N E W S LETTER

Western Resource Center - Region 8

INNOVATIVE MITIGATION Newsletter

Vol. 1 No. 3
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INSIDE

Ecosystem & Watershed Approach to Natural Resource Mitigation/Compensation and Restoration

The Federal Highway Administration, Region 8 Environmental Team produced a **Natural Resources Mitigation Compensation Restoration Guidebook and Case Studies** the fall of 1997. Following the completion of the **manual**, the E-Team introduced *INNOVATIVE MITIGATION*, a quarterly newsletter designed to keep the transportation community informed of creative, successful, as well as unsuccessful, attempts to protect the environment and to mitigate highway impacts. As of October 1, 1998, the Federal Highway Administration will restructure, and what is Region 8 will become a part of the Western Resource Center under the direction of the former Region 9 in San Francisco. Consequently, this will be the last Region 8 E-Team newsletter.

Western Resource Center

Region 8 Environmental Team
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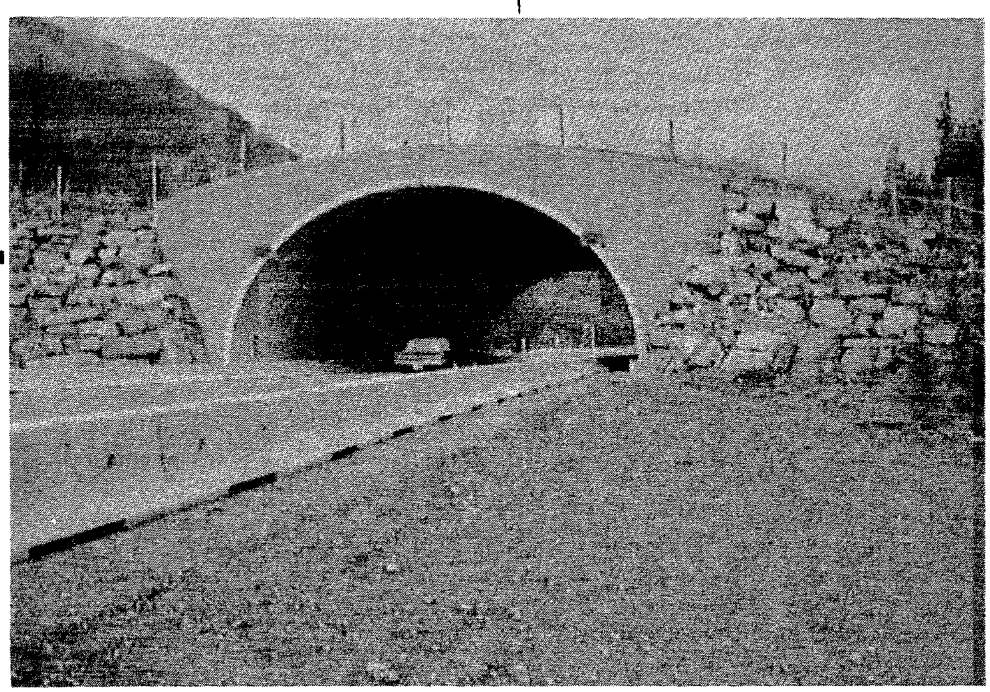
The ECOSYSTEM Approach

The Transportation Equity Act for the Twenty-first Century (TEA-21) charts a new course for state Departments of Transportation in the environmental arena, specifically allowing expenditures of federal dollars for broad scale planning for environmental protection and enhancement. Ecosystem and watershed planning for environmental protection, mitigation, and enhancement is therefore the selected topic of this last Region 8 newsletter. We are grateful to Parks Canada, the Fish and Wildlife Service, The Nature Conservancy, the Colorado Natural Heritage Program, and the Departments of Transportation in Minnesota, Oregon, Florida and Washington for contributing articles on their research for this issue.

Highways and Wildlife - Conflict Mitigation in Banff National Park, *By Bruce Leeson*

Parks Canada has undertaken an innovative and costly program to reduce the impact of roadways on wildlife in Banff National Park in Alberta, Canada. Banff, Canada's first National Park has always been renowned for its spectacular mountain scenery and diverse wildlife population. Canada's first transcontinental railway and **Trans** Canada highway (TCH) bisect the park through the Bow River Valley, a distance of about 75 km. This rich **montane** environment is home to large numbers of a wide variety of Rocky Mountain wildlife. Elk, mule and whitetailed deer, moose, bighorn sheep, wolves, coyotes, black and grizzly bears, cougars, Canada lynx, wolverines and a wide array of **smaller** mammals and birds which occupy the valley were recorded in



roadkill accidents, some almost daily. With increasing speeds and volumes of traffic on the TCH, wildlife collisions escalated. Planners and managers tasked with upgrading the highway (twinning) from two to four lanes were faced with a formidable challenge to undertake the controversial project in a way which met modern day requirements for fast and safe travel and at the same time safeguarded the ecological integrity of this World Heritage Site. Exceptional efforts were devoted to the wildlife collision problem which was predicted to seriously worsen if the roadway was upgraded as proposed.

The highway construction which began in 1979 has accomplished the twinning of 47 km of roadway in three separate phases. A wide range of environmental protection measures have been employed to preserve the heritage resources of the park. Page wire fences 2.4 m high were erected for the full length on both sides of the highway right of way to preclude wildlife entry onto the roadway. Wildlife underpasses were constructed under the highway to address the concern for habitat connectivity. By 1992 ten underpasses of varying sizes and configurations had been built in the first 27 km of twinned roadway. Research revealed the fences to be highly effective for avoidance of wildlife collisions - 97% reduction in the incidence of vehicle/elk collisions. Most species adapted readily to the underpasses to travel throughout their habitat, both on a seasonal and daily basis. For example, in the 12 month, period of November, 1996 through October, 1997, 2,458 wildlife visits were recorded at the underpasses, with a successful through passage rate of 98%. This included elk, deer, coyotes, black and grizzly bears, wolves and cougars. However, as planning for Phase IIIA proceeded, a concern arose that some wary carnivores, specifically certain individual wolves and grizzly bears, might not be adapting to the underpasses as well as ungulates and that alternative passage opportunities should be provided. Consequently, the last 18 km of twinning which was constructed between 1995 and 1998, includes two overpasses in addition to ten new underpasses.

Extensive collaboration with wildlife researchers in Europe and United States , and site research in Banff was conducted in advance of designing and constructing the Banff overpasses. The overpasses which span the full length of the right of way on two concrete arches over the driving lanes are approximately 120 m long, with a 50 top width - see photo. Berms are incorporated on top to conceal wildlife, reduce traffic noise and eliminate headlight visibility. The overpasses are landscaped to achieve continuous ground and litter cover, and 70% shrub and forest cover which is similar to and continuous with adjacent natural cover. Fencing was continued as before, but with a new feature. A 1.5 m chain link skirt attached to the bottom of the page wire is buried at a 45 degree angle to discourage grizzly bears and wolves from digging under the fence, which has occurred several times in the first 27 km. It is recognized that a grizzly bear could easily tear through the fence, but surprisingly that has occurred only a couple of times in the past ten years. The overpasses cost about $2 million Canadian each (U.S. $1.4 million), for materials and construction. The most elaborate underpasses, 4 X 7 X 60 m elliptical, multi plate steel culverts cost about $125,000 Canadian, for materials and installation. The fence materials and installation, for both sides, cost about $100,000 Canadian per km.

An intensive and multi year research program to determine the effectiveness of the most recent TCH wildlife protection measures is underway. This is a continuation of research which has proceeded since completion of the first installations in 1984. Although ungulates, coyotes and black bears discover and utilize all the crossing structures quite readily, wolves and grizzly bears seem to take a longer period of familiarization. Attractants such as scents or foods have not been used to entice wildlife to the crossing structures. Since completion of Phase IIIA in October, 1997, live grizzly bear passages have been recorded, all at underpasses, and two as recent as Labour Day, 1998. Wolves have developed a strong pattern of using one of the older underpasses at the west end of Phase II, near the beginning of Phase IIIA. Elk, deer, black bears, cougars, coyotes, pine martens, hares and voles have been recorded using the overpasses on a regular basis.

At this point, ten months after the commencement of service for the Phase IIIA wildlife protection features, the results are encouraging. Nevertheless, the overpasses are subject to high public and media interest, and some controversy. Average summer daily traffic past the locations where the overpasses are highly visible is 20,000 vehicles. Any construction activity in Banff National Park is intensely scrutinized from many view points - financial, scientific, environmental advocacy, and plain common sense. Most commentators are satisfied that a reasonable expense has been incurred to achieve the needed twining and protect Canada's flagship national park - $30 million for 18 km, with 30% of that budget for environmental protection measures. Some special interest groups criticize that the highway is a significant barrier to wildlife movement, the overpasses are too small and wrongly designed, and should have been more costly elevated roadways which carry the vehicular traffic over the landscape. Parks Canada scientists hold the view the overpasses will be successful, but it will take several years for all wildlife to develop a regular pattern of use. Parks Canada will continue the research and report findings to all interested observers.

Bruce F. Leeson, Senior Environmental Assessment Scientist, Parks Canada, Calgary, Alberta, (403) 292-4438.

NATURAL HERITAGE PROGRAMS, *By Katie Pague*

The International Network of Natural Heritage Programs and Conservation Data Centers is a credible and readily accessible source of information about rare and endangered species and significant ecosystems. The Network's 85 data centers are designed to collect, organize, and share information needed to improve conservation, land-use, and natural resource management decisions. Together these programs are among the most widely consulted sources of information about the condition and location of species and ecosystems of conservation concern.

What is the Natural Heritage Network?

Started more than 20 years ago, the Natural Heritage Network is a partnership between public agencies and The Nature Conservancy, a private, non-profit organization. The Network now encompasses all 50 U.S. states, six provinces of Canada, and 13 countries in Latin America and the Carribean. Within the U.S., these programs generally are called natural heritage programs. Most heritage programs are independent entities, operated by state or federal agencies. Natural heritage programs typically are run by state agencies with a natural resources mandate. In some states, heritage programs are a part of public universities, while in a very few states they are operated in the Conservancy.

The fundamental role of the Natural Heritage Network is to allow conservation priorities to be set based on sound scientific information, and to respond to specific information needs of conservationists, agencies, businesses, development planners, and natural resource managers. Heritage information assists biodiversity conservation in two major ways:

- Identifying those species and ecological communities at greatest risk and the places where they are found so that specific actions can be directed towards their protection; and

- Guiding land-use decisions so that development activities may anticipate and avoid sensitive areas, and minimize degradation of biological resources.

How do Heritage Programs Work?

Natural heritage data centers are staffed by scientists and information specialists knowledgeable about the species and ecosystems found in their jurisdiction. These botanists, zoologists, ecologists, geographers, and information managers piece together facts about the status, location, condition, and needs of rare and endangered species and ecological communities. Information derives from many sources, including existing 5cientitic literature, natural history collections, and expert references; satellite images and aerial photography; and most important, from firsthand observations and field surveys. By assessing the relative conservation status of each species and ecological community, the heritage programs can efficiently target their inventory and information management efforts toward those species and ecosystems in need of the greatest attention. The information gathered is entered into a computer database and mapping system where it is available for easy retrieval, review, and use.

Operating as a Network

While individual heritage programs are independently operated, each uses a common set of standards and procedures for inventory and information management. Use of these standard methods allow programs to meet their own needs and at the same time together create a complementary and comprehensive resource. By sharing information, local knowledge and conservation priorities can be viewed from national and international perspectives.

Key to the success of this effort is use across the Network of a standard computer software package, the Biological and Conservation Data (BCD) System. This award-winning computer system is the sixth generation of biodiversity information management software developed and supported by The Nature Conservancy. Because conservation and land-use decisions must consider the human as well as natural context, the BCD system allows land-use and cadastral data to be integrated with biological and ecological information.

Role of The Nature Conservancy

The Nature Conservancy provides many of the coordination functions that enable these widely distributed data centers to function together as a network. Training, technical assistance, scientific support? and research and development are among the roles that The Nature Conservancy provides for the 85 data centers and more than 800 heritage network staff. Central scientific support, central database administration, and research and development functions are based out of the Conservancy's home office in Arlington, Virginia. Seven regional heritage support offices furnish Front-line training and technical assistance to Network participants, More than 90 Conservancy staff, many of the Ph.D-level scientists, are involved in supporting the heritage network's efforts.

Uses of Heritage Information

Heritage information is relied upon by many groups and individuals for many purposes. More than 80,000 outside requests are made to heritage programs annually. The private sector (consultants, corporations, and private landowners) represents the largest single category of users, generating about 37% of these data requests. State agencies (27% of requests) and federal agencies (18%) constitute other major information users, while the conservation and research community (10%) and county and local agencies (S%) also are represented. Major types of users include:

Conservation planning:

The integration of biological and land-use information is used routinely to identify critical natural areas in need of protection, and to set conservation priorities from local, regional, national, and international perspectives.

Environmental Review/Development Planning:

Heritage information is used extensively to review the potential effect of proposed projects on rare or endangered species and fragile ecosystems. This information also routinely serves as an ecological model early warning system for developers looking to improve the environmental sensitivity of projects and to avoid lengthy and costly permitting delays.

Natural Resources and Protected Area Management

Stewardship of natural areas requires detailed knowledge of sensitive and endangered biological features. Information maintained by heritage programs on parks, reserves, state and national forests, and other specially administered areas is used to improve planning and management practices.

Research and Education:

The Natural Heritage Network works in close collaboration with the academic and research community. Results from heritage inventories often advance the state of knowledge about our natural world, and help guide new basic and applied scientific research. Heritage information about the condition of our living resources also is important for environmental education and raising public awareness of biological diversity.

For additional information on the Natural Heritage Network or on specific Natural Heritage Programs, search for "Natural Heritage" on the internet.

ECOSYSTEM RESEARCH at Washington Department of Transportation,

By Jim Schafer

The abundant and unique natural resources in Washington State leads to some special challenges for WSDOT. Biodiversity, connectivity of habitats, threatened and endangered species and protection of our salmon resource and their recovery are issues that need to be recognized in our research program if we are to have the necessary answers for project development and construction activities as well as permitting needs.

A study just completed for the Research Office by the University of Washington School of Fisheries deals with a topic critical to WSDOT these days - the issue of juvenile salmon passage through culverts. We needed to find out what was known about the extent of movement of juvenile salmon throughout the watershed during the time they are in freshwater, to find out if this is a critical issue in their life cycle, and to find out what is known about their ability to pass through culverts. It is estimated that there are 3,000 stream miles of spawning and rearing areas in Washington that are blocked by road crossings; fifty percent occur on state and local roads managed by WSDOT, cities and counties. There are thousands of culverts in smaller streams in Washington, on state and local roadway systems, that need to provide fish passage In addition, there are thousands more on forest roads. Information is needed to develop design guidelines for roughness, turbulence and velocity on new and existing installations to pass fish as well as water.

This study showed that juvenile salmon need to move up and downstream almost immediately, sometimes for great distances, to reach a better food supply, to escape summer high water temperatures, to avoid normal intermittent denaturing of small streams in the summer, and avoiding high turbidity. In the fall and winter, there is a massive redistribution, as fish move from a few meters to over 50 kilometers to find winter habitat to escape storm events.

From this project we have developed a strategic research plan that will look at fish biology, swimming ability and hydraulic design. We have coordinated with Oregon DOT and Alaska DOT as well as Canada on this work. In addition, support from FHWA will help us launch a cooperative research effort to find a solutions to issues that are very important in the region, and will have a broad application.

Habitat connectivity for wildlife, and roadway safety, is being addressed by a cooperative project with the US Forest Service - Forestry Sciences Laboratory in Wenatchee, Washington. A methodology to analyze highway barrier effects on animal populations and wildlife vehicle collisions is being developed in the eastern Cascade Mountaiu range along Interstate-90 in Washington. Fragmentation of habitats and connectivity of populations of wildlife has become a major conservation issue in the Pacific Northwest, especially for species associated with late-successional forests. Major highways may be a barrier to movement and sources of mortality that results in fragmented populations and threats to long term viability of the population, especially those slow to reproduce, or those with a large area of movement or dispersal -generally medium to large forest carnivores (marten, fisher, lynx wolves and grizzly bears). In addition, deer and elk roadkill is a safety issue on I-90 and a resource loss issue when migration and movement corridors conflict with this major highway.

I'his study is examining the relationship between highway corridors and wildlife, in terms of habitat connectivity and human safety, and-develop a general methodology For integrating transportation and large scale landscape planning. Using some modem tools such as remote sensing, GIS and on-site inventories, multi-scale analysis (landscape plus highway) analysis will lead to possible management strategies for both. An important part of this study is to determine if animal passage through and utilization of existing highway structures can meet their needs for movement, and to document and evaluate structures and locations that currently provide wildlife crossings. Outcomes should include strategies that can be taken by both DOT and adjacent landowners to reduce wildlife roadkill, information on use of various highway structures for crossings and also provide information on connectivity needs for wildlife.

The WSDOT Research Office is also sponsoring ecosystem research on behalf of Washington State Ferries. Nearshore marine issues in Puget Sound involving outmigrating salmon, salmon predators and biological productivity are being investigated by University of Washington researcher Dr. Charles Simenstad and a Battelle Marine Sciences Lab team. Critical permit issues involved with eelgrass (a common rooted seagrass) and salmon prompted an in depth look at the relationships between ferry dock structure, shading and operation and some natural resources including fish and eelgrass.

A technique for replacing eelgrass has been developed to compensate for shading effects of new or wider dock structures. A survey to identify possible underdock predators is underway, as well as a behavior study of schools of outmigrating salmon, to determine if they are affected by dock structure or operation. If impacts are discovered innovative ways to mitigate these effects will also be included in this work.

Please feel free to contact me if you have any questions about this work, or are interested in current research reports. Also, see our web site at: http://www.wsdot.wa.gov/ppsc/research

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EcoRegion-Based Conservation in The Nature Conservancy, By *Betsy Neely*

Introduction

The mission of The Nature Conservancy is to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lauds and waters they need to survive. In response to the need to plan and work at larger geographic scales to conserve biodiversity, the Conservancy has adopted an ecoregional approach and new conservation goal. Ecoregions are relatively large land areas delineated by biotic and environmental factors that regulate the structure and function of ecosystems within them. Planning at the ecoregional level will help maximize the chances of capturing all conservation targets in sufficient numbers and distribution for their long-term survival. The ecoregion units adopted for conservation planning were delineated by Robert Bailey of the U.S. Forest Service and amended by the Conservancy.

The Conservancy's new conservation goal is the long-term survival of all viable native species and community types through the design and conservation of portfolios of sites within ecoregions. A portfolio is a mite of sites that, if properly protected and managed, will collectively conserve native species and community types representative of an ecoregion. Long-term viability will be ensured by protecting multiple viable or recoverable occurrences of species and natural communities within ecoregions. This approach will enable the Conservancy and others to achieve a greater vision of success. Partners are crucial to the quality and success of ecoregion-based conservation. Ecoregional plans help to identify where the Conservancy and other agencies and organizations need to work on the ground, along with the strategies and actions needed, to conserve natural diversity.

Central Shortgrass Prairie Ecoregion

The Conservancy recently completed the first iteration of an ecoregional plan for the Central Shortgrass Prairie Ecoregion, which encompasses approximately 90,700 square miles and includes parts of seven states: Colorado, Kansas, Nebraska, New Mexico, Oklahoma, Texas and Wyoming. The ecoregion is characterized by rolling plains and tablelands dissected by streams, canyons, badlands and buttes, and is dominated by shortgrass, mixed-grass and sandsage prairie. The primary ecological processes controlling the natural systems are climate, grazing, and fire. Approximately 90 percent of the Central Shortgrass Prairie Ecoregion is privately owned; the remainder is owned and managed primarily by state and federal agencies.

Biodiversity Trends

Grasslands are considered to be one of the most imperiled ecosystem types in North America and worldwide. The majority of the Central Shortgrass Prairie Ecoregion has been cultivated, with only 40 percent remaining in large untilled landscapes. Bison and other native herbivores have been extirpated or greatly reduced throughout the ecoregion. Grassland birds, such as the mountain plover and lesser prairie chicken, have shown steeper and more widespread declines than any other group of North American species.

Conservation Goal and Targets

The conservation goal for the Central Shortgrass Prairie Ecoregion-based Conservation Plan is to identify a portfolio of sites and a set of strategies needed to protect all the species and natural communities representative of the ecoregion. The key communities and species targeted for conservation are natural plant communities, fish assemblages, globally imperiled and federally listed species, and endemic and/or declining species.

Portfolio of Conservation Sites

To conserve the natural diversity of this ecoregion, The Nature Conservancy and its partners must concentrate their efforts on 71 conservation areas, supporting at least 53 plant communities and 77 species, in the Central Shortgrass Prairie. This portfolio of sites encompasses approximately 22 percent of the total area of the ecoregion. Further inventories are needed to refine boundaries and identify the best examples of other targets not fully captured in the current portfolio.

Threats and Opportunities

For the majority of the portfolio sites, current management practices are maintaining the ecological processes needed by the targeted species and plant communities. The concern is that future practices or off-site influences will affect long-term viability of species and plant communities. The primary threats to the conservation targets across the ecoregion are altered disturbance regimes, agricultural conversion, residential development, water pollution and groundwater withdrawal. Threats to multiple sites across the ecoregion provide ideal opportunities for the Conservancy and its partners to work cooperatively with others, particularly private landowners and industry. To address these potential threats and ensure the long-term protection of the biodiversity within the ecoregion, the Conservancy and its partners must employ a mix of strategies. An Implementation Steering Committee is being established to help track and coordinate future conservation actions in the Central Shortgrass Prairie.

Colorado Rocky Mountains Ecoregion

The Conservancy is gearing up to develop a conservation plan for the Colorado Rocky Mountains Ecoregion, which covers parts of Colorado, New Mexico and

Wyoming. This effort will involve identification of conservation targets and conservation goals, an experts workshop to obtain input on the targets and goals, selection of sites, identification of threats to targets, and development of strategies to ensure the long-term viability of species and communities. The Conservancy is seeking partners to participate in this planning process. This plan will provide key information to guide land use decisions in transportation. If you are interested in learning more about this exciting effort, please contact Betsy Neely, Director of Conservation Planning, The Nature Conservancy, 1244 Pine Street, Boulder, CO, 80302, 303-444-2950 or bneely@tnc.org.

Planning for Natural Resource Protection and Mitigation in Colorado

By Lee Grunau

As anyone who has ever visited Colorado knows, this state contains a magnificent collection of majestic mountains, river-scoured canyons, and limitless prairie vistas. These landscapes provide our human populations with beautiful home sites, a perfect climate, and indispensable ecological services such as clean air and water. But they do even more. This variety of landform, geology, and vegetation provides sanctuary for many species of plants and animals which are extremely rare and potentially vulnerable to extinction.

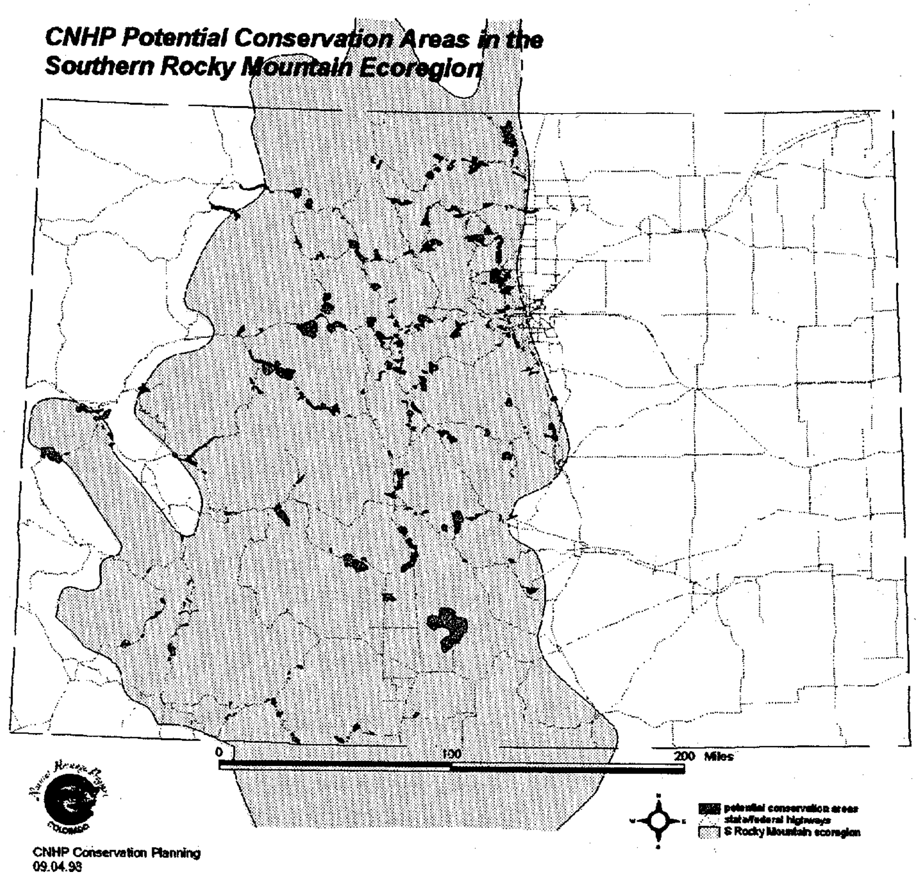
In order to protect these significant biological resources, the Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA) have joined with the Colorado Natural Heritage Program (CNHP) to proactively plan for the mitigation of impacts on sensitive species and plant communities. Using state-of-the-art GIS technology, CNHP has compiled point location data for over three hundred rare or imperiled species, sub-species, and plant communities known to occur within one half mile of roadways. Of these, *73* are known from fewer than 20 locations in the world and 19 are federally listed!

Using these data, CNHP's scientists have identified approximately 3 14 number potential conservation areas based on the biological characteristics and ecological needs of these species and plant communities. Eighty-four of these potential conservation areas are of outstanding or extremely high significance from a global perspective. Put another way, loss of these sites could contribute to the ultimate extinction of some plants and animals living there.

In the coming months, CNHP planners will be working with CDOT personnel to evaluate these significant sites for potential adverse impacts from highway activities. High quality mitigation sites will be identified for those species judged to be most vulnerable.

Information provided to CDOT as a result of this project will allow CDOT personnel to review all proposed projects using the most current and comprehensive biological data available, and to work with CNHP planners to mitigate potential impacts by protecting sensitive biological resources elsewhere.

This pilot project has focused on the mountain region of Colorado (the "Southern Rocky Mountain ecoregion"), but CDOT and FHWA plan to conduct similar evaluations on the remainder of the state in coming years. And this is just the first step. These preliminary analyses will allow CDOT and FHWA to identify urgent research needs to ensure successful mitigation. For example, while we think that the globally rare slender spiderflower (*Cleome multicaulis*) may be affected by highway work, little is known about how this plant responds to changes in hydrology, application of herbicides, and other construction or maintenance activities. This kind of research is often



expensive and time-consuming, so a prioritized approach will be crucial.

Prioritizing research and planning for **mitigation** and other protection efforts **is a specialty** of the Colorado Natural Heritage Program. All 50 states and Canadian provinces, as well as several Latin American and Caribbean countries have heritage programs (sometimes called "Conservation Data Centers") which compile and analyze biological data using standardized methodology. If you would like to partner with your state's Natural Heritage Program for mitigation research and planning, visit the intemet directory **www.heritage.tnc.org.**
For additional information contact **Johannah** Dottri at (703) 841-5321.

ECOSYSTEM RESEARCH IN FLORIDA DOT
*By **David Zeigley***

Wetlands, Newts & Highways

Wetlands are not always wet - at least not all of the time. Some wetlands contain surface water for only limited periods of time during any given year. Such temporary, or wet weather, ponds with hydroperiods of less than one year, are called 'ephemeral' ponds. In spite of their temporary nature, ephemeral ponds are critical habitat for hundreds of species of invertebrate and many species of vertebrate animals. About 250 such ponds are located in the Munson Sandhills region of the Gulf Coastal Lowlands south of Tallahassee, FL. **Many** of these ponds are located within the Apalachicola National Forest on either side of that portion of US-3 19 which connects Tallahassee and Crawfordville.

For many years, Dr. Bruce Means has been studying these ponds and the animals that inhabit them. He has determined that about 30 species of **frogs,** salamanders, turtles and snakes require these ponds to complete their life cycles. Two among these 30 are **globally** rare and have been under review by the U.S. Fish and Wildlife Service for **listing** as Threatened qecies. The two rare species are the striped ***newt (Notophthalmus pertriatus)*** and the gopher frog (***Rana capito***). We know that the life cycles of many of these animals include a migration or dispersal from the ponds to upland areas during some stages of adulthood. Similarly, they return to the ponds for breeding and early development. We also know that the presence of the highway contributes to the direct mortality of some of the migrating ephemeral pond users.

Yet there are many things about these animals we do not know. Most of the important aspects of the life cycles of these species are **unknown**. Almost nothing is known about the distances away from breeding ponds that these animals move or what they do in the uplands during the terrestrial periods of their lives. We do not know how important the hydroperiod (both duration and seasonal occurrence) is to these animals. We know nothing of the indirect mortality (ii any) inflicted upon these animals by the presence of the highway.

The long range plans of the Florida Department of Transportation **(FDOT)** call for **4-laneing** US-3 19 through the Munson Sandhills region of the Apalachicola NF. During the **environmental** impact review stage of the planning process, the possible adverse effects of the highway improvements on the ephemeral pond dwellers came to light. Would direct mortality (roadkill) increase? Would increased volumes of highway runoff be detrimental? What steps could be taken to mitigate the damaging effects of the new, wider highway?

With only a limited amount of information available about the affected animals, these questions could not be conclusively answered. The only solution would be to get busy and try to obtain as much additional information as possible prior to the **final** design and construction of the highway. And what better way to get information on these creatures thar to develop a research project with Dr. Means as the principal investigator?

Bruce is currently under contract to FDOT working on a study entitled "Reducing Impacts on Rare Vertebrates That Require Small Isolated Water Bodies Along US Highway 3 19". He is going to try to **obtain** as much information as possible about life cycle aspects, dispersal distances, effectiveness of road underpasses (culverts) and hydroperiod requirements. At the conclusion of his study (mid **1999**), in addition to learning more about the ephemeral pond dwellers of the Munson Sand Hills, he will hopefully be able to tell FDOT what they can do to soften the impact of the highway on these rare creatures.

Fragmentation Effects of High-Speed Highways on Grizzly Bear Populations Shared Between the United States and Canada,
By Christopher Servene

Abstract: Grizzly bear (Ursus arctos horribilis) populations in the conterminous United States are grouped into 6 recovery areas, live of which presently have bears. Four of these **five** areas are contiguous with Canada. High-speed highways bisect many of these ecosystems including the Northern Continental Divide, **Cabinet-**Yaak, Selkirk, and North Cascades. These highways are habitat fragmentation factors. Highway impacts include vehicle collisions and avoidance of vehicle noise by bears, inhibition of movement by loss of vegetation and changes along highways, fencing and other barriers along or between highway lanes, and the human developments that occur along highways. These highways have the potential to fracture grizzly bear populations across the United States - Canada border by inhibiting movements, increasing mortality, and inhibiting genetic and demographic exchange. Maintaining opportunities for demographic and genetic linkage between United States and Canadian' grizzly bear populations enhances survival and recovery potential for grizzly bears. I propose a three phase approach to deal

with this issue including:

1) development of information on how grizzly bears relate to and cross highways and development of a conceptual model to identify sites where highway crossings by grizzly bears would be most likely;

2) development of crossing structures and highway design modifications at such specific sites; and

3) monitoring effects of highways on populations of bears and use of mitigation measures by bears in a long-term effort to assure population connectivity.

Figure 3. **The grizzly bear recovery areas in the U.S. and southern British Columbia and Alberta, Canada.**

Introduction

Grizzly bear populations are currently divided into five separate populations south of Canada (Fig. 1). High-speed paved highways occur within and between habitat of each of these populations. Current distribution of grizzly **bears** is less than 2% of the former range of the species south of Canada. Historical reductions in range and numbers of grizzly bears were due to human factors including direct hilling, habitat loss, and conflicts with human activities. Habitat and population fragmentation resulted. Fragmentation of once contiguous populations increases risks to the survival of these populations. As **high-**speed highways are "improved," traffic volumes and vehicle speeds increase, fencing along highways increases in height and effectiveness, vegetation is cleared along roadsides, topographic challenges increase as cut slopes aud other structural factors accelerate along roadsides, concrete dividers are often placed between lanes, and lane numbers increase. All these factors decrease crossing possibilities for wildlife and increase habitat fragmentation impacts of highways.

Current grizzly populations in the United States south of Canada exist in five areas, four of which are contiguous with grizzly populations in Canada (Figure 1). Maintenance and survival of these United States populations is dependent upon connectivity with Canadian populations. High-speed highways running east-west bisect four Canadian populations and three of four United States populations forming potential fracture zones to contiguous populations of grizzly bears and other large carnivores. Points of fracture in all populations occur along these highway corridors both in Canada and the United States. Efforts to maintain contiguous grizzly bear populations in these areas must focus on highway corridors.

Effects of high-speed highways on numerous species of wildlife are well documented (Bashore and Tzilkowski 1985, Woodward 1990, Dwyer and Tanner 1992, Belden and Hagedom 1993, Gleason and Jenks 1993, Knight and Kawashima 1993, Reijnen and Foppen 1994, Romin and Bissonette 1996a,b). However effects of highways on grizzly bears are largely unknown, Previous research on grizzly bear/road interactions have been confined to tertiary or unimproved road systems (Archibald et al. 1987, Mattson et al. 1987, McLellan and Shackleton 1988, Kasworm and Manley. 1990, Mace et al. 1996). High-speed highways can cause direct grizzly bear mortality through impact with vehicles or indirect mortality through displacement and reduced reproductive potential (Mace et al. 1996). Limitation of highway crossing opportunities for grizzly bears within and between small, isolated populations can have profound demographic and genetic effects (Ralls et al. 1986, Servheen and Sandstrom 1993, Mills and Smouse 1994). Current information is insufficient to specifically describe potential effects of high-speed highways to disrupt or prevent movements within or between occupied grizzly bear habitat.

UNDERSTANDING AND MITIGATING THE EFFECTS OF HIGHWAYS

Potentially harmful effects of highways may be mitigated by modifications to highway design and placement. However, recommendations for mitigation must be based upon detailed information on specific effects of highways on grizzly bears. Obtaining such specific data requires precise diurnal and nocturnal monitoring of grizzly bears that live near highways, monitoring traffic levels, and detailed information on associated vegetation and topography. Grizzly bears occur at low densities, range widely, and generally occupy steep, mountainous terrain. Previously, technology to collect precise movement data on an animal with these characteristics did not exist. Recent development of the Global Positioning System (GPS) by the military and its subsequent availability in a wildlife collar system now presents the opportunity to collect such data (Biggs et al. 1997). Frequent and accurate positions of instrumented grizzly bears can be obtained day and night and in any weather. Accurate GPS locations (+\- 50m differentially corrected) combined with computer geographic information system (GIS) technology now allows detailed analyses of the effects of highways on grizzly bears.

Mitigation of the impacts of high-speed highways on grizzly bears requires information on spatial and temporal distribution of areas used by bears along high-speed highways and for crossing such highways. If specific use areas and crossing areas can be identified by topographic, vegetational, and temporal characteristics, then highway designers can use such information to place crossing structures in areas of highest use, provided structures can be developed. Such information can also be used to minimize landscape and vegetation modifications which might inhibit use near highways and the ability of animals to cross highways. The following information would increase the possibilities of mitigating effects of high-speed highways:

- document frequency and timing of highway crossings by grizzly bears and spatial, temporal, vegetative, and topographic features associated with highway crossing sites;
- determine relationships between frequency and timing of highway crossings and highway traffic volume;
- examine the spatial distribution of documented crossings and identify crossing areas, if they exist, as discrete features;
- if crossing areas exist, determine relationships between crossing areas and natural characteristics of the site including topography and vegetation;
- if crossing areas exist, determine relationships between crossing areas and anthropogenic highway corridor features including human developments, roads, railroads, and bear attractant sources such as human foods;

A PLAN OF ACTION

I propose a three phase action plan to address impacts of high-speed highways on grizzly bear populations and habitat across the United States/Canada border in the states of Montana, Idaho, and Washington. This plan of action involves three phases:

1) identify characteristics of grizzly bear habitat use in association with highways and highway crossing sites used by grizzly bears and develop a conceptual model based on these data to predict where crossing is most likely;

2) identify mitigation measures for design of structures or highway designs that will facilitate crossings; and;

3) monitor highway impacts on an ongoing basis to provide feedback and assessment of these impacts.

This plan of action is suggested to meet habitat and population effects of these highways on grizzly bears. Without a plan of action, I believe that the future of the remaining grizzly populations will be threatened by the effects of these highways. When combined with impacts of other human activities such as private land development, excessive mortality, and disturbance, high-speed highways can have a serious impact on bear survival.

Identify Characteristics of Highway Crossing Sites Used by Grizzly Bears

The first phase of this action plan proposes identification of the characteristics of highway crossings by grizzly bears. This phase would require description of spatial, temporal characteristics of crossings, as well as understanding the vegetative and topographic features of crossing areas. It is not known whether bears prefer particular characteristics for crossing sites along highways, or whether crossing is more random. It seems logical that there is a relationship between vehicle volume, vegetative cover, highway width, and crossing frequency by bears and other wildlife. The location of mitigation measures such as crossing structures or vegetative and topographic features which might require special management to accommodate crossing may be identified through this first phase.

Emphasis Areas

Locations have been identified as emphasis areas for data collection and application of the program:

1. U.S. Highway 2 between East Glacier and West Glacier, Montana

This is a major travel corridor and the only high-speed highway bisecting the Northern Continental Divide Ecosystem. It is a 2-lane highway separating Glacier National Park to the north, and the Bob Marshall Wilderness complex to the south. Associated roadway topography varies from flat, valley bottom to steep mountainside. The highway crosses the Continental Divide at Marias Pass (elevation 5282 ft.). Vegetation is primarily coniferous forest in western portions of the study area, with open grass/forb/aspen communities in eastern portions. Avalanche chutes, preferred grizzly bear foraging areas (Waller and Mace 1997), occur in numerous locations. often close to the highway. The highway lies in the valley bottom, following the Middle Fork of the Flathead River in the western portion of the study area. A railroad parallels the highway for it's entire length. This railroad line is a major freight corridor between Chicago, IL and Seattle, WA. It is also the primary means of transporting grains from eastern Montana and North Dakota to west coast markets.

Trains have been a significant source of grizzly bear mortality. Grizzly bears have been attracted to the tracks by the presence of spilled grain. Small concentrations of seasonal homesites, businesses, ranches, and small communities exist within the highway corridor, but the majority of the area is undeveloped. Significant numbers of bears are presumed to cross the highway as it lies within a high density grizzly bear area (T. Manley, pers. comm.).

2. U.S. 89, 49, and 17 between East Glacier, Montana and the Canadian border.

These are high-speed highways on the Blackfeet Indian Reservation near the east boundary of Glacier National Park along the Rocky Mountain east front. Associated roadside topography is flat to steep hillsides. Vegetation is primarily grass/forb/aspen communities with patches of coniferous forest. This highway has lower traffic volumes and fewer homes and businesses than the Highway 2 study area, and lacks an associated railroad corridor. Private ranches and tribal lands border the highway. Seasonal grizzly bear crossings of these highways have been documented by an existing grizzly bear study conducted by the Blackfeet Nation. The Blackfeet are cooperators in this project.

3. The Trans Canada Higbway through Banff National Park in Alberta and associated areas on the Trans Canada in British Columbia.

This is the main east-west highway across Cauada. Traffic volumes may exceed 20,000 vehicles per day during peak travel periods. Recent improvements in this highway have created a four lane highway and have included wildlife-proof fencing along both sides of the highway. Efforts to develop crossing structures began with the construction of wildlife underpasses, and eventually included wildlife crossing overpasses.

As the study progresses other locations may be selected based on the presence of bears and specific highway characteristics.

Data Collection Methods

Error testing - GPS collars are a new technology. Testing of their functionality has been limited (Rempel et al. 1995, Moen et al. 1996, Bennet et al. 1997, Rumble and Lindzey 1997). To successfully obtain a position fix, the collar must be in line-of-sight of at least 3 satellites in the GPS constellation. Satellites must be spaced widely enough to meet Dilution of Precision criteria programmed within the collar. Satellites closely spaced result in poor locational accuracy. In areas of rugged topography, successful fixes may not be obtained or limited satellite visibility may result in more 2D fixes (no elevation) relative to 3D fixes. Locational accuracy may decline as the proportion of 2D fixes increases as it is less accurate than 3D fixes. Further, dense stands of timber may interfere with GPS signals, thus precluding fix attainment. Currently, the extent of collar testing has been inadequate to determine the effects of terrain and vegetation on GPS positions. Moen et al. (1996) found no effect on accuracy due to canopy cover or stem density, but observation rate declined with increasing canopy cover. Bennett et al. (1997) found no statistical differences in location error and observation rate due to terrain, canopy cover, or vegetation type. Rumble and Lindzey (1997) found a 50% failure rate in stands where canopy cover was greater than 70%. They suggest a negative linear relationship between tree density and observation rate, but observed no effect due to topography. These 3 studies were conducted in areas of relatively low topographic relief.

Prior to capture and collar deployment, a survey of potential study areas was conducted to evaluate satellite visibility and probability of success. This investigation was the first study involving the use of GPS radio-collars on grizzly bears in mountainous terrain. Initial testing of GPS collars on Grizzly bears in Yellowstone Ecosystem in Montana, Wyoming, and Idaho showed that fixes can be obtained. Preliminary collar tests in the Middle Fork Flathead River area in Montana have also obtained successful fixes.

Capture

Standard trapping techniques (Johnson and Pelton 1980, Jonkel1993) are used to capture grizzly bears within study areas. Trapsites were placed systematically throughout the study area to obtain a representative sample of resident bears. Only adult bears were instrumented due to the weight of GPS collars (about 5 lbs.). Captures occurred during spring. Five to seven collars were deployed in each study area. Females are the preferred experimental unit, although 1 to 2 males were also collared. Females may be less likely to cross highways, but are more likely to remain in the vicinity of the highway corridor. Males, having much larger home ranges, are more likely to roam far from the highway corridor (Mace and Waller 1997). However, males are vital for the exchange of genetic information between metapopulations (Craighead 1994). Grizzly bears with prior history of habituation or food-conditioning were not collared or included as study animals. Bears with a history of human habituation may be more likely to cross highways, thus confounding research results. However, captured bears may become management bears due to attractants in the corridor. Further, bears captured in the corridor may have an unknown history of habituation, or be offspring of bears with a history of habituation. Instrumented bears demonstrating habituation or food-conditioning will be identified and accounted for in subsequent analyses.

GPS collars • Successful documentation of highway crossings require a frequent sampling interval. We proposed obtaining 1 position fix every 15 to 30 minutes. Such sampling intervals shorten collar battery life to 20 days. However, by using a collar with an FM link, we can remotely alter the sampling interval to maximize locations during periods of expected crossings, and minimize sampling during periods when crossings are unlikely, thus conserving battery power. Expected battery life will range from 20 days (continuously within highway corridor) to more than 1 year (never within highway corridor). Field personnel monitor presence of collared bears within the corridor to determine when GPS sampling intervals should be intensified. All collars are affixed with a cotton spacer to ensure collar retrieval (Hellgren et al. 1988). Recapture efforts are continuing, in order to maintain a sample of marked individuals.

Traffic Monitoring

Vehicle counters are located within each study area to document traffic volumes and temporal distribution of traffic volume. Counters are located at 6 to 8 sites depending upon the study area.

Data Layers

Detailed digital maps of roads, trails, vegetation types, physiography, topography, and human development were obtained from the Wildlife Spatial Analysis Lab at the University of Montana. Additional data layers will be developed as needed.

Data Analysis

Home ranges will be determined from recorded locations of each collared grizzly bear. We will use multivariate statistical techniques to explore relationships between crossing sites and highway, topographic, physiogmphic, and disturbance variables. Specific methods used will depend upon the nature of collected data, but may include sampling of random vs. used highway segments to identify unique features; polytomous logistic regression (Manley et al. 1993) to relate features to intensity of use; or compositional analysis (Aebischer and Robinson 1992, Aebischer et al. 1994) to identify preferred features along movement vectors.

Vegetative, topographic, spatial, and temporal features associated with grizzly bears crossing highways, and the results of monitoring grizzly bears use of highway crossing structures on the Trans Canada Highway, will be the basis of a conceptual model to identify combinations of factors that could be used by highway designers. The information generated will allow highway designers to position crossing structures and special highway design features based on characteristics of the site, and on knowledge of grizzly bear highway interactions. Landscape level identification of linkage areas can be accomplished with the existing Linkage Zone Prediction Model (LZP) (Servheen and Sandstrom 1993, Sandstrom and Servheen in review, Apps 1997). Site-specific identification of potential crossing areas is the goal of the predictive model (Figure 2).

Mitigation Measures Identification Methods

Using results from the crossing structure monitoring in Banff along the Trans Canada Highway, and bear behavior and movement data along highways, we will develop a list of crossing structure types and highway design modifications to facilitate crossing . The structures and modifications will be keyed to vegetative characteristics, and other characteristics of each specific site predicted as having a high crossing probability .

Monitoring Impacts on an Ongoing Basis

Impacts of highways on grizzly bears should be monitored on a long-term basis. Radio-collaring of bears along highways, especially in areas where special structures or highway design features have been established is the only means of evaluating effectiveness. This type of ongoing monitoring could reveal gradual changes in population characteristics that may occur as a result of highway impacts. Monitoring could determine the value and acceptance of crossing structures by quantifying their use by bears and other wildlife. It may also be possible to monitor genetics across potential fragmentation features like highways.

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Literature Cited

Aebischer, N.J. and P.A. Robertson. 1992. Practical aspects of compositional analysis as applied to pheasant habitat utilization. Pp. 285-293 in Wildlife Telemetry: Remote Monitoring and Tracking of Animals. LJ. Priede and SM. Swift, eds. Ellis Horwood, London.

Aebischer, N.J., P. A. Robertson, and R.E. Kenwood. 1994. Compositional analysis of habitat use of animal radio-tracking data Ecol. 74: 1313-1325.

Apps, C. 1997. Identification of grizzly bear linkage zones along the Highway 3 corridor of southeast British Columbia and southwest Alberta. British Columbia Ministry of Environment, Lands, and parks and WWF Canada. Victoria, B.C. 45 pp.

Archibald, W.R., R. Ellis, and A.N. Hamilton. 1987. Responses of grizzly bears to logging truck traffic in the Kimsquit River Valley, British Columbia Jnt. Conf. Bear Res. and Manage. 7:251-257.

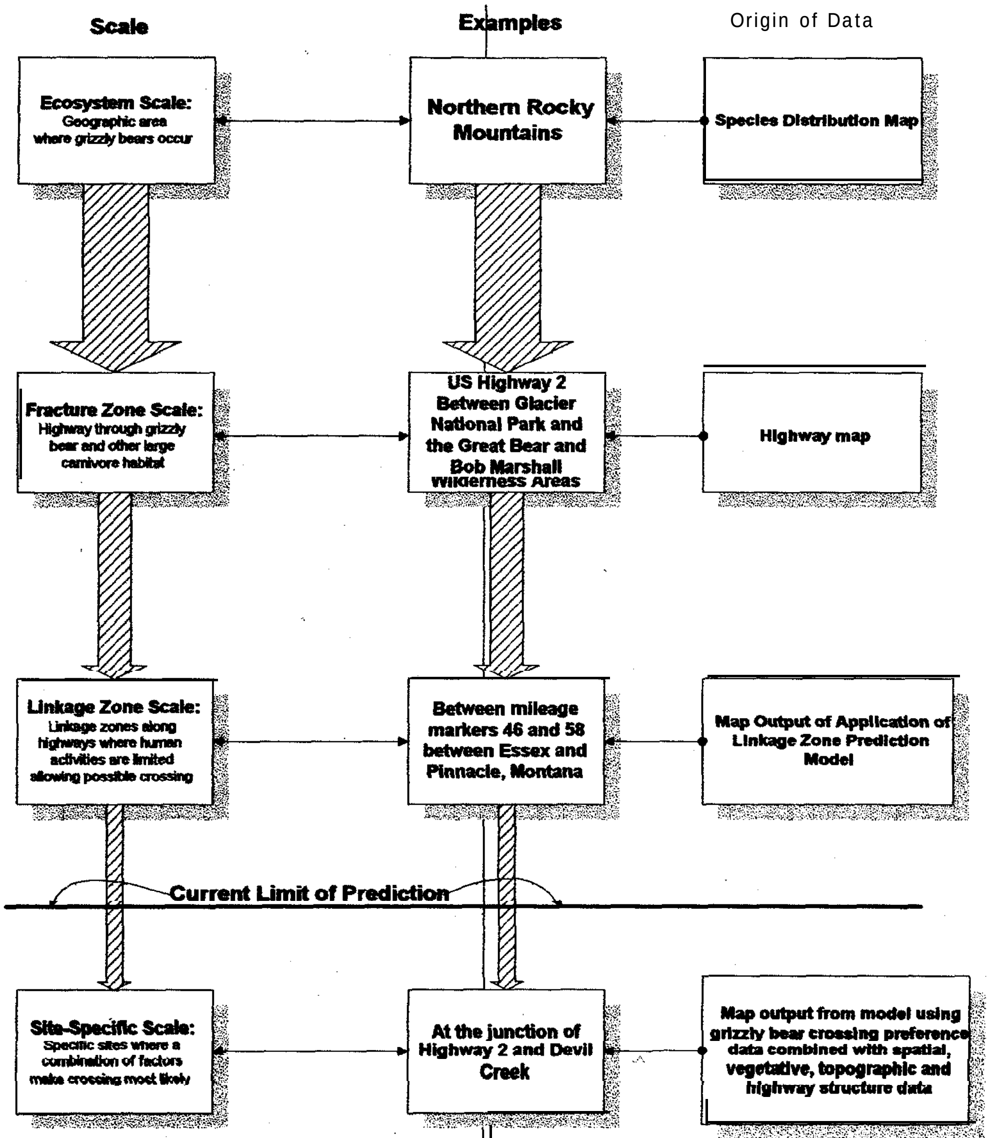
Baahore, T.L., W.M. Tzilkowski, and E.D. Bellis. 1985. Analysis of deer-vehicle collision sites in Pennsylvania (USA). J. Wildl. Manage. 49:770-428.

Belden, R.C., and B.W. Hagedom. 1993. Feasibility of translocating panthers into northern Florida J. Wildl. Manage. 57:388-397.

Bennett, K., J. Biggs, and P.R. Fresquez. 1997. Determination of locational error associated with Global Positioning System radio collars in relation to vegetation and topography in north-central New Mexico. Los Alamos National Laboratory report no. LA-13252-MS, 14 pp.

Biggs, J., K. Bennet, and P.R. Fresquez. 1997. Evaluation of habitat use by Rocky Mountain elk in north-central New Mexico using Global Positioning System collars. Los Alamos National Laboratory report no. LA-13279-MS, 18 pp.

Craighead, F.L. 1994. Conservation genetics of grizzly bears. PhD. Dissertation. Montana State



University, Bozeman. 227 pp.

Dwyer, N.C. and G. W. Tanner. 1992. Nesting success in Florida sandhill cranes. Wilson Bull. 104:22-31.

Gleason, J.S. and J.A. Jenks. 1993. Factors influencing doer/vehicle mortality in east-central South Dakota. Prairie Nat. 25:281-287.

Hellgren, E.C., D. W. Carney, and N.P. Garner. 1988. Use of break-away cotton spacers on radio collars. Wildl. Soc. Bull. 16:216-218.

Johnson, K.G. and M.R. Pelton. 1980. Prebaiting and snaring techniques for black beam. Wild1 .Soc. Bull. 8:46-54.

Jonkel, J.J. 1993. A manual for handling beam for managers and researchers. U.S.D.I. Fish and Wildlife Service, Office of Grizzly Bear Recovery Coordinator, University of Montana, Missoula, 59812. 177 pp.

Kasworm, W.F. and T.L. Manley. 1990. Road and trail influences on grizzly beam and black bears in northwest Montana. Int. Conf. Bear Res. and Manage. 8:79-84.

Knight, RL. and J.Y. Kawashima. 1993. Responses of raven and red-tailed hawk populations to linear right-of-ways. J. Wildl. Manage. 57:266-271.

Mace, R.D, J.S. Waller, T.L. Manley, L.J. Lyon, and H. Zuuring. 1996. Relationships among grizzly bears, roads and habitat in the Swan Mountains, Montana. J. Appl. F&01.33:1395-1404.

Mace, R.D. and J.S. Waller. 1997. Spatial and temporal interaction of male and female grizzly bears in northwestern Montana. J. Wildl. Manage. 61:39-52.

Manley, B. F., L. L. McDonald, and D.L. Thomas. 1993. Resource Selection by Animals: Statistical Design and Analysis for Field Studies. Chapman and Hall, London. 177 pp.

Manley, T. personal communication. Montana Fish, Wildlife and Parks, Grizzly Bear Management Specialist.

Mattson, D. J., R.R. Knight and B.M. Blanchard. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. Int. Conf. Bear Res. and Manage. 7:259-273.

McLellan, B.N. and D.M. Shackleton. 1988. Grizzly pears and resource-extraction industries: effects of roads on behaviour, habitat use and demography. J. Appl. Ecol. 25:45 l-460.

Mills, L.S, and P.E. Smouse. 1994. Demographic consequences of inbreeding in remnant populations. Am. Nat. 144:412-431.

Moen, R, J. Pastor, and C.C. Schwartz. 1996. Effects of moose movement and habitat use on GPS collar performance. J. Wildl. Manage. 60:659-668.

Ralls, K., Harvey, P.H., and A.M., Lyles. 1986. Inbreeding in natural populations of birds and mammals. Pages 35-56 in M.E. Soule' (Ed.). Conservation Biology: The science of scarcity and diversity. Sinauer Associates, Inc. publishers, Sunderland, MA.

Reijnen, R. and R. Foppen. 1994. The effects of car traffic on breeding bird populations in woodlands. J. Appl. Ecol. 3 1:85-94.

Rempel, R.S., A.R. Rodgers, and K.F. Abraham. 1995. Performance of a GPS animal location system under boreal forest canopy. J. Wildl. Manage. 59:543-551.

Romin, L.A. and J.A. Bissonette. 1996a. Deer-vehicle collisions: status of state monitoring activities and mitigation efforts. Wildl. Soc. Bull. 24:276-283.

Romin, L.A. and J.A. Bissonette. 1996b. Temporal and spatial distribution of highway mortality of mule deer on newly constructed roads at Jordanelle Resevoir, Utah. Great Basin Nat. 56:1-1 1.

Rumble, M.A., and F. Lindzey. 1997. Effects of forest vegetation and topography on Global Positioning System collars for elk. ALSM/ASPRS Annual Convention and Exposition. pp. 492-501.

Sandstrom, P. and C. Servheen. in review. Identification of potential linkage areas for grizzly bears in the northern Rocky Mountains. Manuscript in review Wildl. Soc. Bull.

Servheen, C., and P. Sandstrom. 1993. Ecosystem management and linkage zones for grizzly bears and other large carnivores in the northern Rocky Mountains in Montana and Idaho. End. Sp. Bul. Vol XVIII. No. 3.

Waller, J.S., and R.D. Mace. 1997. Grizzly bear habitat selection in the Swan Mountains, Montana. J. Wildl. Manage. In press,

Woodward, S.M. 1990. Population density and home range characteristics of woodchucks at expressway interchanges. Can. Field-Nat. 104:421-428.

Figure 2. Scales of resolution for the relationship between grizzly bears and high-speed highways. The current level of resolution is the linkage zone level. The objective of the proposed plan for action would extend the scale to the site-specific level.

OREGON DOT Research Projects, *By Brett L. Sposito*

Evaluation of Infrared Treatments for Managing Shoulder Vegetation

Environmental concerns have prompted many agencies to seek alternatives to herbicides in controlling vegetation on roadway shoulders. This study was implemented to evaluate the potential for infrared technology to address this need. Infrared technology uses radiant energy to kill unwanted vegetation. Intense heat generated with liquid propane coagulates plant proteins and burst cell walls, killing seedling plants and destroying the tops of established vegetation, Repeated treatments, at regular intervals, deplete the root reserves of established plants and leads to their decline and death.

Infrared treatments were applied at three frequencies (8, 6 and 4 treatments per year). Applications were initiated in southeast Oregon, along a state highway in late fall and then continued from spring through early summer. These treatments were compared to shoulders where herbicides were applied and to shoulders where vegetation was left unmanaged (controlled sites).

Additional study is needed to determine the impact of using infrared treatments on a wide range of vegetation types and to examine how infrared technology can best be utilized within an integrated vegetation management program.

The research project is scheduled for completion by July 2000. For more information, contact Rob Edgar, (503) 986-2846

Guardrail Installation Noise Level Evaluation

Spotted owls, marbled murrelets, bald eagles, peregrine falcons and other wildlife species are sensitive to noise disturbances. When threatened or endangered species such as these are present, construction must be restricted to times when the species are least likely to be disturbed or mitigation measures must be implemented to reduce noise disturbances. Noise levels that are 10 decibels or more above background levels at a nest site or sensitive feeding area are prohibited during certain periods of the year. Presently, there is no current information on guardrail installation noise levels with which to calculate what noise levels would attenuate to at a sensitive site.

The ODOT environmental office evaluates the impacts and mitigation of noise issues. ODOT currently requires noise level evaluation of proposed construction projects when threatened or endangered wildlife may be adversely affected. With no better information to go by, ODOT biologists have generalized that noise levels of a guardrail post punch are similar to or slightly quieter than a pile-driving hammer.
For example, there is a seasonal restriction on construction on the Willamette Highway from milepost 64-70. Eagles are a protected species in this region. Without adequate noise information to calculate with, ODOT biologists must assume worst case in evaluating potential noise impacts, and this usually results in a very restrictive construction timeline for guardrail installation.

Noise levels from other construction activities, such as grading, grinding and paving, have been previously studied. These noise levels have typically not changed over the years and do not warrant further study. Another change has occurred over the last few years that reduces the noise level of a guardrail post punch. Lower cost, steel "I-beam" posts are now the preferred material chosen by contractors, over the formerly popular wooden posts. These steel posts have a smaller cross sectional area, require less force, and seem to produce less noise. This assumption should be ascertained by a noise study.

The research project is scheduled for completion by April 1999. For more information, contact Brett Sposito, (503) 986-2847

Performance of Solvent-Free Emulsions

Asphalt emulsions have been widely used in highway construction and maintenance since the 1920s, initially as dust palliatives and spray applications. More recently, they have been used in more diverse paving applications such as base and surface course mixes, surface treatments and maintenance activities. ODOT uses nearly 500,000 tons of cold mix annually for construction and maintenance at a cost of approximately $10 million. For engineering, environmental and economic reasons, the use of emulsions is likely to increase dramatically in the next ten years.

The decrease in highway funding and the public's heightened environmental awareness demand innovative technology for roads of the 2 1st century. Recognizing the opportunities inherent in this challenge, some commercial enterprises have already developed solvent-free alternatives.
The results of this study could reduce the amount of volatile solvents used in emulsified asphalt concrete yielding economic and environmental benefits. Additionally, elimination of volatile solvents minimizes the fire hazard enhancing working safety during manufacture of the emulsion and construction of the pavement section.

Environmental benefits in terms of air quality are expected because of the elimination of volatile fumes. Given the heightened environmental awareness of the govemment agencies and the driving public, the use of solvent-free technology could enhance Oregon's already positive image as an enviromnentally progressive state.

The research project is scheduled for completion by June 1999. For more information, contact Brett Sposito, **(503) 986-2847**

Roadwaste Management options

Phase 1 consisted of a thorough review of regulations and standards, roadwaste characterization, current management practices, and new technology; this report focuses on road sweepings and stormwater vactor residuals, though the findings also help to clarify proper management of other roadwaste materials. No one set of regulations covers roadwaste management; hazardous and solid waste, water quality, cleanup and other rules are reviewed.

Roadwaste characterization evolved during the 1990s; many tests were run and results varied widely. Total Petroleum Hydrocarbon (TPH) tests, used at underground storage tank (UST) cleanup sites, are not appropriate for evaluation of roadwaste due to H-C bond interference from natural organic constituents. Now, carcinogenic PAHs (seven heavy petroleum compounds) and heavy metals drive evaluation of risk. Fine particles (clays and silts) are more contaminated than coarse fractions. Dissolved contaminants in vactor liquids are low; however, high contaminant loadings are often adsorbed to suspended solids.

Identifying and separating differing roadwastes allows more ready management while requiring less frequent analysis. Practices reviewed address separation of hot loads, mainstream roadwastes, and vactor waste management. Many possibilities are identified for trials; it is expected that Phase 2 (Trial Implementation) will lead to further important findings. The report recommends that trials lead to the development of Best Management Practices to support statewide plan development by ODOT in Phase 3.

The research project is scheduled for completion by June 2000. For more information, contact Liz Hunt, **(503) 986-2848.**

Evaluation of IPM on Water Quality

The Oregon Department of Transportation (ODOT) uses an integrated vegetation management (IVM) plan to control roadside vegetation. IVM programs utilize a suite of practices, including application of herbicides. The extent to which these herbicides are transported from the point of application on the road shoulders to nearby streams is unknown, but if large amounts of these herbicides end up in streams, then the stream biota could be adversely affected and stream ecosystem disrupted. The small streams that often parallel or cross roadways are particularly susceptible because their dilution capacity is small.

A previous study established that many different herbicides can be found in small Willamette Valley streams. Several of the compounds detected in that study are known to be used by ODOT in IVM programs but none could be attributed solely to that use because most of the herbicides applied in IVM programs are known to be applied also to urban or agricultural land. Further study is required, therefore, to assess whether the use of herbicides in IVM programs could be a significant contributor to the load of herbicides carried by streams in Oregon.

Major Components of the Field Program:

1. Three sites were chosen for the collection of data - - one from Eastern Oregon, one in the Willamette Valley, and one from the Coast Range, in order to capture some of the variability due to soil types.

2. The test sites include, at the minimum, triplicate test plots, approximately 7 by 15 feet. These test plots will be used to sample runoff generated by simulated rainfall.

3. Availability for transport in runoff over time will be determined by revisiting the sites over a period of weeks. Persistence in the soil at the test plots will also be monitored by collecting soil samples.

4. Analysis will focus on only a few (yet-to-be-determined) compounds, chosen because they are both a) applied by ODOT in large amounts, and b) expected to be relatively mobile.

5. Collected runoff will be used to conduct laboratory toxicity bioassays. The focus of the testing during this phase of the project will be on tests that conform to accepted standards (e.g. 24/96 hr tests, done on rainbow trout, daphnia, algae) in order to make the results comparable with test results reported in the literature, and to make them most easily understood by interested parties outside the USGS and ODOT. Because the collected runoff represents the upper limit on concentrations entering the stream, a standard dilution series (using the runoff at 33%, 10%, and 1% of full strength, for example)is also part of the toxicity testing.

6. The timing of compound application and collection of samples is consistent with ODOT's normal procedures for the compounds involved, but a spring test and a fall test will also be conducted.

7. The testing of a tracer that is inexpensively analyzed, such as bromide, will be incorporated into the study design to establish whether its behavior in the environment is similar to a particular class of pesticides.

8. At one of the three test sites, runoff from test plots and stream samples will be collected during a natural rainfall event, as a means of establishing a limited comparison between the concentration in runoff and the concentration in the receiving stream.

The research project is scheduled for completion by July 2000. For more information, contact Rob Edgar, (503) 986-2846

Clackamas River Basin Nutrients

Highly productive populations, "nuisance" levels, of filamentous green algae change the stream habitat and water chemistry and can cause shifts in the structure and function of benthic food webs. These algae foul stream channels and reduce the replenishment of oxygenated water into salmonid spawning gravels and may decrease intergravel DO concentrations, harming developing salmonid eggs and invertebrates. Benthic algae often control the pH and DO concentrations in streams. Algal photosynthesis and respiration can cause dramatic fluctuations of DO concentrations and pH to levels that can cause avoidance behaviors, stress, and death of fish, particularly salmonids.

The project will characterize algal grow'th and levels of temperature, DO, and pH in the Clackamas River Basin that potentially affect beneficial uses such as providing favorable conditions for aquatic life, recreational fishing and boating, and providing clean, potable drinking water. Also, the research will provide spatial and temporal baseline data on physical, chemical (nutrients), and biological conditions in the Clackamas River, 'its tributaries and major reservoirs, aud relate these conditions to potential sources or causes.

The research will assess management scenarios that would result in improved algal/nutrient conditions in the basin. The project is scheduled for completion by October 1999. For information, contact Rob Edgar, (503) 986-2846.

IWOSYSTEM RESEARCH in Minnesota DOT

By Greg Busacker

98 Research Report

Salt Tolerance in Short Stature IYative Grasses

This study was undertaken to determine the utility of using short-stature native grasses along the edge of heavily traveled highways in Minnesota where soils can be described as being sodic, compacted, dry, low in nutrients, and subjected to frequent disturbance.

Laboratory studies showed that all of the grass species were able to easily tolerate NaCl concentrations of 1000 ppm (mg/g). Forbs were much more sensitive to NaCl than the grasses. The relative salt tolerances of the species varied depending on the life state (germination, seedling, and maturity) and on the parameter considered for indication of salt tolerance (% germination, delay in germination, seedling survival, or biomass.

Generally, the native plantings along the shoulders and inslopes were found to be minimally successful with only about a 10-20% cover of the desirable native species present and an indication that the native species are not increasing as the stand ages. Although germination and seedling establishment were initially high, large losses of desirable species occurred within 1 meter of the pavement edge after the first winter with the exception of the non-native alkali grass Puccinellia distans.

This reduction of the desirable species appears to be unrelated to NaCl levels in the soil during the growing season between 1 and 4 meters of the inslope. The high disturbance especially by snowplow blades, along the first meter of inslope seems to be a probable cause of this species decline, although the potentially high NaCl levels in soil during the winter months when the soil is frozen and the plants are dormant has not been ruled out as a causal factor. Based on the results of this study, Mn/DOT mix 300 (presently called 30A), which contains native species as well as the non-native Puccinellia distans, was most successful at providing vegetative cover along the highway inslopes in this region.

Determination of vegetation suitable for roadside plantings is an ongoing effort. This project demonstrated the suitability of Mn/DOT's seed mixes for use within 4 meters of the roadway. The long-term benefit will be reduced erosion and greater trapping of roadside pollutants from the pavement surface.

Project contact person and phone number Bob Jacobson 651.779.5077; David Biesboer, Department of Plant Biology, University of Minnesota http://www.dot.state.mn.us/engserv/environment

Effects of Seeding Date on Establishment of Prairie Grasses

Research to determine the best seeding dates (June, July, August, September) for the establishment of prairies grasses was undertaken in Minnesota. The potential benefits of the project include:

1) less seed wasted due to planting at the wrong time of the year;

2) better flexibility in recommending appropriate seed-mixes for projects with time overruns; and

3) less erosion and better soil stabilization due to prompt turf establishment.

Project contact person and phone number Bob Jacobson 65 1.779.5087

Improving the Nodulation and Nitrogen (N2) Fixation of Prairie Legumes used in Roadside Revegetation in Minnesota

This study empasizes the rhizobia associated with those species of legumes used in roadside revegetation. This project also contrasts different inoculation methodologies for fall and spring plantings of legumes, and determines which are most appropriate to roadside vegetation. Experience gained in these activities will be compiled into a **manual** for the establishment and inoculation of prairie legumes.

Determining the best methods of inoculation and seed pelleting results in better turf establishment. Increased N2 fixation in roadside soils will reduce the need for fertilizers, A **manual** on the specifications for and use of **inoculants** in the establishment of prairie legumes will benefit turf establishment programs region wide.

Contact person, Bob Jacobson 65 1.7795087; Peter Graham, Professor, Department of Soil, Water and Climate, University of Minnesota.

Roadside Prairie and Wetland Restoration: Mycorrhizal/Plant Factors

Post construction roadside reclamation areas have intrinsically inhospitable **conditions**, receiving higher levels of salt and lead pollution **than natural areas**, making establishment of native communities **difficult**. The addition of native **mycorrhizae** to reclamation sites may somewhat ameleorate these harsh conditions.

The primary goal of this project was to study **arbuscular mycorrhizal fungi and** vegetational characteristics at both prairie **and** wetland areas. Objectives included:

1) quantifying the effect of **fungal inoculum** on plant communities at a **Mn/DOT** prairie restoration site near Cambridge, MN;

2) **evaluating** prairie forb germination rates;

3) monitoring revegetation at prairie and wetland restoration sites;

4) characterizing mycorrhizal status of native wetland and prairie areas for comparison to the restored sites; and

5) producing fimgal **inoculum** for incorporation into further reclamation areas.

Experimental inoculation of prairie restoration plots resulted in significantly greater cover by native plant species 15 months after seeding than seen in control plots.

Forb germination studies show high variability among species with regard to germination rate, suggesting that germination test before planting may be a worthwhile investment. Sand **germination**, while rapid and inexpensive, did not yield comparable results to soil germination for all species, making field value of this type of test questionable. Viability stands, on the other had, accurately **identified** species with poor germination and are recommended before large-scale seed investment.

Fiieen months after seeding in the upland prairie plots, native/de&able species comprised a majority of the vegetation, particularly in plots inoculated with arbuscular mycorrhizal fungi. In the wetland area, much'of the vegetation was comprised of native/desirable species, although reed canary grass, an exotic invasive species, was also present.

The results support a holistic approach in creating roadside vegetation communities and provide methods for addressing these issues.

Contact Bob Jacobson 65 1.779.5087; Iris **Charvat**, Department of Plant Biology, University of Minnesota

Mycorrhizal/Plant Factors Involved in Roadside Reclamation

Research was undertaken to test the effect of mycorrhizal amendments at a prairie ' restoration site, to test the germination and viability of prairie forb seeds, to monitor revegetation at upland prairie and wetland restoration areas, to monitor mycorrhizal parameters at undisturbed wetland and prairie areas for comparison to restoration areas, and to investigate spore production for use as inoculum at restoration sites.

Mycorrhizal colonization of plants was greater in the inoculated treatments compared to the uninoculated treatments. Also, the inoculated treatment had a greater percent cover of native planted species. AM fungi were found to occur in low numbers in areas with water saturated soils.

The upland restoration site was found to have a much lower spore maorphotype distribution when compared to undisturbed prairies. A method for producing VAM for future inoculum was determined.

The project established the value of VAM inoculations for restoring upland prairies.

Contact Bob Jacobson, 65 1.779.5087; his **Charvat**, Department of Plant Biology, University of Miiesota.

Factors Affecting Biological Recovery of Restored Wetlands

Research is underway to better our understanding of restored wetlands, wetland functions, and their deficiencies when compared to natural systems and to determine how wetland restoration success is affected by selecting more or less disturbed sites for restoration efforts. The study will improve our understanding of the relative effectiveness of planting and **natural** recolonization from available propagule sources. The development of Minnesota specific wetland bioassessment methods will enable us to adequately assess ecosystem recovery of mitigation sites.

Contact Brad Kovach 651.779.5101; Susan Galatowitsch, Department of Horticultural Science, University of Minnesota

Mapping Prairie Remnants on MnDOT Right-of-Way

This is an ongoing project to map native vegetation, both plant communities and rare plants on Minnesota roadsides. The project is in its second year. This year we begin mapping native prairies on Mn/DOT right-of-way.

So far, the vegetation of I-35 has been mapped. We used experience gained on that project to refine our data collection efforts and increase our productivity.

We hope to map all high quality prairies along roadsides. This will allow us to manage these resources both as a source of native plants and to enhance and protect the prairies remnants.

Contact Larry Puchalski, 651.779.5639.

Beneficial Fungal Inoculum for Prairie and Wetland Reclamation

This project characterizes and develops inoculum production methods for soil fungi associated with the roots of native and naturalized Minnesota plants in prairies and wetlands to assist in restoration projects.

Plantings that had VAM included, survived and had greater plant species diversity. The plantings without VAM had higher weed densities from the amiual weed dispersion methods and lower plant species diversity. This was the first definitive work that showed VAM additions directly correlate with tlie greatest survival and persistence of plant species from diverse seed mixes in artificial soils such as found along constructed roads. The results were similar to what one could see in intact and undisturbed prairie remnants.

Vesicular arbuscular mycorrhizae provide numerous benefits to plants, essentially serving as biofertilizers. This project established the contributions VAM make to improving the soil conditions, which are importaut in promoting plant growth and development. This information is critical to improving conditions for plants in the inhospitable environment found along the highway right-of-way.

Contact Bob Jacobson 65 1.7795087;
Iris Chervat, Department of Plant Biology, University of Minnesota

Developing a Decision Tool to Predict the Ecotoxicological Impacts of Transportation Related Chemicals

This research is to develop a decision tool for estimating the potential toxicity to human and ecosystem receptors of compounds used or released by transportation-related activities. This decision tool will enable Mn/DOT personnel to select compounds for use that will minimize toxicological impacts to the receiving environment. The selection will be based on a rational and consistent method of toxicity assessment that includes regional specificity for Minnesota.

Staff at Mn/DOT will be able to screen chemical compounds used or inadvertently released from transportation related activities for their potential ecotoxicological impact. The model would connect emissions, leakage, leaching, etc., of transportation related compounds with potential adverse effects to the surrounding ecosystem. The proposed model will improve on existing methods of fate and effects determination in the following ways:

1) The fate model will be appropriate for most persistent chemicals, volatile and non-volatile, and those that exist as multiple chemical species such as mercury.

2) The fate of non-persistent chemicals will be addressed by considering time dependent dispersion, in addition to multi media distribution.

3) The fate model will include regional specificity by having a set of submodels based on the Ecological Classification System of Minnesota.

4) Ecotoxicity effects will be estimated by calculating compound exposure to receptor organisms, correct for bioavailability.

5) The outcome of the ecotoxicity assessment will be interpreted with respect to ecosystem structure.

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