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Abridgment

Roadside Management in North Carolina

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North Carolina's climate favors the establishment and rapid growth of vegetation and is complemented by a topography that ranges from flatlands and swamps to rugged mountains and valleys interspersed with streams, rivers, and waterways. Across this terrain, North Carolina maintains the largest state highway system, approximately 120 968 km (75 021 miles), in this country. Maintaining the roadside of this vast highway network at an acceptable level for minimum costs is a formidable challenge. The potential for degrading our natural environment through inadequate, improper, or untimely roadside maintenance is great.

Recognizing this, the North Carolina Division of Highways adheres to a philosophy of roadside maintenance that attempts to maintain a highway facility in as near its original condition as age, normal deterioration, and changing traffic conditions will permit. We also improve those roadside areas where time and nature will assist in the enhancement of the facility.

In recent years, significant design changes have greatly improved the state's ability to maintain our roadsides.

1. Generally, flatter slopes are maintained near the travelway and the cut slopes of drainage channels. This will ultimately facilitate slide removal and maintenance of storm drainage systems.
2. Drainage berms across and down the backs of cut slopes have increased their stability and thus reduced maintenance.
3. Low-growing shrubs and plants at bridge ends reduce the effort required to keep these areas stable and presentable.
4. Detailed erosion control contract specifications and construction standards that include permanent and life-of-contract measures increase the stability of slopes, minimize obstruction of drainage structures caused by erosion, and consequently reduce related maintenance.
5. Ditches inside and outside the typical section are receiving appropriate treatment, such as paved ditches, jute mesh, and fiberglass roving, to minimize erosion. The combination of more stable slopes and ditches will greatly reduce or eliminate the need for back sloping and ditch pulling.
6. By leaving silt detention basins, ditch checks, and silt fences in place after a project is completed, the new project will stabilize itself in time and reduce or eliminate the possibility of damage caused to areas outside the rights-of-way. In the recent past, it was not uncommon for maintenance crews to be required to clean out drainage structures and remove eroded materials from adjacent property almost immediately after acceptance of a new project.

In spite of these and other similar design modifications, anticipated maintenance costs in North Carolina are increasing at an annual rate considerably in excess of anticipated revenue increases. These increases are projected on the basis of no additional maintenance personnel and in spite of a recent 14 percent reduction in our equipment fleet. The professional staff of the Division of Highways is not at this time advocating or anticipating any reduction in the level of services in the foreseeable future. However, it is obvious that the projected increases in the cost of maintenance operations and declining growth rates in revenues cannot continue indefinitely. North Carolina must take every measure possible to offset the spiraling cost of maintenance by better managing maintenance resources and continuing to incorporate into construction projects those features that will result in reduced future maintenance costs.

North Carolina is progressing steadily in the development of a maintenance management system that has reached the stage where planned work quantities and cost of an annual maintenance program by line item activity on both a county and a statewide basis can be reasonably projected. Work is proceeding toward developing the means and methods that will permit objective evaluation of the effectiveness of our efforts and will properly rank line item maintenance activities.

Roadside maintenance is a critical part of the maintenance management process, as indicated by the cost of the following activities in North Carolina.

Activity	Annual Cost ($000 000)
Maintenance of unpaved shoulders	9.7
Routine mowing	5.5
Manual and machine clearing of the roadway	3.5

Activity	Annual Cost ($000 000)
Ditch protection, seeding and mulching, top dressing, plant and plant maintenance, and control of vegetative growth by chemical application	1.6
Rest area and welcome centers	1.2
Litter pick-up, picnic tables, and litter cans	1.2
Repair of on-site and off-site damage caused by erosion	0.5
Approximate total	23.5

This total represents approximately 28 percent of the total estimated expenditure for fiscal year 1975 to 1976 (including resurfacing by state forces).

The maintenance of unpaved shoulders is included as a roadside or landscape item because we consider a rutted, unstable, low shoulder a displeasing sight as well as a safety hazard.

Unpaved shoulders are secondary to resurfacing in maintenance cost. It is significant that North Carolina expends more money on the former than on patching of paved travelways. Unpaved shoulder work function includes the cutting of high shoulder build-up, building up low shoulders, blading the cross slope to a uniform section, and pulling side ditches, including disposal of surplus materials. This is expensive principally because old facilities have substandard pavement widths and shoulders. The ideal solution would be for all projects to be designed with a full depth, full width paved shoulder with the slope of the base course extending to the ditch line or shoulder point, or both. However, from an economic, design, and construction program standpoint, this is not practical for all projects.

In design and construction, a paved shoulder with a width of 1.2 m (4 ft) and with a pavement structure less than that of the travelway is considered the minimum. Past experience indicates that the problems of low and high shoulders are confined to a distance of not more than 0.6 m (2 ft) from the edge of the travelway. After spot paving some 0.6-m wide shoulders on high traffic volume facilities, we discovered that, if an additional full depth pavement width 0.3 to 0.6 m (1 to 2 ft) from the edge of the travelway were given, most of our low shoulder problems would be solved. Furthermore, we felt that this narrower, full depth design would eliminate the need to continue using present color contrast and rumble effect on 1.2-m paved shoulders and would also eliminate replacement problems during future resurfacing operations. This is under study by our design section.

Assigning maintenance activities their relative priorities is a difficult task, as evidenced by experiences during the 1975 mowing season, when we instituted a new mowing procedure. We delayed the first mowing until seed heads were developed and reduced the mowed area, principally along the primary routes. Excessive delays, however, coupled with an extremely favorable early growing season, put the system literally "waist high" in grass and weeds. Public reaction was extreme.

In response, the professional staff made two basic mistakes: drastically raising the level of service over too short a time frame and advertising what we were going to do. However, the end result proved more beneficial than harmful. The public accepted the reduction of mowed areas and 15-45 cm (6-18 in) cut height. Mowing and machine clearing operations are now limited to within 12 m (40 ft) of the travelway except in areas of critical sight distance and where development dictates otherwise.

Maintenance forces have also begun herbicide treatment in areas around and underneath guardrails. This program has been very successful in eliminating unsightly growth and the need for hand labor. However, much care must be exercised in application. Environmental considerations could jeopardize the use of herbicides in the future. This could be offset if designers would place guardrails on pavement, base, or sterilized areas.

It is not an uncommon practice for states to employ meandering mowing patterns, which reduce the mowed areas and thus costs. North Carolina's experience, in most cases, has indicated that varying from straight line patterns adversely affects the cost of mowing. The deadheading time required to cut out the curved areas offsets the advantages gained by reducing the mowed area. This is substantiated by the fact that while mowed areas are reduced, equipment and personnel have remained constant.

A review of our equipment and the personnel required to maintain the previously mentioned horizontal and vertical limits that has just been completed indicates the need for one regular mower and one operator for each 161 to 242 adjusted kilometers (100 to 150 miles) of roadway (adjusted kilometers being computed on the basis of six times Interstate and other multilane divided road kilometers, plus two times the undivided road kilometers, plus one times the secondary road kilometers). The range of 161 to 242 adjusted kilometers takes into account varying growing seasons and roadway typical sections from the coastal areas to the mountains. Contour mowers and operators are assigned to the field divisions on the basis of one mower per 564 to 806 adjusted kilometers (350 to 500 miles).

Looking to the future, the present trend for new construction seems to indicate that the great increases in mowing areas of the past 20 years will not be a problem. Future plans seem headed in the direction of modifying existing facilities rather than building new ones. However, without any increase in area, continuing inflationary increased mowing costs are anticipated unless some substantial changes are made.

Some states have explored the possibility of contracting their mowing out to competitive bidders to lower overall cost. The multiple duties of mower operators (truck drivers, for instance, during the off season) and the possible poor response time of a contractor make this approach of doubtful benefit for North Carolina.

During the months after we reduced mowed areas, we received many requests to harvest the hay on the right-of-way. However, these requests were rejected based on questionable legal authority to allow it, on traffic control and safety problems, plus the fact that such harvesting would be contrary to our original plan of regenerating these areas and beautifying the roadside.

In the maintenance unit, it is believed that the ultimate salvation in mowing rests on the development of an economical low-growing grass. Research being done jointly in Kentucky by the New Jersey Department of Transportation and Cornell University is much needed. The North Carolina public would probably accept an uncut grass height of 20.5 to 25.64 cm (8 to 10 in), and, if such a low-growing grass were established on the primary system, at present prices, we could realize a direct maintenance cost reduction of approximately $50 million over a 20-year period.

We are presently maintaining 5 welcome centers and 44 rest areas at a cost of approximately $1.2 million annually. Two additional welcome centers are currently under construction, and future plans include 10 additional rest area sites.

Maintenance of these facilities includes the buildings, grounds, drives and parking areas, utilities, and the furnishing of supplies. They remain open to the public 24 h a day, 7 d a week. Uniformed custodians are on duty at welcome centers continuously, and at rest areas

16 h a day, 7 d a week. Personnel needed requires five custodians at each welcome center and three custodians per pair of rest areas. These personnel are in an annual salary range of $7000 to $8700.

The duties of custodians include making minor repairs to buildings, general upkeep of the grounds, contact with the public, and the sampling and testing of sewage treatment effluent and water supplies. Regular maintenance forces are responsible for pavement maintenance and some mowing operations.

Over the last 4 years, attempts have been made to reduce staff. However, public demand coupled with excessive vandalism necessitates continued staffing at the current level. The cost of maintenance of rest areas and welcome centers is more or less fixed. There is very little that improved management can do to reduce the cost of this operation. Present trends indicate that the future will require considerably more service in this area. Current expenditures for this maintenance activity could well double over the next few years.

It is difficult to believe that state departments of transportation will continue to set aside these valuable land areas or continue to use them in a way that will require additional expenditures of public funds. Some believe lease agreements could render the same service to the traveling public and also serve as a source of revenue rather than expenditure. In North Carolina, however, there is some question as to whether state highway rights-of-way may be leased, because of the wording of the documents by which the original rights-of-way were acquired.

The maintenance of a relatively litter-free 120 968-km (75 000-mile) system is a formidable and expensive task that consists basically of

1. Routinely scheduled litter pickup by state maintenance forces,
2. Utilization of approximately 250 litter pitch-in cans located on the primary system,
3. Cooperative effort with some county governments permitting the utilization of dumpsters on highway rights-of-way,
4. Enforcement of a general statute prohibiting the littering of public roads, and
5. Cooperative efforts between the Division of Highways and local civic organizations.

State litter crews, generally scheduled to pick up before each mowing cycle, average two laborers using picks and bags and a small dump truck. This may be considered an obsolete means of litter control, but using prison inmates at a cost of $1 a day influences our management. By agreement with the North Carolina Department of Correction, approximately 1000 inmates are furnished daily to the Division of Highways for hand work. During the last reporting year, approximately 5700 inmate days and 10 500 free labor man days were utilized in litter pickup.

The maintenance unit has made numerous studies of the use of litter pickup machines with no success. The major problems appear to be (a) a very high percentage of grass pickup (50 to 90 percent), (b) failure to pick up flattened cans, and (c) frequent breakdowns.

In June of 1972, the North Carolina Beer Wholesalers and U.S. Brewers Association contributed $38 000 toward the purchase of 250 pitch-in cans to be installed across the state. The Division of Highways prepared the sites and installed the containers in our most troublesome litter areas. Observation indicates this has been a very successful program.

In 1973, the North Carolina General Assembly enacted a bill that permits municipalities and counties to place garbage containers on the state highway system rights-of-way. Placement is subject to the approval of the Board of Transportation and is not allowed on fully controlled access facilities. The Division of Highways prepares approved sites on a reimbursable basis, and the municipality, or county, is totally responsible for the maintenance of the containers. Under this program, 150 dumpster-type containers are located throughout 11 counties. This has contributed to a considerable reduction in household garbage being placed on highway rights-of-way in these areas at virtually no expense to the Division of Highways.

In 1971 the North Carolina General Assembly amended an existing statute to make littering of highway rights-of-way a misdemeanor punishable by a fine of not less than $10 or more than $200. After the amendment, the Division of Highways placed appropriate signs throughout the state. In calendar year 1975, 712 convictions were obtained out of 808 arrests; 346 written warnings were issued. The number of annual arrests and convictions has been very constant.

In 1971, before the development of our maintenance data-collection system and based on random sampling techniques, cost of litter pickup was estimated at $2.4 million. During fiscal year 1975 to 1976, the documented cost was $1.2 million. Although costs may not have fallen by 50 percent, it is reasonable to assume that costs are substantially lower for maintaining the same or a slightly better level of service.

In 1973, the North Carolina General Assembly enacted the Sedimentation Control Act of North Carolina. This act established a sedimentation commission, which was given authority to establish rules and regulations governing all land-disturbing activities on one or more contiguous acres. These provisions apply to current highway construction and maintenance activities by state forces. In addition, the regulations require that all previously disturbed land areas that contribute to accelerated erosion and sedimentation be corrected.

This statute, together with subsequent rules and regulations, has had a profound effect on the management of roadside maintenance activities. As examples, all supervisory maintenance personnel must receive training in the latest acceptable methods and techniques in erosion and sedimentation control as may be required in such routine activities as maintenance of unpaved shoulders, blading unpaved roads, pulling ditches, and flattening fill slopes. The methods and techniques include construction of silt detention basins and silt check dams, ditch treatment and brush barriers, and seed-bed preparation and seeding. In order to implement these measures, scheduling of activities was re-examined to provide timely erosion control measures.

In compliance with the act, a 1974 statewide survey of each road was made to determine the extent of existing uncovered land areas on which there was accelerated erosion, and those areas that may be contributing to off-site sedimentation damage. This survey resulted in the development of a corrective program estimated at $5 million. This program required flattening of cut slopes, ditch treatments (fiberglass roving, jute mesh, rip-rap, and so on), construction of silt detention basins, seed-bed preparation and seeding and mulching—with all of this work being carried out by state forces.

The Division of Highways proposed completion of this program within a 5-year span, if funds are available. In the absence of any additional funds appropriated specifically for this purpose, approximately 29 percent of this work has been completed. This program has been planned to completion, although obviously the time must be extended beyond the originally estimated 5 years.

Maintenance of North Carolina's 120 968-km system

is carried out by fewer than 7000 permanent employees, who include district administrative and supervisory personnel. The only major maintenance activity contracted out is plant-mixed asphalt resurfacing. With their rather limited resources, maintenance forces are accomplishing a reasonably productive, efficient operation on this vast highway system.

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Abridgment

Wildlife Considerations in Managing Highway Rights-of-Way

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Over the years there has been an increasing public awareness and concern for our natural environment and a demand that we manage our public lands to ensure their protection and wise utilization.

Highways are often attacked as destroyers of wildlife habitat and detrimental to wildlife populations. Although this is sometimes true, highways often provide a wildlife habitat better than that before the highway was built. In many agricultural states, highways often provide the only habitat for many miles, because the surrounding land is under cultivation.

Few people are aware of the great challenge and responsibility state highway departments have in managing highway rights-of-way. There are over 4.9 million km (3.1 million miles) of rural U.S. highways (1). The Interstate highway system alone accounts for more than 67 500 km (42 000 miles) (1) and each kilometer (0.62 mile) of Interstate utilizes up to 12 hm^2 (30 acres) (2). It has been estimated that the soil and planted portions of highway, railroad, and utility rights-of-way embrace some 20 million hm^2 (50 million acres) of the contiguous United States (3).

Highway rights-of-way are unique compared to other intensively managed land areas, such as parks, forest, and wildlife refuges, most of which are in large single blocks. Highways, however, are long, narrow ribbons. This configuration has both advantages and disadvantages for wildlife management.

The major disadvantages are primarily problems associated with managing these large tracts of land as one unit. For example, to manage a 260-hm^2 (640-acre) wildlife refuge, one would seldom have to travel more than 3 km (2 miles) to reach any one spot within the area. To manage the same amount of highway, an engineer would have to travel at least 21 km (13 miles) to get from one end to the other.

The extensiveness of the highway system is also an advantage. Highways traverse areas of very diverse land use, such as intense agriculture, industry, and city. Because of this, there is increased potential for these areas to support wildlife populations. Highways preserve habitat in urban areas and are often the only large green spaces around. In agricultural areas, highways provide habitat diversity to land devoted primarily to monocultures.

In addition to preserving habitat, highway rights-of-way often create a boundary or transition, called an "edge," between plant communities. Edges increase plant species diversity and often create habitat conditions that were missing before the highway was constructed.

All animals require food, shelter, and water to survive. Most plant communities supply these requirements to at least a few species. Often, however, the number of species or the total number of animals that can be supported by a particular community is low because one or more of these requirements is limited. Highway rights-of-way, in creating an edge, often increase the ability of the area to support a larger and more varied wildlife community; they often supply a requirement for a species that had previously been limited or missing.

In addition to providing habitat for species indigenous to an area, highways may also be responsible for a species extending its range. The kangaroo rat has apparently increased its range northward across the Columbia and Snake rivers via highway and railroad bridges (4). In Illinois, the meadow vale is extending its range southward in response to the state's reduced mowing practices along the Interstate highway system.

Vegetation is not the only aspect of highway rights-of-way that can benefit wildlife. Many species, especially birds, have taken advantage of the various structures associated with highways. Cliff and barn swallows build nests under bridges and in culverts (5, 6). The cave swallow was once considered threatened, because it was thought to be restricted to nesting in sinkholes and caves. Recently, however, they were also discovered nesting in culverts (6).

These few examples demonstrate the great potential highway rights-of-way have for preserving or enhancing wildlife habitat. In order to fully realize this potential, however, highways need to be properly managed. In most cases, this will not require any significant increase in effort or expense on the part of the highway agencies. In some instances, proper wildlife management may result in an overall reduction in highway maintenance expense and effort.

The question now arises of how we can optimize the wildlife potential of highway rights-of-way while providing a safe and pleasant driving experience for the motorist.

The presence of birds and small mammals in rights-of-way is not a significant safety hazard. Collisions, however, with large animals such as deer cause extensive property damage and even human fatalities. Proper wildlife management includes managing against unwanted species. When a highway passes through an area with a high potential for collisions between large animals and motor vehicles, management must focus on reducing collisions.

At the present time, the only practical method for