

Roadside Landscapes – A potential environmental resource ⁽¹⁾

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ABSTRACT

Construction of roads can result in significant ecological impacts; affecting air quality, soil, vegetation, wildlife, and human well-being. These disturbances drastically change the surrounding landscape. This review looks at the potential for roadside vegetation to serve as an environmental resource, improve socioeconomic health and provide beautify for local and regional travelers. Roadside vegetation represents a significant land resource around the world and this vast resource provides the opportunity to use native restoration to counteract the loss of diversity and habitat throughout the world. This paper discusses the history of roadside vegetation, strategies for establishing and managing appropriate roadside vegetation, and public acceptance of roadside landscapes.

Keywords: Highway vegetation, sustainable landscape, perception of landscape, native ornamental plants

RESUMO

Paisagens de beira de estradas – Um potencial recurso ambiental

Construções de estradas podem causar significantes impactos ecológicos, afetando a qualidade do ar, do solo, da vegetação, da vida silvestre e o bem-estar das pessoas. Além disso, esses distúrbios mudam drasticamente a paisagem ao redor das estradas. Esta revisão analisa o potencial da vegetação de beira de estradas para servir como um recurso ambiental, melhorar a saúde socioeconômica e ainda fornecer beleza aos lugares, seus moradores e aos motoristas. As beiras de estradas representam um recurso significativo ao redor do mundo e este vasto recurso proporciona a oportunidade de usar a restauração nativa para neutralizar a perda de diversidade e habitat. Este artigo discute a história da vegetação de beiras de estradas, estratégias adequadas para criação e gestão desta vegetação, e a aceitação pública destas paisagens naturais.

Palavras-chave: vegetação de estradas, paisagismo sustentável, percepção da paisagem, plantas ornamentais nativas.

1. INTRODUCTION

A road right-of-way includes grassy verges, drainage ditches, and possibly bordering hedgerows of trees and shrubs. Roadside vegetation represents a significant land resource around the world. Departments of transportation in the United States manage over 4.8 million hectares (HARPER-LORE, 1998a). In China, the total length of high-speed roads is expected to reach 116,000 km between 2010 and 2020 (CHINESE Investment Net, 2008; CAO et al., 2010a). The Netherlands ranks among the top 10 countries with high road densities in the world (Encyclopedia of the Nations, 2007). With a total of more than 137,000 km of roads, it has an average road density of 5 km per km² of surface area (VISSER, 2010). This density of roads results in large areas of roadside.

Construction of roads can result in significant ecological impacts; affecting air quality, soil, vegetation, wildlife, and human well-being (FORMAN and ALEXANDER, 1998; SPELLERBERG and MORRISON, 1998; FORMAN et al., 2003; COFFIN, 2007). Environmental problems occur due to damage caused by the construction process as well as high speed vehicular traffic (CAO et al., 2010a; XU et al., 2011). Since roads have been constructed in Brazil, especially after 1920s (LIMA NETO and BRASILEIRO, 2001), the native Atlantic forest was degraded; first by land use and then by road construction. In contrast, in the

Brazilian Amazon forest roads were built by the government to promote occupation of the region (PFAFF, 1999).

Roads can be considered agents of deforestation, accelerating forest fragmentation and reducing forest regrowth (YOUNG, 1994; LAURANCE et al., 2002; NAGENDRA et al., 2003; SOARES-FILHO et al., 2004; FEARNSTIDE, 2007, 2008). In the U.S. and New Zealand high road densities have indicated intensive use of landscapes and road density was a strong predictor of cumulative forest loss and fragmentation (SAUNDERS et al., 2002; BRESEE et al., 2004; EWERS et al., 2006). Roadside vegetation is challenging, harsh environments. They contain shallow, acid soils with low fertility and poor moisture retention. Steep slopes and excess sun and wind often result in inhospitable sites (AIRHART, 1980, HARPER-LORE, 1998a). Road construction requires large volumes of fill materials and creates extensive surface disturbance (CAO et al., 2010b). The cut and fill of road construction results in sites deprived of their original soils, with substrates having low soil fertility, high soil compaction and almost absent vegetation, all of which increase erodibility (BOCHET and GARCÍA-FAYOS, 2004; CAO et al., 2006; BOCHET et al., 2010)

Normal roadside functions, as a recovery zone, utility corridor, snowdrift buffer, fire barrier and location for sign posting, act as disturbances that encourage weed growth. When vegetation is disturbed, plants grow back.

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In the past, native plants grew because native seed was in the soil and surrounding area. In the highly disturbed sites along today's roadways, weed seeds are present and invasive species displace native plants. Natural succession no longer results in a desirable plant community evolving unaided.⁽⁴⁾

Despite this bleak picture of typical roadsides, progressive management can result in a wide variety of environmental benefits (COPPS, 1995). This vast resource provides the opportunity to use native restoration to counteract the loss of diversity and habitat throughout the world (GOFF, 1998) (Figure 1).



Figure 1. A diverse mix of native trees and shrubs have been planted along a highway through the city of Wilmington, DE, providing ecological benefits to this otherwise bleak scene.

2. BENEFITS OF ROADSIDE VEGETATION MANAGEMENT

When managed sustainably, roadside vegetation can improve water quality and infiltration (FORMAN et al., 2003); increase diversity of insect life (REIS et al., 2001; HOOPWOOD, 2008); contribute to cost savings (FORMAN et al., 2003; BARTON, 2005); and provide numerous safety benefits (ULRICH, 1979; CACKOWSKI et al., 2003; TIFFAULT and BERGERON, 2003; BARTON, 2005; FORMAN, 2007); while also benefiting the socioeconomic health of the state (BARTON, 2005).

Roadsides are an important resource for wildlife management. The grassy strip adjacent to the paved roadway can serve as refuges for insects in both urban and farmland landscapes. Wet ditches add to the diversity of life roadsides support by encouraging wetland vegetation and harboring aquatic animals. Trees and shrubs associated with many roadside fencerows provide cover for songbirds and other small animals (COPPS, 1995). As farmland and open space decline, the importance of managing the road right-of-way for habitat grows (ANDERSON, 1998). Natural ecosystem restoration along the highway right-of-way provides a marriage between ecosystem restoration and other goals of social importance (JORDAN et al., 1988). Generally regarded as an environmental minus, these corridors offer opportunities for reestablishment of native vegetation, an approach to corridor maintenance that is becoming more popular nationwide (CRABTREE, 1984).

Roadside construction must be viewed as an ongoing biological project rather than a one- to two-year engineering project (TYSER, 1998). Changing highway vegetation from a haphazard result of repeated disturbance to a managed landscape that impacts the surrounding environment, both aesthetically and ecologically, is an easily agreed upon goal. However, the specific composition, implementation approach and management strategy used to achieve that goal can vary significantly.

The European Landscape Convention defines landscape as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors' (COUNCIL OF EUROPE, 2000). Car drivers and pedestrians perceive this landscape in a different way (FROMENT and DOMON, 2006). As highways evolved into significant arteries, people realized that the attractiveness of the landscape viewed from the car was important. Lloyd Benson, senator from Texas, passed a federal bill in the United States in 1987 requiring ¼ of 1% of all highway landscape funds be spent on "native wildflowers." Many states dropped the "native" designation and focused on beautification, using garden flowers⁽⁵⁾. Commercial wildflower mixes are not formulated to recreate a natural meadow. Instead, they feature colorful annuals, less than 10 percent of which persist, requiring annual reseeding (BARTELS, 1992). Research at Cornell University has shown that plots sown with non-native/non-naturalized plants revert to weeds in one to two years (STROUD, 1989). Many states in the U.S. planted annual mixes to

⁽⁴⁾ BARTON, S. University of Delaware, Newark, DE, United States. Personnel Communication, 1998

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fulfill their “wildflower”-planting requirement. These expensive annual plantings are extremely popular with the traveling public. Once a state department of transportation begins a program of high visibility “wildflower” planting, it is difficult to discontinue.

In China, to balance the need for roads that will sustain economic development with the need for environmental conservation during road construction, China’s Ministry of Communications has proposed a more environmentally friendly approach to the construction or repair of highways. Since 2000, they have promoted the development of near-natural greenways. The goal is to decrease the environmental damage caused by road construction and to revegetate the roadside with native vegetation during and after road construction. In total, more than 30 demonstration roads with a total length of more than 1500 km had been constructed throughout China by late 2007 (CAO et al., 2010b). The main purposes of these roads are environmental, ecological, and educational, but they also provide road designers with a means of aesthetic expression to create beautiful scenery (BISCHOFF, 1995). Greenways emphasize the protection of both the natural ecosystem and the local social and cultural values (such as the sociocultural meaning of the landscape to the Chinese people). They protect the environment without compromising social or economic development (CAO et al., 2010b). These greenways also prove that it is possible to reconcile political objectives and urban development with the need to safeguard landscape and environmental quality, while providing new opportunities for public recreation and education (RIBEIRO and BARAO, 2006). China began implementation of the near-natural greenways concept with construction of the Tibetan Plateau railway. To avoid disrupting the seasonal migration routes of animals, planners of the railway added a network of tunnels to their blueprints (PENG et al., 2007).

Over the last few decades, the interest in using native flowering plants on roadsides has increased (BRETZEL et al., 2009). The establishment of a native forb meadow involves a reduction in management costs (BRETZEL and HITCHMOUGHT, 2000) due to the absence of fertilization and irrigation, and to the low level of other management practices, such as reduced mowing. Native forb meadows prevent soil erosion and stabilize roadside soils (BRETZEL et al., 2009). Among highway vegetation professionals, there is a trend towards roadsides that reflect the natural beauty and biodiversity of a region (HARPER-LORE, 1998b).

Texas was the first state in the US to focus on highway beautification. By 1934, directives were issued to delay all mowing, unless essential for safety, until spring and early summer wildflower seasons were over. This has expanded to a full-scale vegetation management system including a combination of selective mowing and herbicide application; wildflower preservation and propagation; landscaping; and public awareness. A variety of maintenance techniques are used including 1) safety, or strip mowing - allows the wildflowers to bloom and native grasses to emerge. Directives to mow around blooming wildflower areas are included in mowing contracts. 2) use of herbicides to

eliminate noxious weeds such as johnsongrass - allows the wildflowers to be visible. 3) 27,216 kg of wildflower seed (native, non-native, annuals and perennials) sowed annually. 4) protection and spread of native remnants by cutting wildflowers before the seeds have dropped and raking up the “flower hay” to spread in other areas or carefully blading a thin layer of topsoil containing wildflower seeds and spreading the soil in a new location (HUGHES, 1999).

Others states in the US have followed suit. For example, Oregon has developed a protocol for managing scenic byways and tour routes differently from conventional roads; protecting native plant communities by controlling mowing height and frequency, using herbicides to selectively control undesirable weeds; hand trimming after brush mowing, and maintaining a higher level of litter pick up service and increased frequency on these special roads (MORAN, 1992). Scenic Virginia, Inc. is an advocacy group formed to protect, preserve and enhance the scenic beauty of VA. Their principal activity is to educate the public about economic, social and cultural benefits of highway beautification, scenic byways and sign control. By public speaking and coordination with other volunteer groups, they work to designate eligible roads as scenic byways, protect vegetation along byways, develop landscape requirements for byways, enact local sign controls, design guidelines for gateway corridors and business districts, encourage litter control and encourage native planting whenever possible (BOYD, 1999). As is the case in many states, an active Federation of Garden Clubs founded and supported Virginia’s highway beautification program (BAKER and BARRETT, 1986).

Among states in the U.S. that have experimented with wildflower plantings, there is now a trend away from this technique. Wildflowers are defined as a group of plants whose flower display is considered visually pleasing and significant in the landscape, but may not necessarily relate to broader ecological goals. Most vegetation management emphasizes erosion control, soil and slope stabilization (ROSS, 1999). In Idaho, wildflowers are no longer planted in beds along the roadside except where extensive beautification/landscape projects are constructed. These projects are usually constructed in interstate interchanges and entrances to cities. Prairie plants now comprise 2,428 hectares of the total 62,726 hectares of Idaho’s highway right of way. Wildflowers are too expensive to put everywhere so, Idaho department of transportation’s landscape architects concentrate on interchanges and rest areas where motorists might be able to take a minute to enjoy their beauty. They use native grasses elsewhere (MUELLER, 1998).

In Nebraska, roadside planners work with the natural environment of the Great Plains, realizing this produces better and more cost-effective results in the long term (THOMPSON, 1999). The Edge of the Wilderness Scenic Byways in Minnesota was one of the first national scenic byways designated by the Federal Highway Administration. Essential to the interpretation of the byway’s resources was the use of local materials (FISCHER, 1999). Ladybird Johnson espoused regional vegetation many years ago

when she said, “wherever I go in America, I like it when the land speaks its own language in its own regional accent” (HARPER-LORE, 1998b). Byways provide insight and access to visitors on what communities find special and important about themselves and our nation. Vegetation management on byways should reflect and respect the character of the individual routes (FISCHER, 1999).

Regions with progressive roadside vegetation management programs have a few important similarities. There is often a focus on using native plants in an effort to establish a regional appearance to the roadside. Context sensitive design is used to integrate roads and roadside into the community and landscape. There is an awareness that the public must be brought into the process of establishment and maintenance. Classifying roads into different categories based on level of importance to motorists can be an important factor in determining appropriate planting and maintenance regimes. Additionally, the trend toward landscapes that augment regional character appears to result in cost-efficient landscapes that are attractive to the viewing public. Several states in the US have demonstrated the importance of involving the public in highway beautification programs. Community participation is an important part of the corridor management plans required by The National Scenic Byways Program (FISCHER, 1999).

The use of plantings other than mowed turf can break up the monotony of roadside vegetation, provide a calming effect on motorists in areas of heavy traffic and provide a way to reduce maintenance costs while providing aesthetic variety to the roadside (BILLINGS, 1990). The Federal Highway Administration in the US is advocating the use of native plants because they are often superior to introduced species. Native forbs and grasses have deep and/or fibrous roots systems providing erosion control (HARPER-LORE, 1998b). Cost reduction can be realized. Maintaining a meadow costs approximately \$20 per hectare per year, less than one-tenth the cost of a lawn (SAUER, 1998). Diversity of grasses, forbs, shrubs and vines provides a more stable community than conventional mowed grass monocultures (HARPER-LORE, 1998a; HARPER-LORE, 1998b; WHITE, 1999). Biodiversity provides food and shelter for small mammals and songbirds, whose habitat is diminishing (National Wildlife Research Center, 1993; ENGLERT, 1998; WHITE, 1999). Native grasses capture precipitation better than mowed turf and deep roots absorb the run off better (HARPER-LORE, 1998b). Native plants celebrate the uniqueness of place while integrating the human habitat into the natural world (WHITE, 1999).

Context sensitive design is an approach to roadway design and management that places emphasis on shared decision-making and preservation of the character of the nation’s communities. The goal of context sensitive design is to enhance “aesthetic, scenic, historic and cultural resources and the physical characteristics of an area giving

a community its identity and sense of place and source of local pride.” (CATES, 1998). A context sensitive design approach seeks to enhance the positive values of both the local community and the natural environment. It implies a process that includes 1) identifying the environmental impacts of the highway on the site, 2) identifying the appropriate natural systems processes most suitable to solving highway problems, and 3) gaining input and support from the community in developing design alternatives (SCHUTT, 1999b).

3. ROADSIDE VEGETATION MANAGEMENT PROCEDURES

There is no simple procedure outlined for the establishment of native plants along the roadside. Methods and plant materials lists will vary from region to region, if not from site to site, resulting in the need for local expertise (HARPER-LORE, 1998b). Compacted soil or stones discourage root growth, especially at germination and cause poor moisture relations (AIRHART et al., 1978; DUSABLON, 1988). Ledge sites offer a beautiful background but soils in these sites are often shallow and very acidic. It is important to test soils at project sites for pH, salinity, organic matter and presence of nutrients (FALLS et al., 1970). Sites with a dense cover of existing vegetation are undesirable and often too competitive for the establishment of warm season grasses and forbs (FALLS et al., 1970).

Weed control is a critical aspect of establishment success. Site preparation is the first and most critical step for effective weed control. Weed interference is the primary obstacle to establishment of seeded wildflowers, prairie forbs, and grasses (SCHRAMM, 1978; MARTIN et al., 1982; JORDAN et al., 1988; DICKENS, 1992; LYONS, 1992; HOWELL and KLINE, 1993; MASTERS et al., 1996). Projects should begin by conducting a weed inventory and test germinating a soil sample⁽⁶⁾. Restoration researchers suggest a combination of careful timing of planting, mowing, burning and the use of nurse crops to control weeds during the early stages of development (JORDAN et al., 1988).

Removal of existing vegetation is the first step in site preparation for new seeding. Most experts recommend the use of a nonselective, non-residual herbicide (such as glyphosate) (SCHRAMM, 1978; LYONS, 1992; SCHRAMM, 1992; HARPER-LORE, 1999). Often one application of herbicide is insufficient to control existing weeds, especially the seed bank present in the soil, so multiple herbicide treatments, allowing weeds to germinate and eliminating them with another application, are recommended. This process can occur over a six to eighteen month period with multiple tillings and herbicide treatments (LYONS, 1992; GORMEL, 1998).

Soil amendments are not usually recommended for

⁽⁶⁾ DIBOLL, N. Prairie Nursery, Inc. Westfield, WI, United States. Personnel Communication, 1998.

roadside vegetation projects (Harper-LORE, 1999). In fact, a study with a one-inch layer of added sewage sludge; wood chip compost; or yard waste compost found that there was less vegetation with compost treatments after the first year and compost increased the percentage of exotic species (PERRY et al., 1999). Fertilization should be avoided since native species are usually adapted to low nutrient sites. Extra fertilizer often promotes weed growth (LYONS, 1992; ENGLERT, 1998; HARPER-LORE, 1998a). Some soil amendments may be beneficial when reclaiming highly disturbed sites. Considerable research conducted in Idaho with organic based (compost/seedmeal) products and soil biological stimulants showed that these products provide slow release nutrients and humus to start the process of rebuilding top soil in disturbed areas. Bush and Koch found that when revegetating slag refuse areas, warm season grasses grew better in plots amended with a thin layer of topsoil (BUSH and KOCH, 2000).

Researchers recommend scarifying soil no deeper than 1.25 cm to reduce weed and erosion problems (LYONS, 1992; WILDFLOWERS in Florida, 1996; HARPER-LORE, 1999). The existing vegetation stubble will provide a root structure below ground to give stability to the roadside⁽⁷⁾.

Two major considerations affect selection of species for roadside planting - ornamental potential and innate potential for stand establishment (DUSABLON, 1988; ROSE-FRICKER, 1991). To achieve the desired ornamental effect, proper scale relationships considering travel speed and project scope are important (ADAMS, 1998). Species must be visible at 80 km/hour for roadside planting (HENDERSON, 1998). Planting wildflowers in concentrated patches will achieve a "mosaic effect" (SCHRAMM, 1992). Site conditions will also guide species selection. The available resources of water, light, and nutrients will determine the types of plants that colonize and thrive in an area (SCHUTT, 1999a). In China, to prevent the spread of non-native plant species along the highways and in surrounding lands, no exotic species are used to revegetate construction sites. Instead, only native species are used, and rare native species are identified in the construction zone and marked for protection before construction begins, or are relocated to a holding area so they can be restored to the site once construction is complete. This approach protects biodiversity (PENG et al., 2007). To protect the rare and fragile vegetation, planners removed vegetation from sites identified for disturbance before the work began so vegetation could be restored after the work was completed (PENG et al., 2007).

The Fermi National Laboratory prairie restoration project has attempted to introduce species in a sequence of "waves" roughly corresponding to the waves of succession that might be expected to take place naturally rather than planting a completely random meadow (JORDAN et al., 1988). Betz (1986) has advocated this "wave" approach and suggests that many of the less successful species in prairie plantings are "late successional" species that require the site modification provided by easy-to-grow "early successional (pioneer)" species. A study by Howell and Kline (1993) showed that competition during the first year and weed competition any year were the most important factors in reducing germination and establishment success. It was suggested that "difficult-to-establish" species might be planted together as they would not be too competitive with each other but might provide some site amelioration and possibly some weed discouragement (HOWELL and KLINE, 1993). Since soil stabilization is critical on the roadside, Henderson recommends including several species that establish readily.

All seed mixes should be site specific. A plant with a local provenance will be genetically better suited to local growing conditions than one that is indigenous to another part of the country with very different growing conditions⁽⁸⁾. Provenance affects winter hardiness, drought tolerance and heat tolerance (BARTELS, 1992).

Specialized drills, broadcasters, and hydroseeders can be used with native seed (HARPER-LORE, 1999). Since native forb and grass seed has a variety of shapes, sizes and covers (fuzzy or slick), most practitioners have found that planting is more successful with seed drill equipment with multiple seed boxes (ENGLERT, 1998; POLLARD, 1999; USDA/NRCS, 2005) (Figure 2).

Different mechanisms of dispersal are used for each type of seed (i.e. picker wheel for fluffy seed). A seed drill places the seed at the proper depth, provides an even seeding rate across the site, increases germination and allows for seeding on a windy day. It does require clean seed and will not seed as efficiently when the box is less than one quarter full (PACKARD and MUTEL, 1997). Therefore, small sites and small quantities of seed, do not work well in a drill. In Delaware, the method of establishing roadside meadows using sawdust as a carrier for grass and forb seed has proven to be successful. The sawdust provides a good germination medium and prevents light from reaching the soil, preventing annual weed grasses from germinating (BARTON, 2005) (Figure 3).

Raking to improve seed/soil contact after broadcasting seed significantly increased the number of seeds germinated

⁽⁷⁾ BARTON, S. University of Delaware, Newark, DE, United States. Personnel Communication, 1998

⁽⁸⁾ DREMAN, Craig. Reveg Edge, Redwood City, CA, United States. Personal communication 1999.



Figure 2. A truax drill seeded deposits meadow seed in a prepared seed bed providing good seed/soil contact.



Figure 3. Sawdust is successfully used as a medium for distributing seed on a highway median.

in a Virginia study and resulted in a greater number of plants flowering and a suitable floral display for roadside planting. In most species, simply doubling the amount of seed planted did not compensate for good seed to soil contact in plant establishment (HARKESS and LYONS, 1998).

Some experts recommend using a cover or nurse crop of an annual or short-lived native species (STROUD, 1989; PACKARD and MUTEL, 1997). Others limit their recommendation of a seedling companion to soils subject to erosion or crusting. In drier areas, however, native plant seedlings may have difficulty competing with oats and an inert carrier should be used (USDA/NRCS, 2005). When plugs are used as part of a forb and grass project, plugs

should not be planted simultaneously with seeding. Seeds dictate a different mowing regimen the first year.

Wildflower sod has been explored as a method for establishing larger colonies on inaccessible areas or other areas needing low maintenance and colorful display (AIRHART, 1980).

Prompt attention to post plant weed control is required on all sites during the establishment year. Mowing is the simplest method of assisting establishment of new grass stands (USDA/NSRS, 2005). The goal is to reduce the shade pressure that the weeds are exerting and secondarily to keep the weeds from producing seeds. A high (15-20 cm) mowing once or twice during the first season reduces competition and opens up the canopy for emerging seedlings

(PACKARD and MUTEL, 1997; HARPER-LORE, 1999; PANCIERA, 1999). Other experts suggest many mowings during the first year ⁽⁹⁾, maintaining the vegetation at 15 cm (ENGLERT, 1998). Mowing in front of or around the plots will retard the growth of encroaching brush and shrubs as well as provide motorists with a better view of the desirable plants (DUSABLON, 1988).

Regular mowing is very expensive in terms of personnel hours, equipment hours and fuel consumption. Except for the immediate shoulder and where dictated by safety considerations (such as intersections, bridges, sharp curves, and farm and field entrances), mowing roadsides is an unnecessary management practice. Improper mowing can increase some weeds' ability to compete and degrade the plant community making the roadside more susceptible to weeds and erosion. With integrated vegetation management, greater emphasis is placed on checking whether certain maintenance practices are giving the desired results (WILLARD, 1999). When this type of management replaces mowing, a different level of technical skill is required for roadside managers. They must be

able to identify desirable and undesirable plant species, understand their life cycles, and understand ecological processes. Contractors require detailed mapping to guide operators (SCHUTT, 1999).

It is possible to change the management of roadsides and other rights-of-way to gradually foster rather than eliminate native communities, simply by altering mowing methods and investing a portion of the maintenance budget in strategic invasive plant control. There is ample evidence to demonstrate the economic feasibility of altering mowing practices but it requires a change of attitude for agencies and institutions (SAUER, 1998). Maintenance staff who are trained to mow turf must be retrained to develop the skills required to manage unmowed rights-of-way (such as species identification and herbicide application). Sustaining native roadside vegetation requires a philosophical switch from maintenance, where endless repetition is necessary, to management, which diminishes or shifts focus as the restored landscape evolves (SAUER, 1998) (Figure 4).



Figure 4. Native shrubs are used to stabilize this forest edge reducing the chance of invasive exotic plant species from proliferating on the roadside.

4. PUBLIC PERCEPTION AND EDUCATION

This paper presumes that roadside vegetation matters to people. In fact, roadside vegetation influences route choices, reduces traffic-related stress and provides cues about a city or state. Studies have established that the character and quality of roadside landscape influences drivers' route choices. In a survey of motorists, Michigan shoppers chose a slow, wooded parkway over a fast, unattractive expressway for over half their shopping trips. Natural vegetation was the reason for route selection provided by

most survey respondents (ULRICH, 1986). Aesthetically pleasing roads can focus road use and travel patterns. Quality roadside planting could be a strategic tool for planning road use levels. In Washington State, two surveys found respondents judged images with increasing amounts of vegetation to have higher amenity values. The more extensive greening led to positive customer preferences and a greater willingness-to-pay for goods and services (WOLF, 2006). Roadsides can generate a sense of place (LAWTON, 1998). In Massachusetts, roadside vegetation is managed to provide control of surface erosion, naturalize

⁽⁹⁾ GORMEL, M. Brandywine Conservancy, Chadds Ford, PA, United States. Personal communication. 1998

the highway into its surroundings and enhance highway aesthetics to provide relief from the monotony associated with a long trip (FALLS et al., 1970).

In China to improve the driver's visual field, the dense belts of trees beside the road, traditionally considered desirable in road construction, have been replaced by local shrubs, flowers, and grasses that interfere less with vision while still providing an attractive view. As a result, authorities have reported that the number of traffic accidents and deaths due to these accidents has decreased steadily despite a rapid increase in the number of vehicles on the roads since the new road construction began (CHINESE Traffic Accidents Net, 2010; TA NEWS, 2010).

To conserve China's natural and cultural heritage and promote ecotourism, road designs now specifically protect the visual landscape. This is an important consideration, because natural landscapes are an important part of China's cultural heritage. Spectacular views of nature reserves are created, protected, or restored, and roads are constructed both to reveal the landscape and improve the driving experience, thereby improving the tourism value of the roads. These goals are complemented by cultural conservation and tourism development (XU et al., 2011). Management of greenways and the surrounding landscapes must combine reductions in resource consumption and the promotion of environmental conservation with economic goals (XU et al., 2011).

Studies showed road users in northern England preferred grass swards with flowering native herbs or occasionally mown grass swards with colorful flowering herbs for re-vegetation along roadsides (AKBAR et al., 2003). Similarly, color slides that depicted aspects of flowering meadows rich in biological diversity received high preference ratings by the participants of a study on visual preferences for agrarian landscapes in western Norway (STRUMSE, 1996). Recently, in situ surveys in Switzerland have shown that species- and flower-rich field margins improved the aesthetic value of landscapes (JUNGE et al., 2009). Another study evaluating species richness found that people prefer scenes with greater diversity of species in both experimental grassland arrays and in natural meadows. Plant diversity in itself is attractive to humans. Intensive management, such as mowing, that reduces species diversity not only has negative environmental consequences but reduces attractiveness, which could be economically important in regions dependent on tourism (LINDEMANN-MATTHIAS et al., 2010).

A study was conducted in Quebec, Canada, by comparing areas managed under either intensive or ecological management. They found that blooming plant colonies and proximity to natural settings were noticed and appreciated by the majority of drivers. Ecological management of roadsides has a role to play in aesthetic appreciation of the roadside and in preservation of natural environments, as long as roadside management is linked to the surrounding landscape (FROMENT and DOMON, 2006).

Respondents to a series of surveys conducted in Delaware, U.S. indicated that color was a desirable component of roadside vegetation. But, color could be provided by colorful displays of trees and shrubs in addition to the traditional display of perennial flowers (BARTON, 2005). Mowed turf, the default vegetation on roadside in Delaware was viewed as desirable, but an un-mowed roadside scene with a mowed edge was rated equally as attractive. By simply mowing the edge and allowing the rest of the right of way to grow into a meadow, departments of transportation can save money, please the public and provide greater environmental benefits (BARTON, 2005; SAUER, 1998). Delawareans expressed a desire for Delaware roadsides to maintain a sense of place by using vegetation that matches the native flora of the region. Roadsides should be managed and a sense of order maintained (BARTON, 2005).

Most departments of transportation have close ties to the public and political community and have catered to the wishes of the public whenever appropriate⁽¹⁰⁾. While some native plant enthusiasts see the potential of the roadside for native plant community restoration, the principal relationship most people have with the roadside is purely visual. Roadside vegetation emphasis is therefore on the aesthetic character of the plants rather than the ecological integrity of the environment (SCHUTT, 1999a). A body of research supports the public's desire for naturalistic scenery along the roadside (KAPLAN and KAPLAN, 1989). The most preferred content categories are the ones where nature is dominant in the scenes. The most preferred spatial categories are open, yet defined, where the ground texture is smooth and trees help define the depth of the scene. Least preferred scenes were ones with large expanses of open sky that lacked distinctive foreground features and scenes with blocked views and dense vegetation (KAPLAN and KAPLAN, 1989). Humans have a need to both understand and explore their environment. A complex scene warrants exploration, but if it is too complex it will be difficult to understand. Coherence is an important predictor of scene preference. Coherent scenes provide a sense of order and direct attention. Scenes that hold the promise of more provide a pleasant challenge to the imagination. A deflected or curving sightline conveys a sense that new landscape information lies just beyond the observer's visual bounds (ULRICH, 1986). The most preferred scenes have mystery or depth and high legibility. Disliked scenes have little coherence or little complexity (KAPLAN and KAPLAN, 1989).

The fact that people spend money to experience beautiful landscapes through outdoor activity, ranging from day-trips to vacations indicates real preferences for scenic beauty (KRUTILLA, 1967). Krutilla divides this value into 1) option value – having the option to enjoy beautiful places in the future; 2) existence value – knowing that beautiful places exist; and 3) bequest value – knowing that beautiful places will be available for future generations.

⁽¹⁰⁾ BARTON, S. University of Delaware, Newark, DE, United States. Personnel Communication, 1998

Public education is a critical component of any highway vegetation program. Native plantings may take three or more years to realize their full potential (ZAK et al., 1977). Educating the public or users of the natural area is often necessary to gain acceptance (ENGLERT, 1998). People expect to see some evidence of maintenance along the roadside. Research by Anne Lucey in Delaware, U.S., showed that when people are exposed to a short video or a printed list presenting the benefits of sustainable roadside vegetation management and the problems with traditional strategies, they increased their acceptance of flowering meadows and native shrubs and trees on the roadsides by rating those images more highly. And they were less accepting of unmown or mown turf by rating those images lower (LUCEY and BARTON, 2011). This study shows the level of educational intervention required in communities to increase the acceptance of modifying traditional roadside management techniques.

Tourism is an important part of a county's economy. It is America's largest services export, one of America's largest employers and America's third largest retail sales industry (after auto dealers and food stores). If the roadside environment does not provide for a visually pleasant traveling experience, tourists will not stay and spend their money in the communities along byways (FISCHER, 1999). Tourists interested in recreational sightseeing come to see the natural character of a place (Figure 5). By managing roadsides with a focus on environmental conditions and regional sense of place, vegetation managers can provide an ordered look that is regionally appropriate (EDGEComb, 1998). In addition to tourism potential, the demand for native plants along the roadway can help the local economy as existing growers meet the increased demands for native vegetation (ORISTAGLIO, 1998).



Figure 5. Native asters and goldenrods bloom to welcome travelers to Delaware at the state line.

5. SUMMARY

Roadsides, while challenging environments, are a significant resource for the preservation and/or creative of wildlife habitat, native plant collections and species diversity. By employing context sensitive design principles, departments of transportation are able to evaluate environmental impacts, preserve and utilize natural systems and accommodate the needs of the local community. Establishment and management of roadside vegetation is a series of complex processes. Site selection of enhancements sites is often determined by specific

road projects. In some instances, enhancement sites can be selected for their existing vegetation and potential to impact motorist. Weed control is the most important aspect of site preparation and will have the greatest impact on vegetation success. There is a significant body of research on seed establishment of native perennial forbs and warm season grasses, but establishment recommendations vary depending on specific site conditions. As in site preparation, weed control is the most important aspect of roadside vegetation maintenance. During the establishment period, a higher level of weed control will be required. Roadside plantings should be designed to require minimal weed

control once establishment has occurred. Periodic mowing and spot spraying are the primary forms of weed control.

Public perception studies indicate a desire for natural, but structured or ordered roadside vegetation. Public education is an important component of any roadside enhancement program.

When changes are made in roadside vegetation management, even positive changes, it is critical to inform the community (Figure 6). Since native or naturalistic plantings sometimes take several years to grow into an attractive state, the community must be brought along with the entire process.



Figure 6. This image is used on signs at roadside enhancement plots tell the traveler that the Department of Transportation is providing innovative roadside vegetation at various sites throughout the state.

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