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Five-Year Evaluation of Highway Mowing Practices in Indiana

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A 5-year evaluation of roadside mowing practices in Indiana was completed in 1976. Findings show that the first mowing cycle is the most critical. This mowing is wasted if done too early because the most rapid growth of grass occurs in early spring. If it is carried out too late or when the grass is wet, injury to the turf may result from piling up of grass and smothering. The optimum height for the first mowing cycle is between 46 and 61 cm (18 and 24 in). To prevent scalping and to avoid piling up and smothering of grass, the grass should be mowed to a height of at least 13 to 15 cm (5 to 6 in). The second cycle of three-cycle mowing is less critical and could be eliminated most seasons if the first cycle were delayed. The last cycle should be delayed so that no more than about 30 cm (12 in) of growth occurs before winter. This leaves the roads with a well-maintained appearance during the winter months and with enough growth to protect the grass from winter killing but not so much growth as to interfere with either fall or spring spraying for control of broadleaf weeds. Unmowed roadsides remained in good condition over the 5-year observation period when combined with the fall-spring spraying rotation for control of broadleaf weeds. A major problem was that brush began to take over in some areas. Addition of a brush-control agent (a three-way herbicide mixture of 2,4-D, dicamba, and Silvex) to the fall-spring spraying rotation for these areas or one-cycle mowing at least every other year is indicated.

Rising costs of roadside maintenance, with respect to mowing operations and the national interest in conserving energy and fossil fuel, make it imperative to consider alternatives to multiple-cycle mowing as a solution to maintenance of turfed roadsides. Two possibilities are currently available: (a) reduced mechanical mowing and (b) chemical mowing by spraying retardants of grass growth. This paper deals with the first of these options.

Conservative estimates of the areas from the outside of the shoulders to the farthest boundary of the right-of-way subject to some type of vegetation management yield figures that suggest that approximately 30 000 hm^2 (75 000 acres) of roadside in Indiana are presently included in some phase of a contract spraying or mowing program. On a typical Interstate route, 1.6 km (1 mile) may have more than 8 hm^2 (20 acres) to maintain. Since the cost of roadside mowing normally exceeds \$62.50/hm^2 (\$25/acre) each season, even when effective weed control reduces mowing, the potential magnitude of cost savings in roadside mowing is considerable.

In 1970, the Indiana State Highway Department reduced its five-cycle contract mowing program to reduce costs and to conserve energy. The reduction in the number of mowings was possible in large measure because of effective weed control through the fall-spring contract spraying program (1).

In 1972, studies were initiated to evaluate these reduced mowing practices. The objectives of the study were to

1. Identify unnecessary mowing cycles so that such cycles might be eliminated,
2. Schedule those mowing cycles that provide the

most benefit at times when they most contribute to the effectiveness of the fall-spring spraying program,

3. Evaluate reduced or limited mowing practices (including unmowed areas) to determine effects of turf and other features, and

4. Inspect actual mowing operations to determine how mowing practices might be improved to enhance appearance and efficiency, to minimize mowing area, and to optimize the production of a healthy turfed roadside.

PROCEDURE

Mowing evaluations were based on uniform test plots established as part of the research project, regular unscheduled inspections of contract mowing operations, roadside areas for which accurate mowing histories were available, and information from other states and countries.

Equipment

This study used only commercially available equipment supplied by either mowing contractors or state crews. Rotary mowers were used for the most part.

Uniform Test Plots

Each 1.6-km (1-mile) long test plot was divided into four subplots: (a) unmowed, (b) one cycle (summer mowing only), (c) two cycles (spring and fall mowing only), and (d) three cycles (spring, summer, and fall mowing). Mowing dates selected were as follows:

Season	Dates
Spring	June 20 to July 8
Summer	August 4 to August 18
Fall	September 22 to October 8

The sections in the test plots were mowed to the fence rather than to the ditch plus 1.5 m (5 ft); this is current practice along Interstate highways in Indiana.

Contract Mowing

Biweekly inspections of contract mowing operations were made each summer beginning in 1972 at various locations throughout the state. Average height of grass, date and height of grass at the time of mowing, overall appearance, evidence of scalping or piling up or skips, and weather conditions if mowing was in progress were noted for each location. Photographs were used to document major observations.

Roadside Areas With Accurate Mowing Histories

Areas of interchanges on Interstates were used to evaluate effects of reduced mowing on turf. Some of these areas were entering their sixth or seventh year of nonmaintenance except for chemical weed control.

OBSERVATIONS

Other than appearance during the growing season, no differences caused by one-, two-, or three-cycle mowing were observed on the Interstate system. In all three types of maintenance, grass remained healthy. The predominant grass species was tall fescue, which tended not to pile up or be smothered by results of late mowing unless the grass was wet when mowed (Figure 1). Figure 2 shows a uniform stand of smooth brome, which can be mowed at almost any stage with good results if the grass is dry.

Where bluegrass was the dominant species, yellow foxtail was sometimes abundant in the late season (Figure 3). Since the foxtail is very succulent, it tends to cause piling up when it is mowed short [10 cm (4 in)] even if the grass surface is dry. The heavy growth of yellow foxtail shown in Figures 3 and 4 led to considerable piling up and subsequent smothering of the bluegrass.

It was found that mowing could be started much later than is generally done. Figures 5 and 6 show portions of I-74 in mid-June when grass was between 46 and 61 cm (18 and 24 in) tall. The roads were not yet unsightly because of excellent weed control obtained with the fall-spring spraying rotation.

In the Indiana contract spraying program, 2,4-D amine form concentrate containing at least 6.9 kg of acid per liter (4 lb of acid per gallon) is used. Ester formulations of 2,4-D are not to be used in the Indiana program. The recommended mixing rate for the herbicide is 7.6 L (2 gal) of concentrate to 378 L (100 gal) of water. The mixture is to be applied at the rate of 60.6 L of total mixture per square hectometer (40 gal of total mixture per acre). Fall application is from September 1 to the first killing frost, and spring application is from March 15 to April 30. The herbicide is applied only once every 3 years, and both fall and spring applications are made to the same roads, starting with the fall application. The table below gives results of an evaluation of the control of perennial weed species by fall and spring applications of 2,4-D amine taken for the Fort Wayne district on June 13, 1977 (1 hm^2 = 2.5 acres):

Weed Species	Weeds per Square Hectometer: Unsprayed	Weeds per Square Hectometer: Sprayed	Percentage of Control
Dandelion	73 950	5 437	93
Plantain	18 487	4 350	76
Wild carrot	134 850	5 437	96
Curled dock	1 087	525	52
Wild parsnip	1 087	0	100
Other	66 337.5	4 350	93
Total	295 798.5	19 574	93

Sight distances were maintained at intersections and on the insides of curves, and guide rails, signs, and other traffic control devices were still visible. This was especially true for roads where bluegrass was the dominant species. Figure 7 shows one of the uniform test plots along IN-28 on July 31. This was very near the optimum time for a bluegrass roadside. In 1973, when this photograph was taken, one-cycle mowing in the first week of August would have been adequate. Even with fescue, which must be mowed earlier than bluegrass, a second mowing might not be required. Once the seed head has been removed, further mowing is often unnecessary. Warm season grasses produced the greatest problems through continued production of seed heads. Examples of this were Johnson grass in the southern third of Indiana and yellow foxtail throughout the state.

A major objective of this study was to evaluate what, if any, harmful results would come from not mowing on grass where weed control was adequate, e.g., along Interstates. The results showed that not mowing caused no deleterious effects on turf and was superior to poorly done one- or two-cycle mowing.

The major drawback to not mowing is brush (Figure 8). In the uniform test plots, unmowed plots contained willow, black locust, and other species 0.3 to 0.9 m (1 to 3 ft) tall by the end of the second year of no mowing.

Figure 1. Piling up along I-65 because of wet grass at the time of mowing.

Figure 2. Uniform mowing test plot along I-74 showing uniform stand of smooth brome.

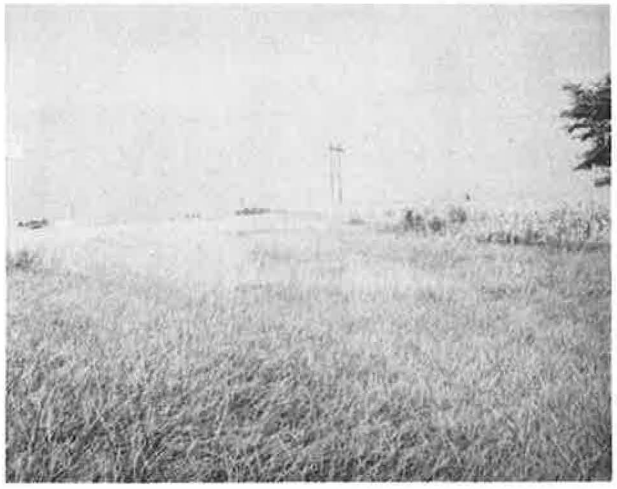

Figure 3. Uniform mowing test along IN-28 on September 10 (note heavy growth of yellow foxtail in the foreground).

Figure 4. Close-up of mowed portion of Figure 3 test area.

Figure 5. Portion of I-74 photographed in mid-June showing grass at proper stage for first mowing.

Figure 6. Side view of portion of I-74.

Figure 7. Portion of IN-28 test plots photographed July 31 (note growth of wild carrot in the foreground).

Figure 8. Brush.

Figure 9. Example of good mowing job along I-74 except for scattered piles caused by mowing when the grass was wet.

Figure 10. Grass mowed to an average height of about 15 cm (6 in).

Figure 11. Portion of I-74 south of Lafayette showing unmowed versus mowed portions as winter approaches and evidence of brush encroachment in the unmowed portion.

Figure 12. Portion of I-74 south of Indianapolis photographed in early June and showing unsightly appearance of red clover.

Other plots, including those mowed only once or only once in 2 years, did not contain brush.

We found no increase in snow buildup on roads where roadsides were not mowed. By early winter, mowed and unmowed roadsides had essentially the same appearance. This was caused by winter killing of warm-season grasses and of leaf blades and seed heads of cool-season grasses.

Major findings from uniform test plots were verified from inspections of contract mowing. Generally, mowing could be delayed much longer with no harmful effects than current mowing policies in most states indicate. If anything, grass in Indiana was being mowed too early and too short.

In general, the contract mowing program was good, certainly adequate. Problems could be traced to weather, inadequate equipment, or contract difficulties. One problem arose when a contractor who was awarded three contracts had enough equipment to handle only one.

PROBLEMS WITH CONTRACT MOWING

Piling Up

Piling up occurs when grass is either too heavy or too wet. Wetness was the greatest contributor. Figure 9 shows a good mowing job except that mowing was carried out right after a heavy rain so that unnecessary piling up was the result (Figure 2). Weedy grasses that contained much water, such as yellow foxtail, also contributed to piling up (Figure 4). The piles tended to smother the underlying turf and leave bare spots open to erosion and weeds (Figure 8). Piling up was avoided by mowing only when the surface of the grass was dry.

Scalping

Scalping occurs when the mower blade cuts into the crown of the grass at the soil surface. Grass that has been scalped either is very slow to recover or is killed. Scalping is largely caused by design problems—e.g., ridges in the right-of-way that are straddled by the mower—but it is aggravated by cutting the grass too short. A mowing height of 15 cm (6 in), shown in Figure 10, avoids much scalping, tends to reduce piling up, and produces a presentable roadside. Although adequate, the appearance is not as "neat" as it would be if the grass were mowed to the recommended height of 10 cm (4 in) (Figure 9). A mowing height of as much as 20 cm (8 in) would be acceptable or even advantageous in certain situations. There is less shock to the root system especially with grass that is tall at the time of mowing.

Skips

Skips are the result of careless mowing. Strips left between mowing swaths are inexcusable, and contractors who allow this practice should be penalized. Generally, trimming around poles, signs, and guide rails was sporadic to good. This is not a technical problem but rather a problem of enforcement. A practical solution is the use of growth-retardant chemicals to prevent grass growth in these difficult-to-mow areas. Cost-benefit studies are in progress to determine if growth retardants (not soil active herbicides) around poles, signs, and guide rails might actually result in cost savings.

A number of roadsides where accurate mowing histories were available were examined. Except for growth of brush in unmowed areas (Figures 8 and 11), no deleterious effects of reduced maintenance were noted. The practice of mowing to the ditch or to the ditch plus 1.5 m (5 ft) provides an attractive roadside (Figure 11) and is a sound practice (a) if adequate sight distances are maintained and (b) if brush is controlled. Brush control, either chemical or mechanical, must be considered an integral feature of the maintenance of unmowed rights-of-way.

A few test areas were encountered where unmowed roadsides have persisted for as long as 7 years without deleterious effects. These sites were located in a true prairie environment where brush invasion is generally less prevalent. Even here, however, introduced species such as black locust did become established. In other nonprairie sites, the woody vegetation was more natural to the environment and presented a continual threat of invasion. One must either accept woody vegetation (brush and trees) in the unmowed areas or be prepared for a continuing fight.

Weed count data on areas that were both unmowed and unsprayed are limited in Indiana because our spraying program has been in operation since 1970. However, weed counts taken in the Greenfield subdistrict 3 years after spraying with 2, 4-D amine show consistent reduction of the "lawn type" of weed species in unmowed areas (1 hm^2 = 2.5 acres):

Weed Species	Plants per Square Hectometer	
	Mowed	Unmowed for 5 Years
Plantain	31 525	1 075
Dandelion	4 350	950
Clovers	8 625	3 062
Common thistle	3 250	3 500
Black medic	13 067	12 000
Common milkweed	1 625	1 950
Wild carrot	17 422	8 750
Knotweed	43 500	12 000
Composites (sunflower family)	6 500	6 875
Yellow woodsorrel	5 500	6 500
Other	15 000	13 625
Total	150 364	70 287

Other species such as canada thistle, wild parsnip, and milkweed are less affected, perhaps favored, in unmowed areas.

A consistent observation in all of our studies was that roadsides seeded to legumes, especially red clover, appeared unsightly early in the season and seemed to require mowing not because of the grass but because of the legumes (Figure 12). This is not caused so much by a height differential as by the color and distribution of foliage. The legumes were only 2.5 to 7.6 cm (1 to 3 in) taller than the grass in most instances. The legumes are a much darker green than the grass. The legumes had the greatest leaf density toward the top, whereas the grasses had the greatest leaf density at the bottom. Visually, the legumes appeared to be nearly twice as tall as the grass and to require mowing. Actual measurements showed that this was not so. In any event, the roadsides appeared unsightly because of the presence of the legumes.

The seeding of legumes can be wasteful. The legumes may actually increase maintenance costs by perhaps as much as one mowing per season. As soon as the area is sprayed for control of broadleaf weeds, much of the legume population is killed. Those that remain create the kind of problem shown in Figure 12. Application of slow-release nitrogen fertilizer might prove less expensive than legume seeding in the long run.

OTHER CONSIDERATIONS

According to the Guide for the Determination of Mowing Limits of the New York State Department of Transporta-

tion (DOT) (2), four categories of features in addition to the quality of the turf and weed control must be taken into consideration in determining highway mowing practices. These are highway safety, topography, adjacent land use, and existing vegetation within the right-of-way.

Highway Safety

According to the New York DOT guide (2),

> Highway safety overrides all other features affecting mowing practices. Sight distances at intersections and on the inside of curves must be maintained. Safety setbacks for major trees must be observed and guide rails, signs, and other traffic control devices kept open to view.

Obviously, maintenance of appropriate sight distances is the most important single reason why both mowing and weed control are required features of roadside maintenance.

Topography

The physical ability to machine mow will also determine mowing limits. Ditches and other drainageways—e.g., those in medians—should be mowed to maintain water-carrying capacity. Slopes 1 or 2 or steeper are normally not in need of mowing beyond the ditch.

Adjacent Land Use and Vegetation

Whenever highway right-of-way borders on agricultural land of high productivity, mowing is justified to keep down weeds and brush, to prevent shading, and for good public relations. It is my experience that highways that border high-productivity farms are mowed regularly—if not by state crews then by the farmers themselves. One uniform mowing test was abandoned because the farmer whose soybean field bordered the test plot mowed the roadside despite personal pleas and large signs that clearly stated DO NOT MOW.

Existing Vegetation Within the Right-of-way

It is often possible to mow around large masses of landscape plantings without mowing around individual plants. Pure stands of tall fescue or bluegrass may be easier to maintain than mixed stands. Certainly weeds and legumes are a factor. When weeds are controlled, less mowing is required.

Use of Chemical Growth Retardants

The need to develop chemical retardants of grass growth to further reduce or eliminate the need for mechanical mowing was identified as one of the most pressing future needs of roadside maintenance operations. Completed studies demonstrate the feasibility of using retardant chemicals to replace all or part of mechanical mowing along Indiana roadsides. At least an additional 5 years will be required for development and evaluation studies. The prognosis for a significant advance in this area is good and could result in additional savings of $1 000 000/year to the Indiana State Highway Commission.

RECOMMENDATIONS

Where mowing is required, safety or appearance or both are primary considerations. Three- or two-cycle mowing with exact timing based on grass height is recommended. The desirable mowing height should be increased from 30.4 cm (12 in) to between 46 cm (18 in) (urban areas) and 61 cm (24 in) (rural areas) with a minimum height for cut grass of 13 to 15 cm (5 to 6 in). (Mowing heights refer to the average height of the seed heads or that part of the grass that determines sight distance and not extended blade length.) Mowing of wet grass should be discouraged to reduce "piling up." Mowing should be done in combination with the fall-spring spraying program to control weeds.

Where mowing is not required, safety or appearance or both are not primary considerations. Eliminate mowing entirely. The fall-spring spraying program for control of broadleaf weeds must then be modified to include a brush-control agent. To eliminate brush along roadsides, a three-way herbicide mixture of 2, 4-D, dicamba, and Silvex has been developed for use in off-road equipment on unmowed rights-of-way. The mixture should be equal parts of an amine salt formulation of 2, 4-D + 2, 4, 5-TP (Silvex) + dicamba (Banvel). Rates are based on a tank mix of formulated products each containing 6.9 kg/L (4 lb/gal) of active material. It is recommended that the material be mixed at the rate of 3.78 L (1 gal) of 2, 4-D amine + 3.78 L of Silvex + 3.78 L of dicamba concentrate to 378 L (100 gal) of water. The mixture should be applied at the rate of 60.6 L of total mixture per square hectometer (40 gal of total mixture per acre). Dates for fall and spring applications are the same as those cited earlier for 2, 4-D amine concentrate. Application is recommended for unmowed rights-of-way once every 3 years (4, 5). For the best results, the fall application should precede the spring application.

IMPLEMENTATION

Some of the recommendations based on these findings were implemented in Indiana on a statewide basis in 1977. The remainder are scheduled for implementation in 1978. After 1 year of implementation, the evaluation is that some areas were able to get by on one-cycle mowing, most areas required only two-cycle, restricted mowing, but that some areas where aesthetics or safety was an issue required three cycles or more. Starting in 1978, areas that are not mowed will be sprayed with a brush-control agent at least once every 3 years.

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Highway Fences as Deterrents to Vehicle-Deer Collisions

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A survey of highway fencing along I-80 in Centre County, Pennsylvania, showed that 2.26-m (7.41-ft) type 3 modified fence has little value as a deterrent to vehicle-deer collisions; many deer crawl under the fence to the planted right-of-way, and the many gaps underneath provide easy penetration. From December 1974 through March 1976, numbers and position of deer were observed from a vehicle driven along 9.65 km (6 miles) of I-80 at night. Bimodal patterns of abundance were found. Deer were most numerous in spring and fall. Of 2577 deer sightings, 74.5 percent were on the highway side and 25.5 percent on the far side of the fence. Comparisons between a control area on the north side of the highway, where the fence was unmodified, and test areas on the south side, where gaps underneath were plugged or the top five wires were removed or repaired or both, showed that large numbers of deer crossed a fully repaired fence. Only six deer were reported killed during the 16 months of the study, and no live deer were seen on the highway. These results, relative to previous findings beginning in 1967, strongly suggest that high traffic volumes prevent deer from venturing onto the highway, thus reducing collisions.

More than 26 000 white-tailed deer carcasses are annually reported as highway kills by Pennsylvania game protectors; many more are undoubtedly injured or die undetected and unreported. We have been engaged in research on vehicle-deer collisions for more than a decade, and the purpose of this report is to share some of our findings.

Four-lane, divided highways that traverse habitats where deer are plentiful—such as Pennsylvania's I-80—are of particular concern. Divided highways have approximately twice as many deer collisions per kilometer as other highway types (1). When planted rights-of-way provide abundant food for deer and the surrounding habitat provides less abundant or less desirable food, the rights-of-way may be visualized as long, narrow pastures with high-speed vehicle traffic. Bellis and Graves (2) noted that 286 deer were reported killed on a 12.87-km (8-mile) section of I-80 in north-central Pennsylvania in the 14-month period after the opening of the highway in 1968.

A study of deer abundance, behavior, and mortality along I-80 in both agricultural and forested areas of Pennsylvania (3) disclosed that deer come to the highway borders primarily to feed, are most abundant between dusk and dawn, and show strong bimodal activity patterns across seasons, being very abundant in the fall—especially in November—and in the spring (summer and winter are times of low deer abundance along the highways). Deer mortality is highly correlated with this abundance on a monthly basis (2).

Early studies on abundance and mortality of deer on rights-of-way were done in 1968 and 1969 along an unfenced section of I-80 when traffic volume was relatively low. In 1970, a fence 2.26 m (7.41 ft) high was installed at or near the outer margins of the right-of-way where it joins the forest. This resulted in a progressive decline in deer mortality in ensuing years. It is not clear whether the decline was due to a fence that prevented access of deer to the right-of-way, to a smaller deer population in these regions, to changing traffic volume on I-80, or to some other unknown factor or factors. We therefore developed a study to determine the effectiveness of fences as deterrents to vehicle-deer collisions in an area known to have a large deer population.

STUDY AREAS

The majority of our work was done along a 9.65-km (6-mile) section of highway that extends from mileage marker 139-36 just east of Moshannon Creek in Centre County to marker 145-36 just west of the Snow Shoe rest area in Centre County. A survey to determine fence quality and deer crossing sites was made on an adjacent section of highway east of the experimental 9.65-km section and overlapping it by 6.81 km (4.23 miles). It ran from marker 141-24 to 149-44 inclusive, a distance of 13.55 km (8.42 miles). This section included all of the area studied by Carbaugh and others (3) and an additional 10 sectors [606 m (2000 ft)] that extend east to the PA-144 overpass. These 13.55 km were chosen because two types of fence (type 1 chain link and type 3 modified) and a wide variety of cover and terrain types were found there.

A deciduous forest with smaller stands of white pine and hemlock paralleled the highway on both sides. There were numerous streams and springs that cause occasional pools and marshes. A few permanent dwellings and several hunting camps were in the area but none within 500 m (1640.5 ft) of the highway. Strip-mining areas, scattered farms, and the village of Snow Shoe were all located within a 6-km (3.73-mile) band that paralleled the north side. A rest area was on each side of the highway in the fence survey area, which also included the Snow Shoe Interchange.