal of thatch, native

grasses will decline and allow competitive undesirable plants to invade. The perceived lack and limited dissemination of available knowledge on the management of prairie may also be a factor in the willingness of an agency to participate in such plantings.

If native vegetation is to gain favor as a roadside planting material, then department personnel, particularly policy makers, must recognize and understand its value and purpose and promote its planting to be followed by monitoring and research reports on planting and management methods. Prairie plantings are minor components of the ROW landscape, but with recent trends toward reducing maintenance, increasing environmental awareness, and restoring natural settings, its use, along with that of other native vegetation types, may increase. On the basis of present knowledge, prairie appears to be a viable and well-adapted vegetation type for many roadsides and one that deserves additional study.

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Changing the Urban Forest To Fit the 1990s

NORMAN L. LACASSE

The Municipal Tree Restoration Program (MTRP), a public/private partnership of the School of Forest Resources at the Pennsylvania State University, the Pennsylvania Department of Environmental Resources Bureau of Forestry, the U.S. Forest Service State and Private Forestry, and some electric utilities was established to help communities undertake comprehensive tree replacement and tree care programs. Educational and training opportunities are made available to community leaders on the proper selection of tree species for specific sites, proper planting techniques, and tree maintenance programs. Replacement trees are provided to qualifying communities as test plantings to determine the suitability of selected cultivars to street-tree use. Various services have been provided to 60 communities since MTRP was initiated 4 years ago.

Trees in the urban areas provide many amenities to society, and their benefits have been well documented. These benefits include shade, uptake of carbon dioxide, filtration of air pollutants, erosion control, habitat for birds and small mammals, aesthetics, and recreation. The cooling effect of trees in cities has taken on an even greater significance in recent years because of global warming. It has been estimated that one-third of the area of a typical American city or town is covered by tree crowns. However, it is also well known that urban trees can cause many problems. Examples include heaved sidewalks, which create difficulties for pedestrians; leaves and plant debris in the fall; power interruptions and costly cleanups after violent storms; clogged sewers; and hazards to motorists from improperly designed roadside tree plantings.

Can such a valuable resource be managed to minimize these problems while preserving the benefits?

When problems are analyzed, it becomes obvious that many of the problem trees were planted many years ago when species selection was limited. In many cases, trees were dug up from the forest and transplanted in the community. These trees did well until urban residents insisted on above-ground and underground utilities, paved roads, concrete sidewalks and curbing. Add to this urban air pollution, deicing salt, and other environmental insults, and the result is conflict between trees and the environment we have created for them. Furthermore, in many communities, little or no maintenance has been performed over the years, except the removal of dead trees. Repeated trimming by utilities results in deformed trees and creates infection courts for decay fungi. Trees weakened by fungi sooner or later end up as a liability to the community.

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Pennsylvania has many small communities in which such trees were planted before and shortly after the turn of the century during the City Beautiful movement. Unfortunately, when some of these old trees are removed, trees of the same species are often planted in the same or a similar location. Planting these new trees will result in the same problems. To correct this problem, a program was started in Pennsylvania 4 years ago and has proven quite successful. The program, the Municipal Tree Restoration Program (MTRP), is a partnership of the School of Forest Resources at the Pennsylvania State University (Penn State), the Pennsylvania Bureau of Forestry in the Department of Environmental Resources, and some electric utilities. New York and Maryland have joined the program.

The main objectives of MTRP are to create an awareness among community leaders of the importance of trees in their communities and the need to undertake a comprehensive tree-care program. The program was initiated in the participating utilities' service areas through three types of two-day workshops. The first type of workshop consisted of intensive training in urban forestry for utility and bureau foresters. Six such workshops were conducted in Pennsylvania, New York, and Maryland. The second type of workshop was designed for community leaders, shade-tree commissioners, and other interested persons. The subject matter of these workshops consisted of background information on the importance of urban forestry, the fundamentals of a sound shade-tree program such as proper selection of tree species and cultivars (cultivated variety), correct planting procedures and the importance of maintenance, and information on where to get assistance. Nine such workshops have been held in the three states. A third type of workshop on the use of cultivars as street trees was offered twice to anyone interested. More than 300 people have now been exposed to the specifics of urban forestry through these workshops.

The next step in the program is to work directly with the community contacts made at these workshops and help them initiate projects in their communities. A typical project usually starts with a street-tree inventory and the development of a tree replacement plan. The next step is to select the correct species or cultivars for a given location. Correct planting procedures and the need to undertake a maintenance program are emphasized. Tree-planting plans are usually prepared by the service foresters and utility foresters in consultation with the community contacts. In communities in which utilities have provided funding, 50 replacement trees are provided for planting under utility lines. The community selects 25 trees of one cultivar of a species and 25 trees of another

cultivar of the same species. It is the responsibility of the community to plant the trees properly.

The reason 25 trees of 2 separate cultivars are planted per community is to provide the basis for a statistically valid comparison. Data are collected from these trees right after planting and on a yearly basis. As more and more cultivars are planted across the state, considerable information will be gathered on their performance in urban environments. This information will enable those responsible for urban tree planting to select cultivars better suited for street trees.

Since the program was started 3 years ago, 18 communities in Pennsylvania and 1 each in New York and Maryland have planted performance tests of 50 trees in each community. The following species and their cultivars are being tested: Amelanchier Cumulus, Robin Hill, Spring Tyme, and Tradition; Crataegus Crusader and Ohio Pioneer; Malus Brandywine, Centurion, Harvest Gold, Madona, Spring Snow, and Sugar Tyme; Prunus hillieri Spire; Prunus sargenti Columnaris; Pyrus calleryana Aristocrat, Autumn Blaze, Bradford, Cleverland Select, Red Spire, and White House; and Syringa amurensis Ivory Silk and Summer Snow. Although it is too early to draw any conclusions on any of the cultivars, differences have been noted that will undoubtedly be beneficial in future plantings. Survival and care of the trees have been excellent everywhere. Compilations and evaluations from these tests over the next several years should enable urban foresters to do a much better job in matching cultivars to site requirements.

More than 60 communities have become involved in MTRP. Additional test plantings will be made as funding from the utilities continues. The program has been most successful in communities in which individuals have taken the lead and pursued the program with local government officials.

Another significant accomplishment of the program was the development of a notebook on street-tree cultivars. Five states, the U.S. Forest Service, and Penn State University collaborated on this venture. The notebook consists of a set of 122 street-tree factsheets illustrated in color. The notebook has proven to be extremely valuable to service and utility foresters as they work with communities in developing a street-tree planting plan. The notebook is for sale by the Agricultural Publications Department at Penn State.

The cultivar factsheets in the notebook contain the following information for each cultivar: patent or trademark; height and width at maturity; hardiness zone; information on crown, foliage, flowers, and fruit; description; advantages and limitations of the tree; and site and culture requirements. Cultivar information is also included when the factsheet is on a species. Each factsheet is color coded for suitability of the cultivar under electric lines, and each sheet contains one to three color plates. One large plate shows the tree at or near maturity; the other plates show specific features of the cultivar, such as flower color, fall foliage, or fruit.

The outlook for accomplishing the objectives of the program is most encouraging. Many of the communities that have participated in the program have now qualified as Tree Cities USA, a program administered by the National Arbor Day Foundation. The overall results of the program are community pride, healthier trees in Pennsylvania communities, and a safer roadside environment for pedestrians and motorists alike.

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Identification of Typical Highway-Utility Interaction Problems and Potential Solutions

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The interaction between state highway agencies and utility firms sharing highway right-of-way is exceedingly complex. Many opportunities exist for difficulties to arise. Typical utility-related problems are examined and potential solutions are described. This paper is based on a 2.5-year study of utility difficulties in the Alabama Highway Department. The study included interviews conducted with highway managers, utility industry officials, contractors, utility consulting engineers, highway agencies in other states, and national utility authorities. The project resulted in more than 300 suggestions for improvements to the highway-utility process in Alabama; the suggestions were condensed to 85 topics for study and possible policy changes. Approximately 30 topics are reviewed in this paper. They represent problem areas common to virtually all states. Identification of these topics and potential solutions should assist other state highway agencies in evaluating procedures and improving the highway-utility interaction processes.

For 2.5 years, a University of Alabama research team identified, studied, and restructured the highway utilities policies and procedures of the State of Alabama Highway Department (AHD). The mission of the study team was twofold: to analyze and revise utility policies and to provide state-of-the-art documentation to guide day-to-day highway-utility interactions. The study culminated with a 325-page document that was published in December 1989. The new manual was introduced through training sessions in 8 locations around the state; more than 1,200 people attended the sessions.

This paper was prepared to review the types of highway-utility problems encountered during the Alabama study and to introduce potential solutions identified by department managers and the university research staff. The staff found that the same types of problems existed from state to state and prepared this paper to focus national attention on several common issues.

RESEARCH WORK TASKS

About 30 typical highway-utility problem areas are discussed here. These issues were identified during the research work tasks described in the following paragraphs.

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Literature Review

Utility-related state and federal documents, including the *Federal-aid Highway Program Manual* (FHPM) and other pertinent federal publications, were reviewed early in the project. Additionally, 41 utility manuals were obtained from other state highway agencies.

State Utility Engineers

Ten state utility engineers were interviewed during the project. Eight of the interviews involved in-depth telephone discussions. These discussions revealed that the same types of problems were present in virtually every state and identified solutions implemented by a few states.

National and International Organizations

Members of national and international organizations such as AASHTO, TRB, and the International Right of Way Association were interviewed by telephone to provide insight into utilities operations. University staff also attended several conferences (sponsored by these organizations), which provided an opportunity for interaction with members of committees of these organizations.

In-State Interviews

Department personnel at three different levels were interviewed. Forty-one district engineers were interviewed, prompting 30 suggestions for improvements to utilities procedures. The division utility engineers from each of the 9 Alabama Highway divisions volunteered 19 additional suggestions for policy changes. Central office personnel contributed 35 more suggestions for the manual. The different points of view expressed by these three levels of management gave the university staff an appreciation of the variety of problems faced by highway utility personnel. For example, district engineers frequently faced problems stemming from inadequate traffic control plans used by utilities. They were also concerned about the quality of inspection on relocation projects. Central office personnel tended to worry about reducing overall liability associated with utilities actions, and they also concerned themselves with legislative action that might be taken

to improve the state's ability to effectively deal with utilities issues.

External Advisory Committee

More than 40 representatives of industry, consulting engineers, and contractors were brought together to form an external advisory committee. In two day-long sessions, this committee contributed more than 100 suggestions for improving the policies of AHD.

STUDY RESULTS

The research project yielded a variety of changes to the department's approach to highway-utility interaction. Modifications ranged from simple adjustments to existing procedures to an entirely new set of approval processes and forms. Two of the most substantial changes affected policies and procedures throughout the new manual. One was the introduction of three-phase agreements for utility relocation efforts. The utility would be paid for its efforts at the end of each of three project phases: the feasibility study phase, the engineering plans and specifications phase, and the construction engineering phase.

Providing early notification to utilities that relocations would be required was another significant change. Previously, utilities were notified of required relocations as the department completed its own design process. As a result of this project, utilities are now informed much earlier, allowing more time to plan, design, and construct relocations. This also allows anticipation of potential problems.

Many of the new procedures were derived in response to a list of approximately 300 suggestions (condensed to 85 topics) identified in the first year of the project. Twenty-nine of these problem areas are addressed in this paper, along with potential solutions or mitigating procedures. Many of the solutions are tied to the two substantial changes listed previously (three-phase agreements and early notification).

TYPICAL HIGHWAY-UTILITY PROBLEM AREAS

While conducting the Alabama utilities study, the authors identified a myriad of problems in many aspects of the utility accommodation and relocation process. Several typical problems are discussed in the following paragraphs, along with potential techniques for solving or mitigating the problems.

The issues discussed in this paper have potential impacts from trifling to substantial. Highway agencies and utility firms are encouraged to look for and address similar problems at all levels. Finding solutions to large problems offers savings of hundreds of thousands of dollars. Resolution of even trifling problems creates goodwill and understanding among the parties and promotes cooperation and improvement. One thing is certain: the highway-utility process is exceedingly complex and fraught with possibilities for misunderstandings and problems. Plenty of opportunities exist to refine and improve the process.

COMMUNICATION DIFFICULTIES

The most common problem was poor or incomplete communication. Many difficulties were rooted in the failure to communicate. The following are several typical communication problems identified during interviews with employees of AHD and utility industry officials in the state.

1. Highway agency manuals are old, out-of-date, or inaccurate.
2. Highway agency policies exist as (noncirculated) policy letters, or as the rules of thumb of a few managers instead of in publications.
3. Policy changes are not completely disseminated.
4. Interpretations of policy documents change from highway district to highway district, and the utility ends up working for nine different fiefdoms.
5. Neither highway nor utility employees understand (or even read) the FHPM.

Old or Out-of-Date Manuals

The Alabama utility study was generated because the department publications used to govern utility activities were out-of-date. This is not unusual for highway agencies. Copies of utility manuals were obtained from 41 state departments of transportation. More than half of these documents contained substantial amounts of information that should be updated or revised.

There is no easy solution to this difficulty, to which understaffed highway agencies are especially susceptible. One of the ways in which the problem may be addressed is to establish a specific procedure for revising or upgrading the manual, assigning specific responsibilities to specific individuals, conducting the program at least once a year, and delivering revised materials to manual holders. In Alabama, a log is kept of changes to materials in the manual. All utility manual owners may register their manuals (by unique identification number) and receive updates of the changes as they are generated.

Policy in Noncirculated Letters

A second type of miscommunication is the unofficial promulgation of regulations through policy letters written by highway managers to other highway managers. These letters have limited circulation. Utility firms submitting permit applications or preparing plans for relocations have no way of knowing about them. Consequently, a large percentage of utilities initial submittals are rejected because they are not based on the criteria against which they were screened. It is not unusual for highway managers in field offices or in other portions of the agency to be unaware of these unofficial policy letters.

During the Alabama study the problem was addressed by interviewing managers at all levels within the department. During this aspect of the study, the researchers asked many simple questions and asked for rather complete explanations of procedures and policies. As a result, they identified several instances in which policies that were supposedly distributed

widely were not distributed at all. These policies and practices were identified, documented, and published in the comprehensive Alabama Utility Manual. They were also emphasized during the widespread training at the end of the project.

Policy Changes Not Completely Disseminated

This problem is similar to the first two. The department modified its policies and attempted to distribute them to users. The problem was that there was no official distribution process, and many utility firms never received notice of the changes. This is not uncommon if the highway agency does not have a strong rule-making procedure and a clearly defined distribution process for revisions.

The use of a comprehensive manual, a registration process for manual owners, and periodic mailings to distribute changes should help overcome this difficulty.

Each Highway Division is a Fiefdom

Utility firms have complained for years about the lack of consistency from one highway division to another. A utility that had been successful in its construction activities in one part of the state might find that a division engineer in another portion of the state was much more demanding about filling out paperwork, complying with the small details of the permit, and completing other issues that required a high degree of effort from the utility firm but did not greatly improve its productivity. The division engineers interpreted utility regulations and policies differently. In effect, they made their own policies and built their own little fiefdoms.

There is no guarantee that management practices will be absolutely consistent across boundaries of field divisions. The solution attempted in Alabama was to clearly publish department policies (and when possible, the reasons for those policies) in a comprehensive manual. Additionally, an extensive training course was conducted after publication of the manual. An average of more than 25 departmental employees, 30 local government representatives, 50 utility employees, and 10 consulting engineers were trained in each of the department's 9 field divisions. Publication of policies and procedures and widespread training should improve consistency from division to division.

Who Reads the FHPM?

The FHPM is the source document against which the appropriateness of any highway-utility action may be tested. It is frequently referenced in manuals, correspondence, and conversation. Apparently, however, this important document is rarely read or even consulted by individuals whose activities are regulated by it.

During the Alabama training sessions with the largest attendance, the authors referred to the applicable portion of the FHPM while answering a question regarding an unusual situation. During the ensuing discussion with audience members it became apparent that the FHPM was not understood. The authors asked how many in the audience had read the applicable portion of the FHPM. Only 3 of 200 attendees raised their hands. Two of the hands belonged to the authors. Thus, less than 1 percent of the audience (people whose day-to-day jobs depend on the FHPM) had read this vital document.

The FHPM is not widely read for many reasons. One of the most common is that the person who needs it never seems to have a copy. A reasonable way to overcome this difficulty is to make the document more readily available. AHD provided a copy of pertinent portions of the FHPM as an appendix to the utility manual.

HIGHWAY CONSTRUCTION DELAYS

Highway contractors who fail to complete construction projects on time frequently cite utility problems as the cause of the delays. This was vividly illustrated to the authors during conversations with the utility engineers of 10 state highway agencies. Calls were made to identify the most prevalent utility problems and to seek solutions. Construction delays were prominently mentioned by every state. Most of the states suggested that the solution could only come through better cooperation or better planning. One state indicated that it had an innovative solution. It automatically granted a 30-day extension to each highway contractor in anticipation of probable utility relocation delays. Several statements that deal with portions of the construction delay problem are listed next. In general, they address methods to alleviate the delay, or reflect frustration over the nature of the problem. The role of each of these statements will be discussed in the following paragraphs.

1. Master lists of planned highway projects are not available to utility firms.
2. Utilities suffer time compression between notification of required relocation construction and the completion of the relocation.
3. Highway agencies should hold predesign conferences with utility companies to minimize conflicts and save money.
4. Planning and preliminary engineering work should be done by the highway agency and the utility company at the same time.
5. Utility certificates do not give accurate completion dates for utility work.
6. Highway agencies have no way to force utility firms to speed up their work.

Master List of Highway Projects

Highway agencies are reluctant to publish lists of future highway projects except for general lists that show a wide range of possible dates. Uncertainties in funding and possible political intervention make it difficult for most highway departments to establish rigid dates for projects. Even if such dates could be predicted absolutely, it is often undesirable to publish them because they drive property values up and increase right-of-way costs.

Utility firms would benefit from better knowledge of possible time frames for upcoming highway projects. This would

allow utilities to alter their own construction and renovation project time frames to coincide with upcoming highway work. It would also minimize the unfortunate occurrence of new utility facilities being destroyed and relocated by subsequent highway construction. It is highly desirable for utility firms to have a good concept of the time frame for upcoming highway projects.

Time Compression of Utility Design and Construction

Utility firms often face unreasonable time schedules for planning, designing, and relocating facilities. This is especially true when highway projects are suddenly added to the construction calendar.

AHD had traditionally preferred not to notify utility firms of relocation projects until the highway design had cleared the Plan-in-Hand inspection. At this time the final changes in alignment had been completed for the proposed highway project. This occurred at Step 40 in the department's 65-step highway design process. By withholding notification to the utility firm until final highway line and grade had been ensured, it eliminated the possibility that the utility's preliminary engineering work would have to be revised because of a change in roadway geometrics. Unfortunately, it also critically compressed the time span available for utility design and construction.

After the Alabama utility study, the notification of utility firms was changed to Step 19 of the highway design procedure. At this step, utility firms were asked to begin feasibility studies and initial design efforts. After the highway project had advanced to Step 40, and after the highway agency had approved the utility's preliminary concepts, the utility was then authorized to begin the design process. This allows the utility to begin advance planning earlier, to develop better designs, and to proceed through the design-construction process in a more orderly fashion.

Predesign Conferences

An obvious step that can be taken to promote advance planning and cooperation, and thus reduce construction delays, is the use of predesign conferences. Two examples illustrate this point. During the upgrade of an urban arterial from four to six lanes, seven utility firms were asked to relocate their facilities in an extremely confined right-of-way. The utility firms independently developed their relocation designs, with many consequent conflicts with each other. This was finally resolved by a joint meeting in which the department assigned specific portions of the right-of-way to each utility and preapproved the relocation concepts of the various agencies.

A second example illustrates a better way to accomplish relocations. For a complex highway project involving upgrading of a freeway spur, the department's utility engineer held a predesign conference with utility companies to discuss anticipated difficulties and to minimize conflicts. Many immediate benefits resulted. All utilities were allowed an early start with their planning. An electric power utility conducted an extensive feasibility study that resulted in a $200,000 savings by beefing up surrounding substations and abandoning a substation that was to be relocated. Another utility had time to order less expensive poles, and to conduct extensive tests of PCB contamination before right-of-way acquisition.

Simultaneous Planning by Department and Utilities

The ideal concept is to allow the utility to begin preliminary work at the same time that the highway agency begins preliminary work on a project. It is not an easy concept to implement. Many highway projects are initiated but halted before the construction stage. Other projects progress at a normal rate through preliminary engineering and design stages yet undergo numerous last-minute design changes before construction. In both of these situations, the utility firm will go through needless planning and engineering design. In the worse case, the utility might be asked to undertake a rapid design of a relocation project, yet the project might never be constructed. This promotes a "hurry up and wait" attitude, and utility managers become frustrated with responding to false emergencies, leading to callousness and sluggishness in responding to the highway agency.

To address this difficulty, the department separated utility relocation efforts into three phases. The engineering aspects of this work include the following: Phase I—Feasibility study or preliminary concepts of relocation, Phase II—Engineering plans and specifications, and Phase III—Construction engineering.

Each phase of the utility work is keyed to a specific portion of the 65-step highway design process. Each phase begins with a specific authorization, and the utility's effort can be terminated at the end of any phase if the department recognizes that the roadway project is not proceeding as originally scheduled. This offers the utility the advantage of immediate payment for each portion of the work, knowledge of the status of each current project, and insight into upcoming highway projects.

Utility Certificates

The utility certificate is a statement placed in highway bid documents, notifying potential bidders of the anticipated completion dates of utility work. Previously these estimates had been prepared by department field employees on the basis of conversations with utility employees. The utility representatives were generally reluctant to specify dates for relocations. It was to their advantage to remain noncommittal or to be liberal in establishing the anticipated completion date. The estimated dates had to be provided at least 8 weeks before the highway bid letting so that they could be included in the highway project bid documents. At this early date, utility officials were often unsure of the status of their work, or they were hastily attempting to complete design and construction during a compressed time frame.

These difficulties were addressed in Alabama by allowing utility firms to begin planning and design at an earlier phase of highway design, offering predesign conferences, and encouraging utilities to estimate time frames for completion (e.g., 30 to 60 days after bid opening) instead of absolute dates.

This encouraged cooperation and improved accuracy in preparation of utility certificate information.

Requiring Utilities to Speed Up

Statements of this type were frequently heard from highway managers who were frustrated by utility delays and consequent highway contractor claims. As a result of this research project, in which utility management practices were studied, the department chose to switch to the "carrot" approach instead of the "stick" approach. Utilities were offered incentives, such as opportunities for advanced planning and earlier feasibility and design work, to encourage earlier starts to construction projects and stress cooperation over punitive aspects. As a result of policy changes and extensive training, the concept has changed from seeking punishment for "slow" utility firms to seeking incentives for "fast" firms.

TRAINING AND EDUCATION

It became apparent during the research project that employees of both AHD and utility industries were not aware of many pertinent aspects of the highway-utility process. There were obvious reasons for this. For example, massive retirements are occurring in highway agencies across the United States, with more than one-quarter of managers retiring in the current five-year period. Promotions and normal turnover in the labor force add to the number of "new faces" making utility permit and accommodation decisions. Similar personnel turnover is occurring in the utility industry.

The highway-utility process is complex, and the learning curve for new employees is long. Unfortunately, highway employees tend to learn only the highway side, and utility employees tend to learn only the utility side. As new developments or technologies occur on either side of the issue, the other side is lax in identifying and adopting the changes.

To address the widespread need for training and education, AHD desired that its new utility manual be comprehensive and in effect serve as a textbook for instruction for new employees. Additionally, the manual would be written in a way that provided a rationale for department policies and a discussion of the benefits from following the policies. An understanding of the reasons for the policies promotes compliance. A training course was also added to the end of the project to disseminate new policies, procedures, and documents to encourage their use.

REIMBURSEMENT ISSUES

Difficulties become more pronounced when they involve money. Reimbursement for utility relocation work is an excellent example. The following are several reimbursement problems identified in the Alabama study.

1. Provisions of FHPM 6-6-3-1 (governing reimbursement) are not understood, especially when they involve "betterment."
2. Reimbursement for utility work is frequently delayed and should occur more quickly.
3. Highway departments should set up utility planning and engineering budgets as soon as the highway design starts.
4. Utilities should be reimbursed for each phase of utility work: planning, feasibility study, engineering drawings and specifications, and construction.
5. Sometimes utility firms are told to prepare relocation plans for an emergency highway job, but the emergency does not materialize, the road is never built, and the utility firm is never paid for the cost of developing its plans.
6. Small utility firms without engineering expertise must hire a consultant, whose work must be done before payment. If the job is not built, the consultant may not be reimbursed.

Lack of Understanding of FHPM

The guiding concepts for reimbursement for Federal-aid projects are found in Section 6-6-3-1 of the FHPM. Problems arise frequently (especially when small utility firms are involved) regarding which projects and which types of expenses may be reimbursed. Perhaps this is because of disdain that many individuals have for reading the small print in federal documents.

The most persistent difficulties seemed to be with utility firms wishing to enlarge the capacity of their physical plant or upgrade their facilities during a relocation project. This is often a prudent business decision because little additional planning and engineering costs are used in upgrading the capacity or capability. Frequently, smaller utilities are not aware of the FHPM "betterment" clause, which requires that the utility pay for any increased capacity. Explaining this clause and interpreting how to determine the actual cost of the betterment features consume many hours of a highway utility engineer's time, and can create strained feelings between the utility and the highway agency.

In Alabama, this was addressed through creation of a separate chapter in the utility manual to discuss reimbursement. Betterment was specifically addressed. Additionally, the FHPM was reproduced as an appendix to the manual.

Reimbursement is Slow

Reimbursement to utility firms occurs in Alabama about 60 days after the submission of an invoice, which may be filed on a monthly basis. This means that the utility is reimbursed for its efforts 60 to 90 days after the initial purchase of materials and use of labor. Telephone calls to other states indicated that Alabama's practices were not unusual. Typically, a state highway agency spends a great deal of time checking and verifying the invoices of utility firms and approving the invoices at several administrative levels within the agency. This is cumbersome and slow. After the invoice has been approved, a separate administrative document must be processed to have the check prepared in another state agency.

Several states have made deliberate efforts to decrease the length of time between receipt of invoice and payment of the fee. West Virginia has speeded the process by eliminating or minimizing the invoice review process. This occasionally re-

sults in overpayment of the contractor's monthly invoice during the process of construction. To remedy this, a complete review and audit is conducted at the end of the project. The utility then receives any remaining payment. If the audit finds that the utility has already been overpaid, it must reimburse the state.

Utility Planning and Engineering Budgets

Highway agencies usually execute a single reimbursement agreement with the utility to handle all costs for a relocation project. Before the utility can execute the agreement, it must have a reasonably accurate estimate of the cost of the relocation work because the budget is an integral portion of the agreement. A budget that is inaccurate means that the utility may not receive complete reimbursement for its work, or at best, that the agreement must be renegotiated.

To establish a good relocation budget, the utility must conduct planning and preliminary engineering steps. This means that much of its work is completed before the agreement is executed. It is appropriate for the highway agency to recognize this process and to authorize utility preliminary engineering reimbursement at an early phase of the highway project.

Multiphased Utility Work

As discussed in the previous paragraph, utilities must devote considerable effort to preliminary engineering in order to come up with a relocation budget estimate. If the highway agency postpones or cancels the project, the utility firm may have no way to recover the cost of this preliminary engineering work. AHD created the three-phase utility relocation process to ensure that the utility was properly and promptly reimbursed for its work during each portion of a utility relocation project. If the highway project was canceled after the utility had begun its feasibility study, Phase I of the utility work would be completed and the utility would be reimbursed for its work. The three-phase utility agreement also addresses items 5 and 6 in the list of typical reimbursement problems. For example, the department recognizes that on occasion it must begin an urgent road construction project. The utility may be asked to begin immediately and to complete its relocation design as rapidly as possible. At this point, the utility will be reimbursed for its efforts, the relocation plans will be available, and if the highway department must cancel or postpone the project, at least the utility's efforts will have been acknowledged.

Utility Consultant Engineers

A similar problem exists for small utilities that do not have engineering staffs. When they must design a relocation project, an engineering consultant must be engaged. For a reimbursable project, AHD reviews the utility's contract with the engineering consultant, including labor rates and the consultant's estimated total fee for the project. At this point, consultants that serve small towns or small clients face a universal problem. Their clients rarely have the funds available to pay for preliminary engineering work. For utility work, the consultant must perform a large amount of preliminary work in order to accurately estimate the total engineering fee. If the department or FHWA rejects the consultant's proposal for services, the firm has lost a considerable amount of funds. The same situation occurs if the consultant designs a relocation but the highway project is not constructed.

AHD has taken two steps to rectify this problem. First, the department uses the multiphased engineering agreement. Second, the department now encourages small utility firms to utilize continuing contracts for engineering services. The FHPM allows a rapid approval in cases in which the utility has a standing agreement with an engineering consultant, has used the consultant for previous work, and the consultant's fees are reasonable. This arrangement generally improves consistency and quality of the utility's engineering design efforts and makes proper reimbursement of the consulting engineering firm more rapid.

DIFFICULTIES DURING CONSTRUCTION

The single largest difficulty during construction is when relocation of utility facilities runs behind schedule and causes delay to highway contractors. This issue was voiced by virtually every highway agency employee with whom interviews were conducted, in Alabama and in other states. This topic was addressed previously. Other construction difficulties are as follows.

1. Extend time between notification of utility and required end of utility relocation construction.
2. Establish reasonable methods for resolving conflicts during construction.
3. Require compliance with approved traffic control plan.
4. Require utility to keep qualified supervisor on the job at all times.
5. Require utility companies working in the right-of-way to repair damage to physical plant of other utilities.
6. Require highway agency working in the right-of-way to repair damage to physical plant of utilities.
7. Require utility contractors to keep an approved permit drawing on the site at all times during construction.
8. All utility inspectors should be qualified.
9. When consultants design utility plans, require the consultant to do the construction inspection.
10. Require the inspector's name, address, and telephone number on the permit application.
11. Require part-time inspectors to post a schedule of times when they will be at the job site. This helps the highway agency contact them.
12. Require the highway agency to share its inspection records with the utility for comparison of estimated quantities.

Coordination During Highway Construction

A significant issue involves utilities that must be relocated while the highway project is under construction. For example, sanitary sewers may not be placed until a deep roadway cut has been completed. This type of relocation requires close

coordination between the highway contractor and the utility firm.

Alabama now asks that during design of the relocation the utility identify any activity that must be completed after the highway contractor has begun work. Notice of this activity is placed in the supplemental provisions portion of the highway bid documents, giving prospective bidders adequate notice of the special circumstances.

Resolving Conflicts

Conflicts can arise between the utility and the highway contractor, or between multiple utilities competing for the same limited right-of-way space. The highway agency should provide a clear procedure for resolving these conflicts as soon as they occur. Multiparty conferences are an excellent way to address these issues. Often the conference will reveal that none of the parties were aware of the complete situation. Once all the facts are available, these issues are usually much easier to resolve. When necessary, the authority resides with the highway agency to resolve these questions; however, it is much preferred for the parties to arrive at a mutual resolution, using a procedure that is clearly defined in highway agency documents.

Traffic Control Plan

Adequate traffic control is necessary on utility construction projects for two reasons: (a) safety of employees, pedestrians, and motorists, and (b) liability. FHWA has emphasized traffic control to state highway agencies, which are now emphasizing it in construction work and utility permits.

The national *Manual on Uniform Traffic Control Devices* specifically states that persons working in the highway right-of-way installing or maintaining utilities are subject to the provisions of the manual. Many large utility companies have adopted a series of standard traffic control device configurations and use them whenever possible to ensure adequate warning to oncoming motorists. AHD has periodically offered a training course on work-zone traffic control that is open to highway contractors and utilities. Additionally, it has printed and distributed work-zone traffic control workbooks, and an entire chapter of the *Alabama Manual on Uniform Traffic Control Devices* deals with work-zone traffic control.

Inspection of Utility Facilities

The list of construction difficulties contains several statements dealing with inspection of utility facilities. These concerns emerged during interviews of highway and utility employees. Highway managers wanted to ensure that the roadway remained structurally sound and that the roadway drainage features and vegetation were reasonably restored to their original condition. This required that the utility firm maintain good supervision or good inspection throughout the project. If the utility had a part-time inspector who visited the construction periodically, the highway manager often had difficulty making contact. Thus, the department now requires that the inspector's name, address, and telephone number be part of the permit application. Additionally, part-time inspectors must provide a schedule of times that they anticipate being on the construction site. This is invaluable when a utility emergency erupts and the appropriate utility employees must be promptly notified.

One difficulty that had frequently arisen involved use of a consultant engineer for design and another agency or another person for construction inspection. More conflicts arose, which were more difficult to resolve because the design and inspection were performed by two different parties. For example, if the design contained serious flaws, the designer might never learn of the problem and might continue to design the same types of flaws into future work. Another example involved special aspects of the design in which the consultant made special efforts to customize it to local conditions. The construction engineer might be unaware of the issue and might eliminate the special design in a futile effort to save money. A third and convincing issue involved change orders. On almost every construction project, the conditions in the field turn out to be different than anticipated by the designer. Change orders are used to allow modifications of work as needed. If the design engineer and construction engineer are the same, requests for change orders are easy to evaluate, and the project may be kept on schedule and pointed to a successful conclusion. When design and construction are handled by separate parties, change orders are not handled as promptly or accurately.

Other Construction Issues

Several other topics are presented in the list of construction difficulties. These are listed as reminders of potential trouble areas. In Alabama, they were handled with simple statements in the utility manual defining responsibilities or issues that would be monitored.

CONCLUSION

Just a few of the hundreds of potential difficulties in the highway-utilities interface have been discussed. These problems and their potential solutions have been offered to encourage other states to seek improvements to the highway-utility process.

In closing, the authors point out that an overriding consideration and a major reason for the success of the Alabama study was the open attitude exhibited by managers of AHD, especially the Utility Section. This attitude was matched by the industry representatives of the external advisory committee. The attitude of openness and serious consideration of any and all suggestions allowed the authors to probe deeply into sensitive areas involving long-standing policies, finances, and responsibilities. Consequently, substantial improvements were made because the involved parties were dedicated to improving cooperation and increasing efficiency on both sides of the highway-utility interface.

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