NCHRP SYNTHESIS 305

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Interaction Between Roadways and Wildlife Ecology

A Synthesis of Highway Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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Energy and Environment, and Safety and Human Performance

Research Sponsored by the American Association of State Highway and Transportation Officials
in Cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD — THE NATIONAL ACADEMIES

WASHINGTON, D.C.
2002
www.TRB.org

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

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The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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NCHRP SYNTHESIS 305

Project 20-5 FY 2000 (Topic 32-11)
ISSN 0547-5570
ISBN 0-309-06923-8
Library of Congress Control No. 2002111522

Price $16.00

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

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The Transportation Research Board evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street
Washington, D.C. 20001

and can be ordered through the Internet at:

http://www.national-academies.org/trb/bookstore

Printed in the United States of America

PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation Research Board

This synthesis report will be of interest to state department of transportation (DOT) staff involved in the development, operation, and maintenance of roadways and how they can effect wildlife and ecological systems across the country. Roadway development choices made in response to population growth can affect many, if not all, forms of wildlife. Such effects include loss of wildlife habitat, fragmentation, mortality, and increased competition. The synthesis reviews and discusses regulatory context (laws, regulations, policies, and guidance); transportation planning and development processes; the types of effects, including habitat loss, fragmentation, and chemical and physical impacts; the scale and assessment of effects; analytical tools, including motorist safety studies and wildlife surveys; conservation measures and mitigation; maintenance (culverts and habitat restoration); and funding sources and deficiencies.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

This report of the Transportation Research Board summarizes existing information related to roadway planning, design, construction, operation, and maintenance practices being used both nationally and internationally, successfully and unsuccessfully, to accommodate wildlife ecology given the challenging background of rapid growth and diminishing natural resources. It includes data obtained from the survey responses of 35 state DOTs in addition to a review of research literature to describe the state of the practice. It reviews the processes, types of effects, analytical tools, conservation and mitigation measures, maintenance, and funding involved in constructing an environmentally sustainable transportation system that acts in cooperation with the natural systems supporting our global civilization. Three case studies showing some actions being undertaken are provided. The report concludes with a listing and descriptions of the major federal regulations relevant to wildlife and the environment.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the available information was assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the author's research in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

ACKNOWLEDGMENTS

Gary L. Evink, Ecologist, Tallahassee, Florida, was responsible for collection of the data and preparation of the report.

Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Gregg Erickson, Senior Environmental Planner/Biologist, California Department of Transportation; Paul Garrett, Ecologist, Federal Highway Administration, Lakewood, Colorado; Mary E. Gray, Environmental Program Manager, Federal Highway Administration, Idaho Division; Alex Levy, Ecologist, Federal Highway Administration, Atlanta, Georgia; Joel Marshik, Manager, Environmental Services, Montana Department of Transportation; Patrick McGowen, Research Engineer, Western Transportation Institute; Paul J. Wagner, Biology Program Manager, Environmental Affairs Office, Washington State Department of Transportation; and Jon Williams, Senior Program Officer, Transportation Research Board.

This study was managed by Jon Williams, Manager, Synthesis Studies, who worked with the consultant, the Topic Panel, and the Project 20-5 Committee in the development and review of the report. Assistance in project scope development was provided by Donna Vlasak, Senior Program Officer. Don Tippman was responsible for editing and production. Cheryl Keith assisted in meeting logistics and distribution of the questionnaire and draft reports.

Crawford F. Jencks, Manager, National Cooperative Highway Research Program, assisted the NCHRP 20-5 Committee and the Synthesis staff.

Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance are appreciated.

INTERACTION BETWEEN ROADWAYS AND WILDLIFE ECOLOGY

SUMMARY

The challenges facing the transportation professional have never been greater. A central challenge is the need to maintain and enhance our environmental quality, because it influences our quality of life and the very support systems required for life on this planet—air, water, and soil quality. There is sufficient evidence to show that through growth and inadequate planning we have taxed some ecological systems, including the native habitats and wildlife populations in many areas of the country. This, in turn, has resulted in a variety of policy initiatives and regulatory processes to address environmental concerns.

Federal and some state wildlife agencies are becoming more involved in transportation issues related to wildlife concerns, and numerous policy and regulatory programs are in place to protect important habitats and wildlife. The FHWA, Environmental Protection Agency, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the U.S. Army Corps of Engineers at the federal level, and numerous state agencies through state regulatory programs, are working together with the state transportation agencies to improve the environmental quality of our transportation programs.

A survey conducted for this study indicates that although many states are attempting to address wildlife issues, most do not do so early in the transportation development process; that is, the planning stage. In some states, the environmental resource agencies lack sufficient staff to assist in early planning. The need for involving and training planners on environmental issues is evident.

Emerging issues such as habitat fragmentation and connectivity for wildlife, critical habitats, increasing numbers of threatened and endangered species, and secondary and cumulative impacts have further complicated matters for the transportation industry. Because of the linear nature of transportation projects, the potential for involvement with a variety of habitats and wildlife is high.

In some areas of the country where growth continues to encroach on native habitats, the existing process is working, but not without difficulty. New alignment transportation projects present unique issues because they can open up previously inaccessible areas, thereby causing associated changes in habitat quantity and quality. In some states, transportation agencies find their projects crossing some of the last remaining habitat, whereas in other areas they may enter public lands being managed for wildlife values. Because of the magnitude of potential impacts, this can prolong coordination of project issues. Avoidance and minimization of impacts are essential in some sensitive habitats.

When avoidance of impacts is not possible, the process of coordination among the transportation departments and the resource agencies is critical. Efforts are underway throughout the country to increase the staff that is available at these agencies through the transportation

agencies' funding of resource agency positions. Concepts such as streamlining and context-sensitive design are helping to focus attention on the need for improving the coordination process and for considering the environmental issues early in the process. Context-sensitive design is being used on very environmentally sensitive projects, such as US-93 in Montana, thereby helping work through environmental issues that might otherwise stop the project. The results of the survey indicated that if transportation departments address wildlife issues early in the planning process, this can contribute to streamlining the process.

One factor that has hindered the ability of the states to deal with wildlife issues is the lack of accepted methodologies for evaluating potential habitat and wildlife impacts and developing mitigation strategies. Despite efforts such as the International Conferences on Wildlife Ecology and Transportation and a number of research projects undertaken around the country, no universally accepted methods have resulted. This has lead to the formation of a committee under the direction of the National Research Council's Board of Environmental Studies and Toxicology to create a conceptual framework and approach for the development of a rapid assessment methodology that transportation agencies can use to assess and alleviate ecological impacts of road density.

Wildlife, wetlands, and ecosystem management are topics in a chapter in *Conference Proceedings No. 28: Environmental Research Needs in Transportation: Report of a Conference* (Transportation Research Board, The National Academies, Washington, D.C.). Implementation of these research statements will be important. As states address wildlife interactions with roadways, effective techniques for evaluation of potential impacts to wildlife and habitat from the species to landscape level, evaluation of secondary and cumulative impacts, and evaluation of the effectiveness of mitigation techniques will become increasingly important.

Most states are evaluating habitat and wildlife impacts on their projects and in some cases have elevated the class of action to Environmental Assessment/Finding of No Significant Impact or an Environmental Impact Statement based on environmental issues, including wildlife. The level of concern expressed in the public involvement process has influenced the class of action. Coordination is also leading to satisfactory resolution of such issues, with the result that the environmental features are being incorporated in many transportation projects across the country, including the restoration or preservation of habitat as mitigation and the addition of wildlife underpasses, overpasses, bridge extensions, enlarged culverts, and fencing by many states dealing with the realities of wildlife conservation and motorist safety. From a wildlife conservation perspective, the impacts addressed include habitat loss, habitat fragmentation, degradation of habitat quality, road avoidance zones, increased human activities, direct mortality, reduced biodiversity, genetic isolation, chemical contamination, changed hydrology for fisheries, reduced access to vital habitat, disruption of processes important to animal life cycles, and disruption of the food chain. The measures being taken by the states are designed to help remedy these impacts. The technology to fully evaluate the effectiveness of the various measures is available, but is not widely used. Instead, simple, nonanalytic monitoring methods are employed to determine the success of initiatives to accommodate wildlife ecology.

Habitat-related mitigation and conservation measures are being used to address the broader ecological concerns associated with reductions in habitat and wildlife connectivity. In combination with fencing and crossing structures, these measures are believed to be the most effective by the regulatory agencies and advocacy groups, although long-term research on these measures is currently insufficient.

From a motorist safety perspective, the number of collisions with wildlife and the human injury and fatality associated with these accidents, as well as the financial costs, are significant. Indications are that the number of accidents is increasing. However, in areas where these impacts were comprehensively addressed, wildlife collisions have almost been eliminated. Over the long term, the savings associated with reduced human injury/mortality and vehicular damage could offset the cost of mitigation measures.

In recent years, most states have anticipated these costs. Some states have even set up separate funding mechanisms for mitigation to ensure that the costs do not disrupt the work program. However, there is need for additional funding to remedy those existing situations on highways with no improvements programmed for the future through retrofit. Some states are also having problems justifying habitat and wildlife mitigation that is not associated with listed species, because there is no regulatory imperative. However, many states are now addressing the broader habitat and wildlife issues as part of the affected environmental analysis and providing measures to avoid, minimize, or mitigate those impacts despite the lack of regulatory imperative.

In Europe and Canada transportation agencies address habitat and wildlife issues by placing the emphasis on the larger landscape planning that provides wildlife habitat and related measures to complement transportation system planning. In Europe, a plan is being developed for habitat connectivity throughout their transportation system that involves international cooperation among most European nations. This plan inspired a Wildlife Mortality Study Tour sponsored by AASHTO and the FHWA International Outreach Program for technology transfer. The result was a report that documents the successes of the Europeans as a result of these efforts. The research conducted on these activities could help state transportation agencies better understand the possibilities of such planning.

Although positive things are happening, they are happening slowly. However, the direction is toward increasing acceptance of the need to consider wildlife-related issues and continued improvement of efforts to address these issues. Wildlife measures compete with all of the other transportation needs for funding. Consequently, dedicated funding would help to expedite the intentions of the context-sensitive design and streamlining initiatives through early planning and commitment of funding for ecological and wildlife measures.

CHAPTER ONE

INTRODUCTION

In the end, we will conserve only what we love, we will love only what we understand, we will understand only what we are taught. Bada Dioum, Senegal

BACKGROUND

Although the interactions between wildlife ecology and roadways have only recently received national and international attention, the origins of these relationships date back to when the first roadways (trails) opened this country to human habitation. Since those early days, the need for humans to have access and mobility has resulted in a primary road system of approximately 4 million miles (Cook and Daggett 1995). Approximately three-quarters of this mileage is in rural areas, where most of the remaining wildlife habitat is located. Using an average of 5 acres per mile, Cook and Daggett estimated that highways, streets, and rights-of-way have eliminated approximately 20 million acres of habitat.

Transportation development in this country creates great challenges for wildlife conservation. The reasons for this are (1) private lands are being developed at an unprecedented rate; (2) agriculture, urban sprawl, and industry are encroaching on natural areas (Flather et al. 1999), and (3) management of public lands has lead to the loss of important habitats and associated species. Modern demands for mobility and access have resulted in a built-up demand for transportation infrastructure. Although the transportation industry tries to move to a more diverse modal mix, the automobile continues to be the public's preferred mode of transportation. In this environment, the transportation industry is struggling to satisfy the mandate to provide safe and efficient transportation in an environmentally sound manner. The challenge is to build an environmentally sustainable transportation system and other human infrastructure that does not permanently damage the natural systems that support our global civilization.

SCOPE AND APPROACH

This synthesis study reviews the interactions that occur during the planning, design, construction, operation, and maintenance of roadways that can affect ecological systems and wildlife. A questionnaire was used to determine how the state departments of transportation (DOTs) are addressing ecological and wildlife-related matters given this challenging background of rapid growth and diminishing natural resources. Information obtained from the 35 state DOTs that responded to the survey, along with a review of research literature, is used to describe the state of the practice. Survey results are intended to provide qualitative information about processes, types of effects, analytical tools, conservation/mitigation measures, maintenance, and funding involved in coordinating transportation planning with potential habitat and wildlife impacts.

Chapter 2 reviews the regulatory context in which the state DOTs are carrying out their mandate to provide a safe and efficient transportation system in an environmentally sound manner. This chapter presents an overview of the primary local, state, and federal regulations that the states felt to be the most important in their survey responses. (Appendix C contains an annotated listing of the primary federal regulations with relevance to wildlife and the environment.) The planning and project development process used to address the regulations is discussed in chapter 3. This chapter reviews avoidance and minimization, planning, National Environmental Policy Act (NEPA) studies, public involvement, and engineering studies as relates to wildlife. The types of effects that transportation facilities and activities can have on wildlife are covered in chapter 4. The topics are divided into those related to footprint and physical presence, those related to construction and operational aspects, and secondary and cumulative effects. Because of the linear nature of most transportation facilities, the scale of assessment needed and resulting effects can cover a wide spectrum; this is covered in chapter 5. Analytical tools such as motorist safety studies and wildlife/habitat studies presented from the state surveys and literature review are contained in chapter 6. The conservation and mitigation measures, successful and unsuccessful, obtained from a state survey are discussed in chapter 7. Recent approaches such as programmatic agreements, as well as standard structural and habitat techniques are described. The maintenance of structures and habitat by the transportation departments is examined in chapter 8. Chapter 9 is a look at the funding sources and funding deficiencies identified during the state survey. Chapter 10 contains three case studies that demonstrate some of the actions being taken. The Florida case study examines the results of a statewide effort by the state transportation agency to address wildlife concerns. The Banff case study is an example of providing connectivity through a major highway corridor in a national park setting. The significant planning and public involvement process used to arrive at project concepts for U.S. Highway 93 in Montana is the third case study. The conclusions of the synthesis study are contained in chapter 11. A Glossary providing the definition of terms not normally recognized and a section on nomenclature (acronyms) are provided at the end of the report. In addition, Appendix A contains the responses to the questionnaire and the states that responded to the questionnaire are listed in Appendix B. Appendix C provides a listing and description of the primary federal regulations that are relevant to wildlife and the environment.

A continuously updated source of information on the latest activities in the area of wildlife in transportation can be found at the website for the Center for Transportation and the Environment (www.itre.ncsu.edu/cte/wildlife.htm).

CHAPTER TWO

REGULATORY CONTEXT

OVERVIEW

Many of the actions of transportation agencies are in reaction to federal and state laws. Therefore, it is important to have at least a basic understanding of the applicable laws before looking at the elements of compliance—process, analysis of impacts, conservation measures/mitigation, and funding. This chapter is not intended to be an exhaustive discussion of regulations related to wildlife and transportation, but rather is meant to familiarize the reader with the important wildlife-related legal obligations that individuals involved in advancing transportation projects must consider. Although these requirements do not vary at the federal level, each state can have regulations that complement or expand the responsibilities under federal regulations. It is important that persons involved in transportation development understand these policy directives and legal requirements to address wildlife and habitat considerations. Survey respondents cited the following environmental regulations as those they most often encountered:

- National Environmental Policy Act (NEPA), Public Law No. 91-190.
- Clean Water Act of 1977, Sections 401 and 404.
- Endangered Species Act of 1973, as amended, 16 USC 1531 et seq.
- Coastal Zone Act Reauthorization Amendments of 1990—Section 6217.
- Coastal Resources Management Program—October 1987.
- Federal Coastal Zone Management Act of 1972, P.L. 92-583, as amended.
- Section 4(f) Evaluations and Approvals for Federally-Aided Highway Projects with Minor Involvement with Public Parks, Recreations Lands, Wildlife and Waterfowl Refuges and Historic Sites, December 23, 1986—49 USC 303.
- Migratory Bird Treaty Act.
- Fish and Wildlife Coordination Act.

All environmental factors associated with transportation projects can have an impact on wildlife. Therefore, the regulations dealing with the elements of the environment (air, noise, water, etc.) were reviewed for this study and are included in this chapter. The relationships of these elements to wildlife ecology will be developed in the coming chapters.

With the exception of the discussion of state and local regulations, which were identified by a survey of the states, the following is taken from the FHWA publication on the regulatory context (FHWA 1990).

An excellent source of information on environmental legal problems arising from highway programs is "Highways and the Environment: Resource Protection and the Federal Highway Program" (NCHRP 1994).

FEDERAL PERSPECTIVE

Since Congress adopted the National Environmental Policy Act (NEPA) in 1969, the FHWA has built policies and procedures to help meet its social, economic, and environmental responsibilities while accomplishing its transportation mission. The FHWA Environmental Policy Statement (EPS) is a formal expression of the FHWA's commitment to the protection and enhancement of the environment. The FHWA provides the policy grounds and associated procedures for the development of environmentally sound projects. It is the responsibility of the state transportation agencies to meet these standards. For the purposes of this study, it is necessary to understand which elements of the policy apply to federal-aid projects. The following are some of the key elements of the policy:

- Defining the "environment" to include the natural and built environment;
- Consideration of effective communication as critical to success by empowering diverse interests;
- Encouragement of broad-based public involvement early and continuously in the process;
- Integration of environmental goals and impacts by local, regional, and state land-use planning;
- Promotion of multi-modal solutions to transportation and air quality problems;
- Promotion and support of travel alternatives to single-occupancy vehicle use—mass transit, etc.
- Coordination of planning to conform with air quality implementation plans;
- Promotion and support of watershed planning;
- Encouragement of corridor preservation to ensure early consideration of environmentally sensitive areas;
- Support for federal, state, and local efforts to control noise emissions;

- Encouragement of continual consideration of environmental factors throughout all phases of project;
- Consideration of social, economic, and environmental issues equally with engineering issues;
- Support for the merger of NEPA with other environmental reviews and decisions—permits;
- Support for an interdisciplinary approach;
- Requirement of full consideration of avoidance, minimization, and mitigation of adverse impacts;
- Encouragement of enhancement of the natural and human environment;
- Requirement of environmental commitment compliance and implementation;
- Requirement of full compliance with environmental protection laws, regulations, executive orders, and policies;
- Encouragement of mandates going beyond compliance to strive for environmental excellence;
- Support for research and development to raise the level of expertise to state of the art; and
- Support for environmental training to develop environmental professionals in transportation.

It is clear from the FHWA environmental policy that an environmentally sound transportation system is the goal. The challenge is for the states to achieve this goal under the federal-aid transportation program.

An annotated list of major federal regulations that are relevant to wildlife and the environment can be found in Appendix C.

STATE PERSPECTIVE

The majority of respondents have either state law (22 states), planning requirements (9 states), policies (14 states), procedures (15 states), and even court decisions (3 states) requiring that they address ecological impacts. For a state to assume a regulatory program, their regulations must match or exceed the federal standards. (Note that federal law takes precedent over state law, especially as relates to projects involving federal funds.)

Several states have NEPA-like requirements similar to the federal requirements; California has the California Environmental Quality Act; Georgia an Environmental Policy Act; Maine a Natural Resources Protection Act; and Washington a State Environmental Protection Act.

States reporting wetland protection requirements include Connecticut, Ohio, Oregon, Virginia, and Wisconsin. Nebraska and Oregon have state protection of endangered species. Several states described special state provisions for fisheries including Alaska, Colorado, Maine, Ohio, and Washington.

CHAPTER THREE

TRANSPORTATION PLANNING AND DEVELOPMENT PROCESS

The following is not an explanation of how each of the planning, project development, and environmental documents are prepared, but rather an explanation of the importance of each to wildlife ecology and transportation. Where appropriate, references are given that more fully discuss the composition of these documents and how they are processed.

AVOIDANCE AND MINIMIZATION

Avoidance negates impacts to habitat and therefore wildlife, whereas minimization reduces the impact to levels that can often avoid or reduce mitigation. In conjunction with the basic transportation needs analysis, this is a primary objective of the analysis process. State transportation agencies felt that the regulatory agencies are reluctant to become involved in interagency coordination unless avoidance and minimization is demonstrated. When they do become involved, their first input is how to avoid or minimize impacts. Development of a transportation system without adequate considerations for avoidance and minimization can result in long, drawn-out negotiations with the resource agencies. The states reported that demonstration of avoidance and minimization moves the coordination process along as mandated in the streamlining provision in the Transportation Equity Act for the 21st Century (TEA-21).

PLANNING

Unless the planner and the planning process are sensitive to the environmental ramifications of their actions, continuing problems in advancing transportation projects, continuing reduction of quality of life, and continuing reductions in native habitats and their associated wildlife will occur. The states indicated a need for environmental training of planners. The following account of transportation planning is a modified version of information contained on the FHWA website (www.fhwa.gov/planning). A more comprehensive treatment is contained on the website.

Provisions of TEA-21 require that transportation planners, highway officials, and transit interests recognize environmental values and incorporate environmental protection and enhancement measures into programs to develop and improve the nation's surface transportation system. TEA-21 establishes planning as a pivotal strategy in the cooperative approach for financing needed improvements in the nation's transportation infrastructure while maintaining and enhancing the environment. The federal transportation act (currently TEA-21) is a federal-aid program wherein state and local governments finance needed transportation improvements with the use of federal funds made available from taxes collected primarily through the sale of gasoline. Under this funding arrangement, the state DOTs and the metropolitan planning organizations (MPOs) plan highway and transit improvements through the use of an integrated process that includes environmental studies. This results in long-term highway construction programs of projects needed to support the current and future movement of people and goods. Although mobility improvements are the focus, the planning process envisioned by TEA-21 also includes participation by the public and private sectors to support other quality of life objectives. The process incorporates a variety of elements, including environmental protection and enhancement coupled with accessibility to, and equity in, the provision of transportation services. Collectively, these and other elements of the planning process can fit together to help meet a variety of local needs and national priorities including environmental programs.

The transportation planning agencies determine the overall, best way to solve a particular mobility problem affecting the planning area. Information on land-use planning/environmental goals, zoning objectives, and resource protection and management priorities need to be incorporated. This is necessary to ensure that transportation improvement proposals are relevant to public needs and consistent with other environmental planning efforts occurring in the same area. Land-use and environmental information need to be similar in scale. Therefore, corridor-scale, regional, and other area-wide information sources are most appropriate. This level of planning is consistent with the needs for landscape level ecological planning needed for wildlife.

System Planning Studies

The FHWA and a number of state transportation agencies have recognized the need to consider environmental issues early in the planning process. In several states, the success of streamlining the environmental process during project development and environment studies has depended on getting environmental considerations into the process at the systems planning stage so that coordination leads to resolution prior to the Project Development & Environment (PD&E) stage. System planning is the point at which connectivity for wildlife can be evaluated. At the systems level, the cumulative effect of the highways on the landscape can be determined and measures taken to demonstrate avoidance and minimization of environmental impacts to important ecological areas. These considerations then can be applied to the entire system rather than individual projects. Environmentally poor corridor selections can be identified at this stage of planning and coordination carried out to determine whether moving forward to the project stage is in the best public interest. This is part of the balanced approach that is mandated in TEA-21.

Local Growth Management Plans

Local land-use planning is another area where consideration of environmental factors that involve native habitats and wildlife is important. Over the past several decades, urban growth has consumed millions of acres of habitat, with associated reductions in wildlife populations (Flather et al. 1999). Local land-use plans facilitate growth for economic motives. Frequently, environmental impacts do not become a consideration until the quality of life in the area is threatened by the reduction in environmental quality. MPOs and DOTs are responsible for ensuring coordination between land use and transportation plans involving environmental impacts. Avoidance and minimization of impacts to the remaining important ecological areas must be an important factor. Indeed, in some areas restoration of habitats already affected can be a part of the local growth and transportation planning process to restore diminished native habitats and wildlife populations.

Metropolitan Planning Organizations

MPOs can become primary players in the initial review of the environmental considerations associated with various transportation options of urban transportation planning. Early coordination between MPOs and environmental agencies can help prevent environmentally damaging projects. Transportation departments around the country are finding it increasingly difficult to advance environmentally sensitive projects previously identified by MPOs in the local transportation planning process. For many habitats and species, a critical point has been reached and the MPOs can play an important early role in the transportation connection.

Transportation Plans

The use of planning leads to the creation of transportation plans. At this early stage coordination should begin on projects that have the potential to impact wildlife, because this is when plans can still be changed. It is at this point that funding considerations begin and, if features are anticipated for a project, money can be programmed. This is the opportunity to change environmentally sensitive plans. Citizen's awareness and their resulting participation in the transportation planning process are increasing (McMurtray 2002).

Environmental Resource Agency Plans

The environmental information needed for reviewing the transportation system and projects is often contained in environmental resource agency plans. These plans are the result of studies that include public involvement and reflect the environmental point of view. This can also be a source of geographic information system (GIS) information that can be applied at the systems and project stage. When passing near or through resource agency lands, it is important that the goals of these resource management plans be part of the transportation planning process. Section 4(f) of the Department of Transportation Act, which requires the analysis of avoidance when impacting certain parks and recreation areas, can apply if the transportation project conflicts with the management goals as relates to recreation. Facilitating public transportation is not a priority for these public lands; therefore, avoidance and minimization is important. Unfortunately, resource agency plans, like transportation plans, often lack the coordination with other agencies and agency plans that would lead to better implementation of all plans. This cannot be done by transportation agencies at the project development and environmental studies phase of individual projects. However, survey results indicate that this is the point at which most coordination is presently taking place. If sustainability of environmental quality is the goal, it will take early coordination of all of the plans.

Endangered Species Recovery Plans

When wildlife and their habitats become part of an endangered species recovery plan, it signals that previous planning and management for these species has failed. Some of this can be attributed to loss of habitat on private lands previously used by the species, but the management of our public lands has also contributed. If public lands are not being managed to protect these important wildlife resources, the expenditure of funds for wildlife features on our transportation systems will do little to ensure sustainability of these habitats and associated wildlife. This is especially true for the large carnivores that require significant areas of habitat that cross international boundaries.

The states surveyed responded that transportation elements are increasingly becoming a part of endangered species recovery plans because highway mortality can be problematic. In the case of the Florida panther, these highway features were included in the U.S. Fish and Wildlife Service recovery plan for the panther and are proving successful at reducing mortality in the immediate area of the structures on I-75 and SR-29. Unfortunately, the same measures have not been taken on county and private roads, so that highway mortality continues to be a factor in what seems to be an increasing population of mixed Texas cougars and Florida panthers. Transportation measures to protect the Florida panther in south Florida will do little to ensure the continued existence of this species if public land management in the area cannot help sustain the population. It has become apparent that in developing areas of the country, private land cannot be counted on as part of the long-term strategy to sustain these often-controversial species.

Measures taken to protect endangered species also help protect the other remaining wildlife so that the expenditure of public funds is often justified; however, in the cost-effectiveness analysis of what measures are taken on a highway plan or project, the long-term sustainability of endangered species needs realistic consideration. Transportation is but one factor in the consideration of endangered species. Mortality reduction on the transportation system will not, by itself, save any of these species.

Regardless, many endangered species recovery plans contain transportation elements and the highways are an important part of the recovery process for numerous species. Therefore, transportation planners and environmental scientists need to use the information contained in the recovery plans when developing associated transportation plans and projects.

Other Planning Related Studies

A more complete approach to habitat and wildlife considerations in relation to highways can be derived from viewing total landscapes that include numerous ecosystems and associated wildlife. Ruediger et al. (1999) examined key linkage areas for carnivores in three western states—Montana, Idaho, and Wyoming. They argue that the progressive improvement of roads from gravel forest roads to Interstate highways has increasingly separated large areas of important habitat, thereby adversely affecting carnivores and other wildlife species. Sixty-four highways were identified as important linkage areas, with 20 of these described as "high priority." This information, supported by additional studies, could be a way to address connectivity problems for carnivores and therefore all wildlife in these important areas. A systems level approach for highways is also taken by Servheen et al. (2001) and Ruediger et al. (2000).

An understanding of the relationship of the transportation system to wildlife populations in a given area is critical to early planning. Numerous studies to support the decision-making process have been done. In Colorado, two major transportation corridors (I-25 and US-85) were studied to identify those species crossing the highways and to better understand habitat connectivity needs across these corridors (Henke et al. 2002). The study looked at surrounding public lands and documented movement through existing structures and over the highway. Deer and elk were recorded crossing the highways "at-grade." Movement appeared to be correlated to drainages, topography, and habitat. A wide variety of wildlife was using existing drainage structures.

Barnum (2002) studied wildlife crossing sections of two highways (US-24 and I-70) in the southern Rocky Mountains. The study documented at-grade crossings and movement through existing dry wash drainage structures. Results indicate that wildlife use existing structures and that locations where wildlife cross the highways are related to topographic and habitat features in the area. Craighead et al. (2002) looked at wildlife linkage and highway safety in the Bozeman Pass area of Montana, which includes the I-90 corridor. The study identified problem areas and made recommendations about how and where to mitigate mortality and human safety issues.

In Washington**,** Singleton and Lehmkuhl (1999) took a natural system level approach to looking at Interstate Highway 90 from Snoqualmie Pass to Cle Elum. They used a GIS "least-cost path" modeling of landscape patterns to identify important linkage areas for sensitive species. They also did a GIS-based analysis of ungulate road-kill distribution and monitored existing structures for wildlife movement. Automatic cameras and winter snow track surveys were done to look at animal distribution along the highway. The information obtained is being used to determine the need and placement of wildlife mitigation measures. Singleton et al. (2002) also used a weighted distance and least-cost corridor analysis technique to evaluate regional scale large carnivore habitat connectivity needs in Washington. They identified six concentrations of large carnivore habitat and four landscape linkage areas of potential importance to these populations.

Similar studies have been done in Canada. Gibeau et al. (2002) studied the effects of highways on grizzly bear movement in the Bow River Watershed in Alberta, Canada. Using radiotelemetry data, they found that one highway in the area was effectively a barrier. They did find that the bears cross the highways in specific enough locations that recommendations on crossing zones are possible with sufficient data.

Demarchi (2002) evaluated the spatial extent, magnitude, and duration of adverse effects to grizzly bears associated with an all-season gravel road between

Greenville and Kincolith, British Columbia. The result of studies by the provincial and federal environmental assessment authorities was a 10-year monitoring program designed to look at impacts to the bears from the project.

At the individual species level, the Washington DOT is financing studies of the spotted frog (proposed for listing) and lynx to obtain basic biological information for use in future planning and project activities.

Studies such as those cited previously, which seek to better understand wildlife populations and movement in the area of highways, will help transportation agencies in the planning of transportation improvements. This will also increase the probability that wildlife will be an important part of that planning process because of the knowledge gained from the studies.

Only a few states have looked at their entire highway systems in relation to wildlife ecology. Florida contracted the University of Florida to conduct a statewide study to help identify highways needing more detailed study in relation to wildlife. Smith (1999) used a rule-based GIS model to perform this function. Chronic roadkill sites, focal species hot spots, riparian corridors, greenway linkages, strategic habitat conservation areas, existing and proposed conservation lands, and movement/migration routes were used to prioritize areas of highways needing consideration. The areas identified were regionally and nationally significant conservation areas and important riparian corridors. Presently, the areas identified as priority areas are being examined for existing structures (bridges, culverts, overpasses, etc.) that might facilitate wildlife movement. Other high-priority areas are being studied for mitigation measures. Gilbert et al. (2002) did a GIS-based analysis to prioritize black bear roadkill problem areas in Florida and found that 34% of the kills had occurred at 15 chronic problem areas. Using information from these statewide studies, the Florida DOT is able to study the necessity of features in projects in the work program or to program wildlife mitigation retrofit projects in high-priority areas.

In 2001, *The Los Angeles Times* reported that more than 300 wildlife corridors had been identified as vital to California's wildlife populations. A team of 160 experts from public agencies, advocacy groups, consulting firms, and academia looked at wildlife linkage zones throughout California and identified these corridors as necessary to prevent fragmented islands of habitat in a sea of development. The information will help state and federal efforts to purchase habitat and provide connectivity across the state's transportation system.

These system level studies for environmentally sound transportation planning indicate a national need. Much data exist at preliminary levels that could be used to identify linkage area needs for the entire primary and Interstate highway system of the United States. In this way, other interstate wildlife connectivity needs can be identified, such as those documented by Paquet (1995) for the Wyoming Range in Wyoming to Jasper National Park in Canada. Having the large-scale needs identified, land-use and habitat studies similar to those done in Florida could further refine the information. Project-level decisions require landscape-level studies similar to those in Snoqualmie Pass, Washington. Only by integrating project-level decisions with system-wide studies can transportation agencies address the larger connectivity needs of diminishing populations of the larger wildlife species.

Colorado is taking an innovative approach. On corridors with successive highway projects, individual project evaluations often result in replication of environmental impact studies. Therefore, Colorado's initiative, a Corridor Streamlining Evaluation Project, is developing a method for evaluating potential impacts to resources from future projects at the corridor level and during project planning. By conducting studies at the corridor level, several projects can be comprehensively evaluated, saving time and resources, and reducing both redundancy and the number of studies needed. A pilot study is currently being completed for State Highway 24 to evaluate the use of aerial imagery and remote sensing technology to accurately map environmental resources. Future pilot studies are planned. This study, which is building on previous efforts to map wetlands with infrared photography, mapped plant communities, sensitive species habitats, wildlife corridors, historical and archaeological resources, and hazardous waste sites. In addition, a refined application of this technology is being used on the US-285 transportation corridor to support a project feasibility study and environmental documentation. Using remotely sensed data to identify lynx habitat and model probable lynx dispersal routes, the best sites for locating crossing structures can be identified. Overall, the Corridor Streamlining Evaluation Project will allow Colorado to map geographic information and collect environmental data accurately while projects are still in conceptual development. Base maps and collected data will help Colorado decide on project design and develop cumulative impact assessments, as well as to anticipate and identify mitigation needs and opportunities.

NEPA STUDIES

The National Environmental Policy Act of 1969 (NEPA) includes three major goals: (1) It sets national environmental policy, (2) it established a basis for environmental impact statements (EISs), and (3) it created the Council on Environmental Quality (CEQ), which has oversight and interpretation responsibilities. NEPA requires that, to the extent possible, the policies, regulations, and laws of the federal government be interpreted and administered in accordance with the protection goals of the law. It also requires federal agencies to use an interdisciplinary approach in planning and decision making for actions that impact the environment. NEPA also requires the preparation of an EIS on all major federal actions significantly affecting the human environment.

NEPA has affected all federal agencies, including the FHWA. NEPA requires and the FHWA is committed to the examination and consideration of potential impacts on sensitive social and environmental resources when considering the approval of a proposed transportation facility. In addition to responsibilities for examining and considering environmental effects, transportation agencies must also address the transportation needs of the public. The FHWA NEPA project development process is a balanced approach to transportation decision making that takes into account the potential impacts on the human and natural resources and the public's need for safe and efficient transportation improvements.

It is the FHWA's policy (*The Federal Highway Administration's* . . . 1990) that all environmental protection requirements and enhancement goals be completed as part of a coordinated review process that includes and considers the input of other agencies and the public through established coordination and a public involvement process. The states must provide evidence of compliance or a reasonable assurance that compliance will be attained.

Project Development and Environmental Studies

Project Development and Environmental Studies are the NEPA compliance documents for transportation projects that have made it through the planning process. Although the "no project" or "no build" alternative is always considered in the analysis, funding and other forces are in place that usually lead to project development. Therefore, the Project Development and Environmental studies [either Environmental Assessment/Finding of No Significant Impact (EA/FONSI) or EIS] are where environmental factors are documented so that the planned project can advance.

In recent years, the "categorical exclusion" has become a more common means of advancing projects. Although categorical exclusions can greatly accelerate project approvals and implementation, the level of study for habitat and wildlife aspects of the project should not diminish. To qualify as a categorical exclusion, the results of these and other studies related to the project must conclude that there are no significant impacts. This often leads to resolution of habitat and wildlife issues during the studies with any necessary mitigation, so that all stakeholders agree that there are no significant impacts.

The complexity of issues or controversy involved with a project may necessitate more extensive documentation of the factors involved in a project. The level of appropriate documentation is identified in a Class of Action Determination between the state DOT and FHWA and is based on early information and inputs on the project. Most responding states (22) reported that ecological considerations necessitate documentation under either an EA/FONSI or EIS—an indication that these issues are getting the proper level of attention.

Similar to the categorical exclusion, the end result of an EA/FONSI is the finding that a balanced project has no significant impacts. EA studies, which tend to be more extensive than in a categorical exclusion, are conducted to arrive at this conclusion. If a FONSI can not be supported at the EA level, the study is elevated to an even higher level of scrutiny in an EIS. In either case, for the project to advance, the impacts must be addressed and, where necessary, suitable mitigation provided. In an effort to keep the length of environmental documents reasonable, some of the issue areas are studied in separate reports that are summarized in the environmental document.

Endangered Species Consultation

> *Each Federal agency shall, in consultation with and with the assistance of the Secretary (of the Department of Interior), insure that any action authorized, funded, or carried out by such agency…is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary . . . to be critical . . .* [ESA Section 7(a)(2)]

The Endangered Species Act (ESA) is the principle federal regulatory authority that the states must address in relation to wildlife. Any species that is in danger of becoming extinct throughout all or a significant portion of its range is considered endangered and qualifies for a listing. A threatened species is one that is likely to become endangered in the near future. A vast majority of the states (29) responding to the questionnaire have conducted project-related consultations for listed species. Additionally, 14 states reported involvement with critical habitats. The states indicated that satisfactory resolution of the issues through coordination and negotiation had alleviated the need for arbitration or administrative/legal actions. Consultation is a federal process between the FHWA, as the lead federal agency, and the Fish and Wildlife Service (FWS) or National Marine Fisheries Service (NMFS) for marine species. However, the majority of the state DOTs coordinate and prepare an Endangered Species Biological Assessment (ESBA) and transmit it to FWS/NMFS through the FHWA. This delegation of a non-federal representative is authorized by the ESA. Informal consultation is conducted by the states pursuant to a programmatic agreement between the FHWA, FWS, and NMFS.

Most ESA-related involvement is resolved through informal consultation with the resource agencies. Where potential for impacts to a species may occur, the FHWA and not it's non-federal representative initiates formal consultation with FWS/NMFS. Under formal consultation, an ESBA is prepared to describe the proposed action, the listed species or critical habitat involved, and the effect of the action and cumulative effects on the species or habitat. The conclusions and effects determination in the ESBA describes the result of the study in terms of the potential to jeopardize the continued existence of the species. The biological opinion issued by FWS/NMFS to the FHWA is based on the ESBA and concurrent consultation. Typically, the project will not advance until listed species issues are resolved to the satisfaction of FWS/NMFS and they issue a "no jeopardy" opinion with an "incidental take" permit or statement.

The states responded that the ESBA is not a document that just anyone can prepare and successfully coordinate and that specialized training is often necessary. Mitigation and conservation measures for impacts to wildlife were a normal part of resolving wildlife and habitat issues as part of the coordination process in all but one of the states responding to the questionnaire. The various mitigation/conservation measures taken are described in chapter 7. The ESA was one of the laws that brought about these measures. The state of practice for transportation and the ESA is that this is a highly technical area that requires a high level of biological expertise to successfully complete the consultation process and arrive at a satisfactory resolution. When states had difficulty resolving issues it was likely because of one of three situations: the technical expertise was lacking, involvement and coordination with the FWS was limited, or the state could not take the actions necessary to conserve the species.

TEA-21 provides funding authority such that many states are now funding positions in FWS/NMFS to help address staffing shortfalls that result in project coordination delays. In the 22 states that are providing financial support for staffing of resource agencies, the FWS is the main agency receiving those funds for endangered species and wetland/water quality coordination. In some cases, this funding is significant. Venner (2001B) completed a survey of the states and developed a discussion of state funding of resource agency personnel. The survey documented approximately 150 state transportation agency-funded positions nationwide that are primarily in state and federal natural resources agencies.

Other Wildlife Related Studies

A number of other technical studies typically support the NEPA document and they are included or summarized in the NEPA document in accordance with the complexity of the study. These include Habitat and Wildlife Studies, Water Quality Studies, Aquatic Systems Studies, and Wetland System Studies. The complexity and necessity for each of these studies is a project-specific matter. Again, the states responded that for these studies to be credible, a high level expertise of the persons preparing the reports is necessary.

PUBLIC INVOLVEMENT

TEA-21 mandates that the transportation decision-making process will be an open one designed to involve other agencies and the public. The following is a discussion of the importance of this element in relation to wildlife and the state's experience in public involvement. That the states are making a conscientious attempt to involve other agencies, the public, and non-governmental organizations was evident in the responses to the questionnaire and contacts with the states. These respondents also indicated that conflict resolution in coordination with agencies and the public was working to the extent that very few administrative or legal actions were necessary. In other words, programs for public involvement were leading to satisfactory resolution of issues.

Over the past 10 years, there has been a dramatic change in many states in the public involvement process. Technology has become a part of the process, with websites being established, multi-media presentations at public meetings/hearings, and GIS playing an important role in helping everyone understand the status of plans and projects. This has resulted in project and planning improvements related to wildlife. For the most cost-effective process, it is important that agency and public concerns be worked out before design begins.

Numerous examples of extensive public involvement to resolve ecological issues were submitted by the states. Colorado developed an extensive public involvement process for I-25 improvements (Henke et al. 2002). The planning case study (chapter 10) on US-93 in Montana, where an extensive public involvement effort resulted in major considerations for wildlife, is another example. Pennsylvania incorporated stakeholders in the decision-making process by involving them in the process of reducing the number of alternatives to a preferred alternative for the Corridor O Project, a new 25-mile highway in Centre and Clearfield Counties, Pennsylvania (Kisner and Farrow 2002).

ENGINEERING STUDIES

Planning results in project concepts that continue through the project development and environmental studies process into engineering studies. Several of these concepts were mentioned by the states as being particularly important. The states that are having success in getting wildlife considerations into any of the studies discussed here responded that they were doing so by team development of the studies that involved all functional areas including environmental. Most of the states continue to build in new locations and on new alignments and therefore the initial route selection studies are critical to wildlife. Important avoidance and minimization actions can be included at this point. The vast majority of reported projects being developed by the states are along existing alignments. Route realignments provide opportunities to address existing problems for wildlife that are associated with the original roadway alignment. The principle input reported on interchanges was the aspect of access control and secondary and cumulative growth. Many states are experiencing difficulty in resolving interchange issues when the location is in important wildlife habitat. Dramatic mitigation is often necessary. For example, Florida purchased a section of land in each corner of an interchange between Alligator Alley (I-75) and SR-29 to prevent development in important panther habitat (see the Florida case study in chapter 10).

Bridge/culvert replacement and hydrological reports also require input as related to wildlife and fisheries. For amphibians and fisheries, the opportunity for improvements through better connectivity at bridges or culverts is a critical consideration in the hydrology and bridge studies. Many states are having great success in this area. Alaska, Colorado, California, Maine, Minnesota, Montana, Missouri, Mississippi, Ohio, Oregon, and Washington have programs to remedy hydrological deficiencies at bridges and culverts. Many of these states have made improvements to designs in response to threatened or endangered species considerations. Bridge/culvert replacement is also important for terrestrial species. Bridge extensions are the major measure being taken for wildlife accessibility in the states. This is doubly significant, because riparian corridors are important for wildlife movement. Therefore, extending the length of a bridge or increasing the dimensions of a culvert to include fish and wildlife movement can be a most cost-effective measure to accommodate wildlife and fisheries while also achieving transportation objectives (see discussion in chapter 7).

Another engineering concept that is being used in many states is in Context-Sensitive Design. Context-Sensitive Design is concerned with providing new opportunities for simultaneously advancing the objectives of safety, mobility, enhancement of the natural environment, and preservation of community values. Working with community stakeholders to preserve and enhance the human and natural environment becomes a significant component of these projects. Involvement of environmental professionals in all engineering and design studies is proving successful in many states for the streamlining process.

CHAPTER FOUR

TYPES OF EFFECTS

FOOTPRINT AND PHYSICAL PRESENCE

The following are effects attributed to roadways as identified in papers by several researchers (Andrews 1990; Bennet 1991; De Santo and Smith 1993; Ruediger 1998; Forman 1999; Jackson 1999). The discussion is extensive because knowledge of potential impacts is essential to proper evaluation and mitigation of project impacts.

Direct Habitat Loss

The results of the questionnaire indicate that the taking of habitat is an issue in 32 of the 35 states responding to the question. A recent study by the National Research Council (1997) estimates that approximately 20 million acres (approximately 8 million hectares) has been converted to U.S. highways, streets, and adjacent rights-of-way. This represents approximately 1% of the contiguous United States or an area about the size of South Carolina. The number underestimates the commitment of land to transportation because it does not include private roads, parking areas, and driveways.

Loss of habitat is important because the biotic and abiotic attributes of a particular area (habitat), in their total, allow specific species to survive and reproduce in that area (Morrison et al. 1998).

The variability in habitat delineation across the nation makes following wildlife trends very difficult. However, using a macro-habitat perspective of landscape features, Flather et al. (1999) describe the decreasing amount of wildlife habitat and therefore wildlife in the United States. Landscape structure that influences the distribution and abundance of wildlife is primarily affected by vegetation cover and how the land is used by humans (Forman 1995; Janetos 1997). Vitousek et al. (1997) identified human land use as the primary force changing biological diversity.

The cumulative effect of the land-use changes has resulted in a number of critically endangered ecosystems (where the presettlement extent of the system is reduced by more than 98%) by Noss and Peters (1995). Six of these habitats occur in the Rocky Mountain region, seven each occur in the North and Pacific Coast regions, and nine occur in the south.

As these habitats change so do the associated wildlife species. These changes have resulted in a global extinction rate that appears to be unprecedented in geological time (May 1990). This has resulted in efforts to save the few remaining individuals of a species because these are the species with the greatest chance of extinction. This species by species protection is reflected in the Endangered Species Act of 1973 (ESA). In terms of numbers of species listed, plants outnumber animals. For vertebrates, the list in descending order of numbers listed is fish, birds, mammals, reptiles, and amphibians. For invertebrates, clams, insects, snails, crustaceans, and arachnids are cited by decreasing numbers of species.

The quality of direct habitat lost varies with the area that a highway transects. Some habitats such as "critical habitats" for endangered species could be more important than disturbed habitats in an urban setting. Uniqueness and importance for wildlife are factors that need to be considered early in transportation planning to avoid and/or minimize impacts to wildlife. This is especially true when road projects pass through public lands such as parks, wildlife refuges, forests, and wilderness areas. Because these are lands that include wildlife values in the public interest, special care must be taken to include habitat loss as a significant part of environmental studies. On the other hand, there are opportunities to manage highway rights-of-way for native plants and associated wildlife. This is especially true in grasslands, as suggested by Harper-Lore (2002).

Degradation of Habitat Quality

Habitat areas adjacent to the roadway can experience a degradation of habitat quality due to factors such as construction impacts, noise, air quality reduction, light pollution, and invasion of exotic plants. The disturbed areas on roadsides, interchanges, underpasses, and drainage ditches facilitate establishment and migration of invasive species (Seabrook and Dettmann 1996; Parendes and Jones 2000). Reijnen et al. (1995) documented a decline in bird population along roadways with high traffic volumes, attributing the declines primarily to highway noise. Changed conditions along rights-of-way edge in forested or wilderness can lead to different animals and plant communities (Forman 1995; Reed et al. 1996). Forman and Deblinger (1998) discuss a "road effect zone," which although variable along individual roads is estimated to have an ecological affect on 15 to 20% of the land in the United States. Changes in stream hydrology, stormwater discharge, and air quality changes can influence areas adjacent to roads (Trombulak and Frissell 2000).

Habitat Fragmentation

In the survey, most state DOTs (30 of 35) reported habitat fragmentation as a concern for highways traversing wildlife movement corridors. Roads and development fragment habitat into smaller and smaller pieces that can disrupt wildlife movement. Debinski and Holt (2000) conducted a literature survey and canvassed the scientific community to identify completed experimental studies of terrestrial habitat fragmentation to determine if consistent themes were emerging from these studies. They found that studies looked at the effects of fragmentation on species richness, interspecific interactions, the role of corridor, landscape connectivity in individual movement and species richness, and the influences of edge effects on ecosystems. Although they found a remarkable lack of consistency in results, they did find consistency in that corridors and connectivity positively affect movement and species richness.

Habitat fragmentation was one of the major factors leading to wildlife crossing structures along Alligator Alley (I-75) in south Florida (Evink 1990). The four-lane, divided, Interstate highway would have isolated habitat important to the Florida panther, black bear, and other species, north and south of the highway. In Canada, the TransCanada Highway through Banff National Forest would have had a similar impact on many wildlife species (Leeson 1996).

In Europe, a major conference was held in The Netherlands focusing on fragmentation and infrastructure (Canters 1997). A network of European countries, the Infra Eco Network Europe, was formed and is conducting a study under the European Co-operation in the Field of Scientific and Technical Research (COST) Program entitled COST 341, “Habitat Fragmentation Due to Transportation Infrastructure,” which is scheduled for publication in 2002. Measures taken to address fragmentation in the United States and Europe are discussed in chapter 7, which covers conservation measures and mitigation.

Reduced Access to Vital Habitat

Highways can form such substantial barriers that they deny access to important requirements of an animal’s life cycle. An example of this situation occurred in Montana, where mountain goats were denied access to a mineral lick that satisfied a nutritional need (Singer and Doherty 1985). During especially wet years when much of their habitat is flooded, wildlife to the south of I-75 in the Big Cypress Swamp and adjacent environs in Florida use the wildlife crossings to move into dry habitat to the north of the highway (Evink 1990; Evink 1996). Jackson (1996) observed separation by highways of aquatic and terrestrial habitats needed for upland nesting for amphibians. Fowle (1996) saw the same problem for turtles in Montana where upland habitat for nesting was separated from aquatic habitat.

Population Fragmentation

Wildlife populations suffer when fragmented by roads. Dispersal of individuals between populations is important for gene flow, movement of individuals to maintain small populations, and recolonization of areas where a species has been extirpated (Shaffer 1981; Dodd 1990; Gibbs 1993; Fahrig and Merriam 1994). Road crossings can also fragment habitat for fish and aquatic animals (Furniss et al. 1991; Ruediger and Ruediger 1999). Such separation can result in the inability of individuals to find each other for reproduction. This is especially true for species that are shy of roads or do not cross high traffic roads, such as the wolf and grizzly bear (Gibeau 1996; Paquett and Callahan 1996). Pronghorn antelope (Bruns 1977) and mountain lions (Van Dyke et al. 1986) have also shown reluctance to cross roads. In Germany, genetic difference was observed in the common frog where roads were barriers (Reh and Seitz 1990).

Road Avoidance

Wildlife species composition changes due to avoidance of roadways by some animals (Lyon 1983). More recent research indicates that road avoidance has been demonstrated for bobcats (Lovallo and Anderson 1996), wolves (Thurber et al. 1994), grizzly bear (McLellan and Shackleton 1988), and black bears (Brody and Pelton 1989). Avoidance of areas adjacent to roads was apparent in a study of bird breeding and nesting in The Netherlands (Illner 1992; Reijnen 1995; Reijnen and Thissen 1997).

Increased Human Exploitation

Improved human access has lead to increased hunting pressure and poaching in many areas (Manville 1983; Fuller 1989; Cammara and Parde 1990; Ferreras et al. 1992). Human presence in the habitats of some species can influence the animal’s use of the habitat (Witmer and DeClesta 1985; Decampo et al. 1990; Czech 1997). Damage to important plant communities has also been documented (Matlack 1993). Most forest roads are built for human purposes, such as logging, mining, housing development, or other commercial purposes that lead to changes in habitat and, therefore, changes to wildlife (Van Dyke et al. 1986; Seibert and Conover 1991).

Road Mortality

Roadkill is one of the most visible results of roadways through wildlife habitat. Our understanding of the magnitude of roadkills in the United States and Canada is rather limited because of inadequate record keeping. Recent studies indicate that there are few areas of the world with motorized vehicles for which road mortality (motorist safety and wildlife species impacts) is not an issue. In Yellowstone National Park, elk and mule deer are the species most often killed. However, bison, moose, coyote, antelope, beaver, whitetail deer, bighorn sheep, black bear, bobcat, grizzly bear, raccoon, and wolf are among the other animals killed on park roads (Gunther et al. 1998). Ruediger (1996, 1998) has documented the problem for large carnivores. In Canada, the TransCanada Highway has been studied and identified as a mortality factor for elk, mule deer, gray wolf, grizzly bear, and a number of other species (Gibeau 1996; Leeson 1996; Paquet and Callahan 1996; Gibeau and Herrero 1998; Callahan et al. 1999). In Saguaro National Park, Kline and Swann (1998) have monitored wildlife mortality for amphibians, reptiles, birds, and mammals to arrive at management implications of this mortality factor. Also, there seems to be correlation between high traffic levels and mortality in toads and frogs in Ontario as reported by Fahrig et al. (1995). Indications are that the magnitude of roadkill in the United States and Canada is significant enough to deserve thorough consideration in transportation planning and development.

Road Density Relationships

The relationship of road density to wildlife has been discussed as having a negative effect on many of the previously mentioned factors including fragmentation, wildlife movement, and human presence (Forman 1995, 1996, 1999). In North Carolina, black bears moved their home ranges away from areas with high road density (Brody and Pelton 1989). McLellan and Shackleton (1988) observed the same for grizzly bears in the Rocky Mountains.

Anthropic Habituation

The presence of roads and associated development has lead many species to become accustomed to human presence. These animals can become problem animals resulting in their elimination from the population. In the management of black bears and grizzly in Yellowstone National Park this situation is well documented by Gunther and Biel (1998).

Changed Biodiversity

Changed biodiversity is the biological result of the many effects that roads can have on the immediate and surrounding habitats. Biodiversity as used in this report is defined using the Convention on Biological Diversity definition from the Earth Summit held in Rio Janeiro in 1992.

> *The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.*
>
> (Article 2 CBD, 1992)

Effects on biodiversity can be attributed to the simple concept that changes in one component (biotic or abiotic) of an ecosystem will result in changes to other components. However, biodiversity of a native habitat could be increased or decreased as a result of the introduction of a road into a natural ecosystem. Low diversity systems may experience an increase in biodiversity as a result of introduced species resulting from the disturbance caused by the road. Either way the natural biodiversity of the prior system is changed. With the introduction of exotics or species not native to the system, the ecosystem has been negatively affected.

Noss (1990) and Byron (2000) have written important documents on biodiversity. The following thoughts are largely derived from their works. Biodiversity can change at many levels—bioregional, landscape, ecosystem, habitat, communities, species, populations, individuals, and genes. This is a result of changes to the structural and functional relationships in the original ecosystem. Structural changes relate to connectivity, spatial linkage, patchiness, fragmentation, slope and aspect, the distribution of key physical features, water and food availability, dispersion, and range and population structure such as sex and age ratios. Functional relationships include disturbance processes, nutrient cycling rates, energy flow rates, hydrologic processes, human land-use trends, metapopulation dynamics, population genetics, population fluctuations, and demographic processes such as fertility, survivorship, and mortality.

The planner, engineer, biologist, or manager reviewing roadway planning, design, construction, and maintenance needs to realize that all components of a natural system are connected and although the immediate impact to habitat may seem small, the ramifications of any change will be felt through changes to biological diversity.

There are also opportunities to improve situations in disturbed ecosystems through the restoration of natural biodiversity. These need to be identified and used as mitigation opportunities.

Changed Hydrology

Similar to biodiversity, changed hydrology has effects throughout the entire drainage system. It can also change the timing and routing of runoff (King and Tennyson 1984; Jones and Grant 1996; Ziemer and Lisle 1998). Hydrological systems have always changed to accommodate the changing environmental conditions. A change at one point along a system results in upstream and downstream changes that can range from minor erosion and deposition to changes to the entire drainage basin. The hydrological system is constantly in search of its energetic balance. In simpler terms, the energy of the moving water is changing throughout the run and any structural change to the water body will cause changes to the aquatic system—erosion and deposition (Richardson et al. 1975; Ruediger and Ruediger 1999). Adjacent streams adjust to changed hydrology by transporting more or less sediment, thereby changing bed materials, slopes, and water velocities (Gordon et al. 1992). The effects of degradation may progress into the headwaters of the stream (Heede 1986). These changes can have negative impacts on aquatic organisms as well as the surrounding drainage area. Therefore, impacts to these aquatic systems must be considered with avoidance and minimization being the objective.

CONSTRUCTION AND OPERATIONAL ASPECTS

Construction activities and the operation of roads that result in environmental effects in some regards are more obvious than those associated with the actual presence of the road. For example, erosion from clearing for road construction is very obvious, salt spread on roads damages our cars, and oil and chemical slicks are visible after a long-awaited rain. The dangers associated with hauling environmentally dangerous materials on our roads are also obvious, especially if this activity results in a leak or a spill. As a result, almost everyone experiences the noise and disruption associated with roads on a daily basis and know the impact that it has on our personal lives, including headaches, increased impatience, and general deterioration of the quality of life. The following are some aspects that affect natural systems.

Erosion

Erosion might be the number one factor in the degradation of aquatic systems. Unstabilized areas from construction and the operation of heavy equipment, not just roads, lead to millions of tons of soil, organic matter, and chemicals entering our aquatic systems. Unanticipated storms can overwhelm often-inadequate erosion control features resulting in major adverse effects from the deposition of these materials in natural systems. Large areas of important aquatic habitat can be destroyed (buried) in a relatively short period. Cumulatively, erosion threatens every disturbed watershed in the United States. Despite advancements in knowledge and techniques, erosion control remains one of the major problems associated with any construction or operational activity that has the potential to disturb vegetation.

Stormwater Quality

Stormwater runoff has the potential to collect all pollutants and transport them to the nearest water body. Stormwater from roads mixes with stormwater from across the contributing area and can end up in our streams and lakes. Although in most situations the levels of highway-related pollutants from all but the heaviest traffic level roads are below the limits of detection after mixing in the receiving waters, because stormwater is coming from a larger contributing area often results in levels that can impact stream or lake biota. Once high traffic levels are reached, levels of pollutants from roads can become problematic. Therefore, because of the potential for water quality degradation due to stormwater runoff, stormwater treatment has become a standard feature on many high-volume highways in this country.

Maintenance Chemicals

Fortunately, years of refinement in the use of chemicals in highway maintenance have eliminated most of the worst. State maintenance employees also receive required training before using these chemicals on highway rights-of-way. Many states are taking the initiative to reduce the use of chemicals in maintenance just because of the negative image that has resulted for previous use of harmful chemicals (DDT, etc.) and the improper use of chemicals (mass sprayings that kill off large areas of vegetation, improper use around sensitive native vegetation or aquatic communities, etc.). Since the U.S. Environmental Protection Agency (EPA) has begun to regulate the harmful chemicals, the vast majority of transportation departments have become educated in the what, where, and how to use chemicals to reduce maintenance costs while protecting the environment. Some maintenance activities associated with wildlife features, however, would be cost-prohibitive without the use of chemicals. An example of this is the maintenance of vegetation along wildlife fencing so that animals do not use the vegetation to get over the fence. For the Florida case study, there is a total of approximately 80 miles of wildlife fence on the project, and control of vegetation by manual means would be unsuccessful because of the 12-month south Florida growing season. In evaluating the national situation, it was evident that the use of chemicals, other than salt, on highways is only causing localized impacts, which are confined to the road rights-of-way and necessary for often positive purposes for wildlife.

Salts

The EPA (1996) reports that between the mid-1980s to the mid-1990s approximately 10 million tons of rock salt was used on the nations roads and caused at least 11% of the impaired stream mile reported nationally. All living organisms need salt, but as with the human population too much of a good thing can have negative consequences. For freshwater systems, salt at high levels is a pollutant. Subtle changes in salt content can result in impacts to the lowest members of the food chain and move right on up into the top organisms. This is especially true in the upper reaches of watersheds, where dilution is not sufficient to reduce the potential impacts to these aquatic organisms that have evolved in very clean water environments.

Noise Impacts

Highway noise has become a factor in the vicinity of high average daily traffic facilities. The major effects are avoidance of habitat around the roads. Research in The Netherlands indicates that in both forested and grassland habitats bird populations are disrupted by noise (Reijnen 1995; Reijnen et al. 1996).

Hazardous Materials/Emergency Procedures

The EPA (1996) reports that between 1990 and 1994 there were an average of 10,000 hazardous materials spills each year. Approximately 75% of these materials were flammable/combustible materials and approximately 11% were corrosive materials. With the increased transport and use of hazardous materials, including radioactive materials, the dangers to the environment including the human environment become immense. Single accidents have the potential to affect large areas around a highway with catastrophic and long-term detrimental effects. Fortunately, the safety record, for the most part, has been reassuring and emergency procedures are in place in all transportation departments for quick response to such impacts. However, with increased use of chemicals the danger is ever increasing and it is a potential threat to habitats and wildlife along highway corridors. The most damaging accidents in recent history have occurred where spills reached aquatic systems resulting in large-scale downstream impacts.

SECONDARY AND CUMULATIVE EFFECTS

Secondary and cumulative effect analysis is required on federal-aid projects. The difficulty is that the form of the analysis is ill defined; the result of the complexity of factors unrelated to the transportation facility that are a part of the evaluations. Secondary and cumulative impacts of the construction, operation, and maintenance of a project are more easily defined than those associated with planned growth, which was facilitated by the completion of the transportation infrastructure component of that planned growth. The role of growth management has often been laid at transportation's door and in many cases mitigation for growth impacts expected. Certainly transportation is a partner in the planned growth process, but hardly the reason for the growth—that can be attributed to the plan. In all states, agencies other than the transportation agency have responsibility for growth management and planning. The debate about transportation's role in growth and mitigation responsibilities has gone on for years and no totally satisfactory resolution is in sight. [See *NCHRP Report 403: Guidance for Estimating the Indirect Effects of Proposed Transportation Projects* (TRB 1998) for a thorough discussion of this topic. "Considering Cumulative Effects, Under the National Environmental Policy Act" (Council on Environmental Quality 1997) is also a source of guidance on cumulative effects.] The following discussion is confined to the secondary and cumulative aspects of highway projects excluding the growth aspect.

Secondary Project Effects

Secondary impacts (often referred to as indirect impacts) are impacts that occur later in time or are physically removed from the proposed project. An adverse change in air quality down wind of a major project as traffic levels increase is an example of a secondary impact. Noise impacts as traffic increases on a project that results in reduced animal populations for some distance from the road is another example of secondary project effects. Upstream/downstream flooding or changes in hydrology as a result of changes in impervious area are also secondary impacts. Each of these factors can have secondary impacts on plant and animal communities in areas removed from the proposed project such that documentation of these effects is necessary during environmental studies to determine the effected environment and consequences of the actions.

Cumulative Project Effects

CEQ regulations that implement NEPA defines cumulative impacts as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or persons undertakes such other action" (40 CFR 1508.7). A practical guide for evaluating cumulative effects was published by CEQ (1997). The following thoughts as relates to wildlife and highway considerations are taken from this document. First, the direct impacts to wildlife as a result of an action are more easily determined than the cumulative impacts of often ill-defined past, present, and future actions in the project area, making the analysis of cumulative effects more difficult than analysis of direct effects. The dimensions of cumulative effects analysis change dependent on the geographic (spatial) and time (temporal) boundaries defined for that analysis. The most successful efforts to define and resolve cumulative impact issues have been the result of enhancing the traditional components of environmental impact assessment through a collaborative coordination process with interested agencies and individuals during the scoping process; when describing the affected environment and determining the environmental consequences. As relates to wildlife, the cumulative analysis is critical with definition of the spatial and temporal boundaries being the initial challenge. The reader can imagine the size of the area requiring analysis when dealing with far-ranging species such as large carnivores and ungulates. It always takes the inputs of an interdisciplinary group to address cumulative effects in environmentally sensitive areas of habitat and associated wildlife because of the diversity of expertise required to fully understand the ramifications of cumulative actions. Examples of cumulative effects are contained in Table 1.

Growth Management Relations

Any discussion of secondary and cumulative impacts would be incomplete without an understanding of the relationship of growth management planning to the larger scale effects that the actions of many, including transportation, can have on the environment. Like all aspects of wildlife ecology, the places where we have problems are the places where poor growth management planning has resulted in actions detrimental to native habitats and wildlife. This is true on both private lands and public lands. Where transportation agencies find trouble is when poor planning results in the collision of the need for an efficient transportation system and the need for maintenance of native habitats and wildlife, which is often on public lands. Often it is the result of a lack of vision about the secondary and cumulative impacts of the actions contained in a growth management plan that leads to poor transportation decisions.

TABLE 1
EXAMPLES OF CUMULATIVE EFFECTS (from CEQ 1997)

Type	Main Characteristic	Example
Time crowding	Frequent and repetitive on an environmental system	Forest harvesting rate exceeds regrowth
Time lags	Delayed effects	Exposure to carcinogens
Space crowding	High spatial density of effects on an environmental system	Pollution discharges into streams from nonpoint sources
Cross-boundary	Effects occur away from the source	Acid precipitation
Fragmentation	Change in landscape pattern	Fragmentation of wildlife habitat
Compounding effects	Effects arising from multiple sources or pathways	Synergism among pesticides
Indirect effects	Secondary effects	Commercial development following highway construction
Triggers and thresholds	Fundamental changes in system behavior or structure	Global climate change

CHAPTER FIVE

SCALE OF ASSESSMENT AND EFFECTS

In observing environmental factors, from individual organisms to landscapes, it is important for the scientist to look at all scales of the ecosystems being studied. The resolution of data (grain) and the size of the study area (extent) have direct bearing on the ability to determine the true nature of the area being studied and the potential impacts associated with the activity. The responses in Table 2 indicate that states are dealing with the breadth of scales conceivable in environmental assessment and mitigation/conservation strategies. The difference in scale from the life-cycle requirements of reptiles and amphibians to grizzly bear and wolves is significant. It is clear from the responses that some states are addressing issues of scale. Montana's US-93 case study discusses some of the realities of linear projects through multiple habitats and the necessity of dealing with scale. The following is a scientific discussion of important elements for consideration when conducting environmental assessments and determining subsequent measure to address those impacts—mitigation and conservation measures. In some cases, these are complex concepts, but deserve treatment in relation to the forthcoming discussion of analytical tools presented in chapter 6. That states are dealing with these sometimes-complex relationships is evident from the types of organisms encountered on projects (Table 2). The mitigation/conser-vation measures provided, which are described in chapter 7, also reflect an understanding of these relationships in some states.

TABLE 2
TYPES OF ORGANISMS STATES ARE ENCOUNTERING RESULTING IN MITIGATION

Organism Type	Yes	No
Reptiles	24	11
Amphibians	20	15
Birds	32	3
Small mammals	21	14
Other—fish, mussels, plants, beetles, butterflies, marine organisms, turtles	23	12

MICRO-ECOLOGY TO LANDSCAPE ECOLOGY

Every living thing has certain requirements to exist. The adaptive nature of habitat preferences is based in natural selection and has genetic ramifications (Jaenike and Holt 1991). At one end of the scale, micro-environments (habitats) support microscopic organisms that perform important functions in the ecosystem that are not obvious at first glance. At the other end of the scale are the more obvious large carnivores and ungulates (bears, wolves, elk, etc.) that need landscape level areas to successfully maintain their populations. For discussion purposes, we treat all of these organisms as "wildlife," because of their interdependence. Scale is a spectrum that is continuous from the micro- to macro-environments. Each component has a role in maintenance of the whole. The impacts to the total cannot be understood when looking exclusively at the impacts to individual components. The ramifications of an action at one level in the system can be felt throughout the entire system. A look at the three possible levels of spatial data gives a point of reference. At the spatial point level (e.g., individual trees mapped within a forest stand) it is difficult to see the relationship with the landscape. At the geostatistical data level (e.g., environmental variables from geo-referenced sample quadrats) we get a little better understanding of relationships. However, only at the lattice data level (e.g., a land cover map as represented in a geographic information system) do we see the forest. The same is true in the reverse sequence in that it is hard to understand the individual tree from the lattice data level. That impacts at any point in this continuous scale will have ramifications at other levels of the scale is basic in impact analysis. Therefore, it is important to look at everything with the understanding of connectivity.

A simplistic example would be the killing of aquatic micro-organisms by a pollutant. The micro-organisms play a role in the maintenance of water quality that is important to the other organisms living in the aquatic system. Elimination of the micro-organisms can cause water quality changes that affect the ability of other organisms to survive in the aquatic environment. This can move up through the food chain in the aquatic system and eventually reach the macro-scale, when larger aquatic organisms important to terrestrial species are eliminated from the system because of the disruption in their food chain. Therefore, the scientist looking at potential impacts of an action needs to look at the entire system rather than any specific element of the system. For larger organisms, it is necessary to move to the landscape scale to understand relationships to a proposed action. In reverse, the elimination of a higher order organism eliminates a consumer thereby allowing for the overpopulation of organisms back down the food chain (e.g., overpopulation and reduction of health in deer populations through elimination of predators). For example, the current imbalance of the deer populations in many areas of the country has lead to increased kills on the highways.

ORGANISM'S LIFE-CYCLE REQUIREMENTS

All organisms have basic requirements in their life cycle to survive, reproduce, and maintain sustainable populations, including at the most basic level, food, water, and cover (habitat). These are obvious when assessing habitat, organisms, and probable impacts. However, there are many other requirements that can be disrupted with changing land use associated with transportation development. The need to reproduce is predicated on the need to find a mate, which can be hindered through fragmentation of habitat. This is especially true at the two ends of the scale spectrum—small organisms with small home ranges unable or reluctant to cross wide corridors or large organisms with huge home ranges that have to cross many dangerous corridors to even find a mate [see Fahrig and Merriam (1994) for one end of the spectrum and Ruediger (1996, 1998) for the other end of the spectrum].

Another example of the less obvious points in an organisms life cycle is that different habitats may be needed at different points in a life cycle. Amphibian is a Greek construction meaning "double life," which bears reference to the typical aquatic and terrestrial aspects of their life cycle. Amphibians need the ability to cross transportation facilities separating their aquatic and terrestrial habitats (Langton 1989; Fahrig and Merriam 1994; Jackson 1996; Means 1996).

Sizes and Types of Habitats to Satisfy Requirements

Size is a relative thing. Generally, less mobile animals require smaller habitats. Evolution has enabled a given species with the mobility to satisfy their species-specific needs. However, generalities do not usually work in ecology and there are many exceptions. Birds are often small organisms, but flight gives them the ability to travel great distances to satisfy their life requirements. The home range requirements of different species are dependent to a large part on the diversity of habitats required in the life cycle of that organism.

Few species require just one habitat type to satisfy all of their life-cycle requirements, although the diversity of habitat types needed varies in a species-specific manner. Impacts to a habitat that is required by a species can eliminate a species from an area even though the remaining habitat requirements remain intact.

Seasonal Relationships

With seasonal changes, an organism's life-cycle requirements change. Some organisms merely slow their metabolic processes to cope with the seasonal change. Others move to less severe climates by migration, which often can involve traveling great distances. States that deal with migratory birds regularly deal with this fact of nature. Other species such as the grizzly, caribou, and other inhabitants of mountainous areas move up and down the mountains using different habitats during the seasons. This can cause problems when highways cross these seasonal movement corridors. Habitat use in the Everglades is dictated by the wet and dry seasons, with a more general use of the area during dry seasons. This was a consideration in measures to protect the Florida panther and other wildlife along Alligator Alley (I-75), where crossings were placed in the highway to allow wildlife movement to the drier northern areas during exceptionally wet years when habitat values were diminished in the area to the south of the highway (Evink 1990).

Patch Size and Shape

Ecosystems are a patchwork of habitats of varying size and shape. The importance of patch size and shape at the organism level are presence/absence, size, and quality. The shape of these patches has implications to edge effect. Patch size and shape may have important species-specific ramifications when evaluating habitat and organisms.

Edge Effects

Edge effect is seen when interior woodland habitat areas are opened by a highway corridor. The habitat edge that is created will have a different species composition than what was present in the previous wooded community. This effect was seen in the breeding bird populations when I-95 was built in northern Maine (Ferris 1979). The effect has the potential to be negative or positive depending on given site-specific considerations. If an edge species is rare in an area, the opening of edge can have a positive effect on the population if it is a species that is not susceptible to highway mortality. Red-cockaded woodpeckers, an endangered species in Florida, are known to use trees along road edges for nesting and feeding. On the other hand, some interior bird populations seem to suffer with the opening of these habitats.

Landscape Heterogeneity and Integrity

Landscape heterogeneity is the variability of plants and organisms over the landscape. The integrity of these landscapes assures the health of the components of that heterogeneity. How this heterogeneity varies over time and space and the subsequent landscape responses greatly influence the distribution and performance of organisms occurring on the landscape. Heterogeneous landscapes alter ecological interactions by modifying fluxes of organisms, material, and energy. How organisms perceive and integrate patterns of heterogeneity is not well understood. The integrity of these components of the landscape greatly influences what succeeds in a given landscape. For some organisms, a very heterogeneous landscape is best, whereas for others a more homogeneous landscape will lead to success. Complex landscape heterogeneity allows a wide variety of organisms to live in the same landscape using different elements simultaneously for feeding and cover. Changes to that heterogeneity by the taking of habitat can change the fluxes, resulting in ramifications throughout the landscape.

Biodiversity

Biodiversity forms the fundamental biological systems and processes that sustain life on this planet. An excellent discussion of biodiversity assessment in relation to road projects is contained in Byron (2000). The three levels at which biodiversity is usually defined are genetic (genetic information in an individual), species (variety of living species), and ecosystem (variety of habitats, biotic communities, and ecological processes). The earth's biodiversity is the result of millions of years of evolutionary history and is constantly changing with the changes in ecosystems and associated species. At the ecosystem level, protection of water resources, soil formation and protection, nutrient storage and cycling, pollution breakdown and absorption, climate stability, maintenance of ecosystems, and recovery from unpredictable events are all supported by the biological diversity of the planet. To humans, the resources represented are food, medicinal resources, wood products, ornamental plants, breeding stock, future resources, recreation, and cultural values. In total the value of biodiversity is inestimable. Our quality of life and for that matter life itself depends on it. Unfortunately, the activities of man, including transportation, are changing the biodiversity of the planet—often in a negative manner. Each element of natural biodiversity that is eliminated by conversion to infrastructure reduces the total. The conservation of biodiversity by avoidance and minimization seeks to maintain the very life support systems provided by nature and therefore sustainability.

Succession and Evolution

Things are constantly changing and what you see today is not what will be there in the future. An accurate picture of what exists along a proposed corridor says little about what will exist over the life expectancy (design life) of a project. The vegetative communities that are inventoried along the corridor, the species composition carefully documented, and the land use of those communities is constantly changing. The changes on the short-term are called succession, whereas on the long term evolutionary selection is taking place. This issue is turning up on transportation projects across the country, especially as it relates to wildlife habitat on public lands. Mitigation strategies to deal with wildlife need to take into account that what is out there now is not what will be out there forever. The connectivity attributes of a habitat feature may change with successive changes in land use. Therefore, a mitigation design that accounts for these changes will stand the test of time. The survey results indicate that few of the structural mitigation measures being implemented by the states have been researched for long enough to prove their effectiveness over time. Natural succession along transportation projects is another fact of life that leads to the wisdom of ecosystem level and programmatic approaches to mitigation, such as the Tall Grass Prairie project in Colorado, the upland banking project in Florida, and the Coal Canyon Corridor in California.

CHAPTER SIX

ANALYTICAL TOOLS AND PROJECT MONITORING

MOTORIST SAFETY STUDY

One special study concern is motorist safety and the problems resulting from vehicular collisions with wildlife. Animal/vehicle collision studies are used as an analytical tool to identify overall trends and problem areas because collisions with larger animals can result in substantial damage and personal injury. The act of trying to avoid hitting an animal can also result in accidents. It is clear from the information gathered that collisions with wildlife are a serious motorist safety problem.

No terrestrial group of animals in the developed countries of the world is immune from being killed on roads. Whether they fly, walk, run, or crawl, move fast or slow, if they cross highways, members of a species are killed. For some species, highway mortality can be a significant factor (Clarke et al. 1998). For example, the toll for invertebrates can be staggering, as evidenced by the number of smashed bugs on automobile windshields.

New databases are being developed to analyze the severity of deer collisions. Currently, some of the best information on deer collisions is being assembled by the Deer Vehicle Collision Reduction Working Group (www.deercrash.com), which is soliciting data on vehicle-related deer kill from the states. At present, the site is primarily recording information on the midwestern states, but it has the potential to become a national clearinghouse for mortality information.

Conover et al. (1995) estimated that nationally more than 1.5 million automobile collisions with deer occur annually. These collisions result in more than 29,000 human injuries and more than 200 deaths. Rue (1989) estimated that 0.029% of the collisions with deer result in human mortality. Romin and Bissonette (1996) concluded that collisions with deer are on the increase.

Vehicular damage can be severe and this is especially the case in states with high deer populations. Conover et al. (1995) estimated that annual damage to vehicles from deer collisions exceeds $1.1 billion. Another economic impact of animal mortality is the loss of the animal for hunting. Romin and Bissonette (1996) estimated that the value of a mule deer harvested in Utah was $1,313.

Databases such as WARS 2000—Wildlife Accident Reporting System (Sielecki 2000) and the Washington State DOT deer kill database (Carey 2002) are being developed by transportation agencies to (1) identify wildlife accident-prone locations and wildlife accident trends, (2) direct wildlife accident mitigation efforts, (3) evaluate the effectiveness of wildlife accident mitigation techniques, (4) provide wildlife data for highway planning purposes, (5) model and forecast wildlife accidents, and (6) establish policies and strategies for wildlife accident issues. These databases are developed from a variety of data sources. Police collision records, maintenance staff records, and roadside surveys by researchers are three information sources reported by the states.

HABITAT AND WILDLIFE STUDY DESIGN

The following discussion applies to the study design for analysis of impacts to aquatic, terrestrial, and riparian communities. A typical overall study design for a long linear project will involve many smaller studies of habitats and wildlife encountered by the footprint of the project. In large areas of land with mobile wildlife populations, the study area can take on landscape dimensions as fragmentation and connectivity become considerations. Each project will have its own character as aspects such as nonhabitat features and past modification play into otherwise straightforward habitat evaluation. Therefore, study design will vary on a project-by-project basis.

Scale, as discussed in chapter 5, is an important consideration in study design. Once scale has been addressed for the important habitats along a corridor, study elements can be applied to documenting the importance of each habitat encountered and the potential for significant impacts. The following section is a discussion of some of the elements and approaches that the states are using.

STUDY ELEMENTS

From the transportation agency responses, it is clear that the states understand that the study of natural systems requires specific expertise and training, just as the engineering of roads requires specific expertise. Specific expertise, such as the ability to classify and delineate ecosystems and wildlife home ranges, interpret remotely sensed data, conduct field surveys of habitats and wildlife, organize natural resources data, analyze and interpret natural resources data, and coordinate with scientists and the public are just a few of the talents needed to ensure the credibility of the studies and success in the regulatory process. Therefore, it takes an interdisciplinary team involving transportation scientists and engineers, regulatory personnel, state and federal wildlife personnel, local experts, conservation groups, and other interested parties in a collaborative process of discovery of what is involved on the project, the affected environment and wildlife, and the measures necessary to avoid, minimize, and/or mitigate the impacts to wildlife. The following is how most states handle habitat and wildlife studies on large and complex projects.

In this country, natural systems have been studied to the degree that a basic understanding of those systems exists. Scientists involved in highway studies gain an understanding of the systems in their area of responsibility. Some of the less common systems have even been extensively studied to document their importance. Excellent references can be located for the purposes of learning about the ecological areas within a state. In Florida, such an example is *Ecosystems of Florida*, edited by Meyers and Ewel (1990).

Studies to support the NEPA document or defend the categorical exclusion class of action determination normally begin with a thorough literature search and consultation with local experts—not just those in the resource agencies, but also universities, private citizens, conservation groups, etc. Scientists obtain this information and identify other sources of expertise at the beginning of the studies. State studies of habitat and wildlife can best be described as classification-oriented using principle components as indicators of habitat quality. That is to say they look at the habitat classification (e.g., bottomland hardwoods) and the principal species typically associated with that classification (vegetation and wildlife) along the corridor.

The states are using black and white aerials, infrared aerials, or GIS with the typical section superimposed on these images. GIS are being used in 23 of the responding states, whereas Global Positioning Systems (GPS) are used in 15. States are using GIS and GPS as an efficient way to evaluate long corridors with landscape type issues as well as smaller projects. ArcView was the most frequently used GIS format, while Trimble Navigation was reported as a popular GPS system. GIS and GPS are becoming valuable tools in the system and project level studies, although most states are just exploring these possibilities or have limited resources.

States are also using their Natural Heritage Programs or other state agencies for GIS information. A few state transportation agencies are contributing to the development of data layers. Florida has completed a study of the entire state and is actively using the information in system planning and project development studies (Carr et al. 1996; Kautz et al. 1999; Smith 1999). An interagency effort (Southeastern Ecological Framework) is taking place to develop this type of GIS information for the entire southeastern United States.

The Missouri DOT used GIS to identify environmental constraints for a large project on I-70 between Kansas City and St. Louis (Unruh et al. 2002).

These tools are used to determine the degree of involvement with associated habitats and wildlife. The identification, classification, and delineation of those ecosystems encountered by the project are completed early in the study. This is true for all of the types of ecosystems (terrestrial, aquatic, estuarine, etc.) discussed in this report. This is the point at which involvements with regulated communities and wildlife (wetlands, threatened and endangered species) are determined.

Field evaluations are frequently conducted with personnel from the regulatory agencies to arrive at a mutual understanding of the natural values in the project area and discuss potential impacts. To improve record keeping during field trips, Maine is acquiring field data software and hand-held computers to create "electronic field books." Discussion of avoidance/minimization measures and mitigation strategies often begins in these field studies.

Eleven states reported on what analytical techniques they use. The Wetland Functional Analysis (WET II) and Hydrogeomorphic Method of wetland functional assessment (HGM) were the two most often reported. Although site-specific variability occurs in wetlands, most qualities of these ecosystems will be evident from the existing knowledge of the local area. This is the basis for the development of HGM (Brinson 1993). HGM employs reference systems to provide baseline information on the typical wetlands type for a given ecosystem. The scientist looks at the attributes of the wetlands encountered along a proposed corridor or project in relation to this idealized reference wetland to determine relative importance in terms of functions performed that give it value to mankind. Although similar assessment techniques for uplands were not reported, the approach of comparative analysis of ecosystem quality, using actual and/or conceptual images of a pristine ecosystem, is sometimes used collaboratively by the state transportation and resource agencies to determine habitat quality.

WET II (Adamus et al. 1987) is also used to evaluate the functions of the study wetland. This approach documents functional aspects such as wildlife habitat and quantity/quality attributes of wetlands. Although a functional analysis technique for upland ecosystems has not been developed, the concept of looking at functions is also applicable to all ecosystems during the quality analysis phase of study.

Kansas was one of the few respondents with a state-specific "Wildlife Habitat Assessment" technique that was developed by their Department of Wildlife Protection. The Washington State Departments of Ecology and Transportation each have a Wetland Functions Best Performance Judgment Tool and a Wetland Functions Characterization Tool for Linear Projects, which were developed specifically for Washington wetlands that are based on WET II and HGM.

In particularly sensitive situations, the actual sampling of a system may be necessary to document the presence of key elements that are considered important or are protected (rare species). This is typically done in a plot or transect-type assessment within the larger habitat. For protected species, mere presence/absence is usually insufficient and a complete inventory of the corridor and adjacent habitats is generally necessary. The extent of any adjacent habitat inventoried varies with the species being considered and the vulnerability of the species to potential impacts from the project. These considerations are generally not already defined, but become determined through coordination with the resource agencies. The end result is habitat and species characterization in the area of the plan or project.

The FWS Habitat Evaluation Procedure (HEP) is used by some states (USFWS 1980) where the project warrants the expenditure of time and effort, as it is not a rapid assessment method. The technique is designed to provide a consistent means of assessing project development impacts by (1) assigning a quantitative index value for existing habitat conditions, (2) determining the difference between the index value of existing conditions and conditions that will result from a proposed project, and (3) demonstrating, in habitat-value units gained or lost, the beneficial or adverse impacts anticipated as a result of the proposed project. One of the weaknesses of HEP is that it uses Habitat Suitability Index models to look at a limited number of end-point species and uses the habitat requirements of these target species to generate a sublisting of environmental variables that must be analyzed or quantified. Measured variables of habitat information are entered in an interactive program that outputs a Habitat Suitability Index from 0.0 to 1.0. Input variables are adjusted to reflect the post-construction situation and the indexes are compared for impact analysis. Because of its labor-intensive nature, HEP has not become the standard for evaluating habitats on transportation projects. The Pennsylvania DOT developed and received approval to use a modified HEP for wildlife habitat evaluation and upland mitigation (Dodds 1996). This technique was abandoned because of the level of effort and manpower needed to complete the evaluations. Subsequently, a community-based, landscape-level, terrestrial mitigation decision support system was developed (Maurer 1999). In some cases, HEP is being used by the FWS for large areas such as South Florida to evaluate the cumulative impacts of numerous actions including roads.

Roadkill and snow/sand track monitoring are also frequently being used to identify animals and record their movements within a study area (Scheick and Jones 1999; Singleton and Lehmkuhl 1999). On complex projects, studies are often contracted to other agencies [state game and fish or environmental agencies, FWS, U.S. Forest Service (USFS), EPA] by the state DOTs. A few state DOTs are financing more sophisticated radio-telemetry studies for important species in important ecological areas of their states—Florida (Land and Lotz 1996; Roof and Wooding 1996; Eason and McCown 2002) and Montana (Waller and Servheen 1999). These studies are using the latest technology, such as hair sampling for genetic identification of individuals in population estimates (Eason and McCown 2002). Wills (2002) reports using a similar technique with barbed wire hair traps to monitor travel corridors used by black bears in the Great Dismal Swamp National Wildlife Refuge in Virginia. Boarman et al. (1998) used a passive integrated transponder system for tracking desert tortoise to study movement through a series of culverts along California Highway 58 in the Mohave Desert. It became clear that it was necessary to start this type of study early in the process so that information is available for decisions in the planning or PD&E process.

State DOTs are becoming more involved in aquatic studies because of increases in listed species—principally mussels and fish. Mussels and fisheries have suffered the cumulative effects of years of modifications of aquatic habitat through impoundments, channelization and dredging, sedimentation, and water pollution. For mussels, the decline over the past century has been dramatic (Neves 1993). A comprehensive review of the problems in aquatic systems is contained in Loftus and Flather (2000).

For the water quality portion of aquatic systems analysis, a pollution risk assessment is done to determine the potential for water quality impacts. This involves observing the contributing area for discharge through the transportation drainage system and estimating the potential for pollution. For the erosion aspects, best management practices are used in a pollution control plan to address the requirements of the National Pollution Discharge and Elimination System. Typically, if stormwater impacts to the aquatic system exist, best management practices are required.

Similar to terrestrial communities, studies and classification of aquatic systems give the scientist a basis for evaluating the potential for impacts. Resource agencies or other groups have extensively studied many aquatic systems, and involving this expertise in project development is important. As mentioned earlier, the important considerations in relation to aquatic systems are erosion, stormwater, channel modifications, and bridge/culvert characteristics for aquatic organism movement.

Ecological models are being developed that contribute to the scientist's knowledge of some aspects of wildlife ecology and roads. Some models with relevance to transportation look at systems level aspects such as locating wildlife permeability features. Smith (1999) developed a Florida statewide assessment model. Singleton and Lehmkuhl (1999) developed a "least-cost path" model for identifying linkages in Washington. Clevenger et al. (2002) developed a GIS-generated expert-based model for use in identifying habitat linkages and mitigation planning. With the increasing use of GIS and GPS capabilities in transportation, there is the potential for development of effective decision-making models for application at both the system and project level of transportation development.

The need for standard analytic techniques for assessing wildlife ecology and transportation is evident from the state responses. This need is being addressed by a committee formed by the National Research Council's Board on Environmental Studies and Toxicology. One objective of the committee is the creation of a conceptual framework and approach for development of rapid assessment methodologies.

CHAPTER SEVEN

CONSERVATION MEASURES AND MITIGATION

Conservation measures and mitigation related to wildlife or habitat impacts are largely the result of regulatory programs at the state or federal level. The regulations that most states are addressing are contained in chapter 2 and Appendix C. The measures taken are the result of a collaborative process with the environmental resource agencies. The results vary greatly because of differing interpretation and regulatory philosophies at the state and federal resource agencies.

In addition to regulatory programs, state initiatives, such as greenway programs, state land acquisition activities, and other programs to provide wildlife connectivity, influence the planning and project development process. Where it is a state or federal goal to provide connectivity and significant amounts of money (local, state, and federal) have or are being expended to purchase lands for linkage and core areas of habitat, transportation agencies have responded with parallel structured measures for connectivity on the highways. Provisions for connectivity on the highway system will increase as research better defines the important linkage and core areas in relation to the transportation infrastructure.

Projects that feature retrofits and enhancements to solve existing problems are being constructed by several states. Often there is the opportunity to carry out this type of project in conjunction with other activities, such as trails or rails-to-trails projects.

Motorist safety, wildlife conservation, and public interest have influenced the implementation of these projects. Examples of projects that were the result of each of the above motivations are contained in this chapter and the case studies in chapter 10.

STRUCTURAL TECHNIQUES

A Wildlife Crossing Structures Toolkit is being developed as a searchable internet-based database by a partnership of the USFS, Bureau of Indian Affairs, National Park Service, FWS, FHWA, and Utah State University. The toolkit can be found at www.crossingstructures.com, which is currently under development.

As the importance of reducing wildlife mortality for both wildlife conservation and motorist safety has become more widely recognized, some states have begun employing structural measures to address problematic areas of highways. Jackson and Griffin (1998) researched factors important to the success of structural measures and indicated that size, location, light, moisture, temperature, noise, substrate, and fencing can prove species-specific factors to be considered in designs. Most states responding to the questionnaire have taken measures. However, few states reported that they have actually researched the effectiveness of the measures. The following is an account of what is being used and the results of published research about the effectiveness of the measures.

Fencing

Fencing is a common practice used throughout the world to keep animals off highways. Twenty-eight of the states responding are using fencing to protect wildlife (Table 3). The most frequent application is to keep deer off of roads. Deer are locally overabundant in a number of states, and fencing has proven to be an effective way to keep deer off the roads (Ludwig and Bremicker 1983). Clevenger et al. (2001) reported an 80% reduction in ungulate–vehicle collisions on the Trans-Canada Highway in Banff National Park after fencing. They recommended methods of modifying motorist behavior and fence designs to reduce mortality at the fence ends.

California reported an interesting fencing application in areas with kit fox and coyotes. They provide a gap under the fence just large enough for the kit fox to negotiate at full run so that they can escape predators such as the coyote.

Iowa plans to place finer mesh fence at the bottom of regular fence to prevent smaller wildlife such as turtles, snakes and other small animals from getting on the Eddyville Bypass and Highway 63 at the Bremer–Chicksaw county line. This fencing approach is commonly used in Europe to keep smaller animals off highways. Fine-meshed fencing buried at the bottom is successfully used in association with pipe culverts (Figure 1) with diameters approximately 0.4 m to 2.0 m (1.31–6.56 ft) for small animal connectivity under the highways in Europe (FHWA 2002).

Typical fencing applications are rectangular mesh or chain link fence from 2.6 to 3.0 m (8.5–10 ft) high. Florida and some European countries use strands of barbed wire along the top of the fence to discourage animals from climbing over the fence. Also used is finer mesh wire of

TABLE 3
STATE USE OF STRUCTURAL MEASURES FOR WILDLIFE

State	Bridge Extensions	Wildlife Underpasses	Wildlife Overpasses	Culverts	Fencing	Other
Alaska	Yes–for moose	No	No	Yes–fish passage	Yes	No
Arkansas	No	Yes–three 4’ × 4’ box culverts on I-440 east of Little Rock	No	No	No	No
California	Yes–10% for wildlife and river restoration	Yes–SR-71 San Bernardino for bobcat and coyotes Tool road–deer and other wildlife	Planning one for antelope	Yes–for passage of San Joaquin kit fox	Yes–for Desert Tortoise and deer	Modified bridges for bats, amphibian and fish passage; median barrier design and interchange decommission
Colorado	No	Yes–Berthoud Pass, 7’ × 8’ and 3’ × 4’; Muddy Pass, two 8’ × 12’ planned; SH9, North of Silverton, 8’ × 12’ and 7’ × 8’ planned. Planned dimensions may change for final	No	No	Yes–various areas of state	No
Connecticut	Yes–Route 7, Brookfield	Yes–Route 6 proposed	Yes–Route 6 proposed	Yes–for fish passage	Yes–Route 6 proposed	Yes–nesting boxes for falcons
Florida	Yes–Wekiva River for bear and 13 bridges on I-75 for Florida panther, etc.	Yes–I-75, 23 8’ high × 120’ long bridges; SR-29, three 8’ high × 24’ wide box culverts and one 8’ high × 120’ long bridge; SR-46, one 8’ high × 24’ wide box culvert; US-1 Florida Keys, two crossings for Key deer planned	Yes–I-75 in Marion County	Yes–US-1 in Florida Keys for crocodiles; Payne’s Prairie US-441 for reptile and amphibians	Yes–I-10 and other locations for deer, I-75, SR-29, and SR-46 for crossings	Yes–barrier wall on Payne’s Prairie for reptiles and amphibians, nest boxes for blue birds, nesting platforms for osprey, poles to keep birds off bridges, motorist education signs, speed bumps with signing, reduced speed limit, reduced lighting for sea turtles
Georgia	Yes–for wildlife in several locations	No	No	Yes–for fish passage	Yes–for black bear	No
Hawaii	Yes–projects on Kauai	Yes–projects on Kauai	Yes–on Kauai	Yes–on Kauai	Yes–on Kauai	No
Idaho	Yes	No	No	Yes–for fish passage	Yes–for ungulates	No
Illinois	Yes	No	No	Yes–for small mammals	Construction for snakes & plants	No
Iowa	Yes–Hardin County US-20 Iowa River Bridge	No	No	Yes–baffles, Dubuque County, Iowa-32	Yes–Jones County, US-151 barrier fence for herps	No
Kansas	No	Yes–wildlife/ livestock on I-70 west of Topeka; US-75 south of Topeka; US-69 Marais des Cygnes	No	Yes–US-69 Marais des Cygnes; 20th St. Leavenworth	Yes–US-69 Marais des Cygnes	No
Kentucky	Yes–US-60 for Copperbelly water-snake, Henderson /Union	Yes–Deer crossing in design US-68 Land Between the Lakes, in design	No	No	No	Yes–numerous bridge designs for mussels

TABLE 3 *(Continued)*

State	Bridge Extensions	Wildlife Underpasses	Wildlife Overpasses	Culverts	Fencing	Other
Maine	No	Yes–cattle culverts rehabilitated in Dixfield; Sangerville for wildlife	No	Yes	Yes–numerous locations	Yes
Michigan	Yes–US-131 over Little Muskegon River for deer	Yes–large culvert for deer on M-6	No	Yes–small mammals on I-475 and herps	Yes–deer on M-6	No
Minnesota	No	No	No	No	Yes–deer	No
Mississippi	Yes–Hinds and Rankin County Airport Parkway	Yes–Hinds and Rankin County Airport Parkway	No	Yes	Yes	No
Missouri	Yes	Yes	No	Yes	Yes	Yes–median ballooning for Ozark bears
Montana	Yes–US-93	Yes–US-93 and Goat Lick at Glacier National Park	Yes–US-93	Yes–for herps, small mammals, and fish	Yes–all interstate fence is small mesh for small mammals	Yes–preserving and reestablishing vegetation for grizzly linkage zone
Nebraska	Yes	No	No	Yes–turtles	Yes–for turtles	No
Nevada	Yes	Yes	No	Yes	Yes	No
New Hampshire	Yes–NH-101 for wildlife	Yes	No	Yes–wildlife, salamanders	No	Yes–bird boxes
New Jersey	Yes–I-295/195 Mercer County	Yes–Route 31, Hunterdon County	Yes–I-78, Union County	Yes–various locations around state	Yes–various locations around state	No
New York	Yes–Rte 155–Albany, Taconic State Parkway	Yes–Northway, Albany to Plattsburgh	No	Yes–Rte 21, Canandaqua Lake, Long Island	Yes–Montezuma Refuge	Yes–culvert baffles, fish ladders, eel barriers
Ohio	Yes–for wetlands	No	No	No	No	No
Oregon	Yes–many	No	No	Yes–many	Yes	No
South Carolina	Yes–Carolina Bays Parkway and Conway Bypass, Horry County	Yes–Carolina Bays Parkway and Conway Bypass, Horry County	No	Yes–Carolina Bays Parkway and Conway Bypass	Yes–same projects	No
South Dakota	No	Yes	No	Yes–US-18 for turtles and elsewhere for fish and Topeka shiner	No	No
Texas	No	No	No	Yes–for ocelots, Houston toads, and small aquatics	Yes–drift fence for Houston toad	Yes–use old signs for bat habitat under bridges
Utah	No	Yes–many highways and freeways	Yes–one deer overpass	Yes	Yes–with the crossings	Yes–funded osprey platforms
Virginia	Yes	Yes	No	Yes	Yes	Yes–falcon nesting boxes
Washington	Yes	Yes–I-90	No	Yes–fish passage	Yes–elk along I-90	Yes–deer reflectors and motion-activated signs
Wisconsin	No	No	No	Yes–Butler's garter snake, Waukesha County; in design	No	Yes–nests for barn and cliff swallow during maintenance
Wyoming	No	Yes–deer underpass, Nugget Canyon SW Wyoming and modified culverts throughout Wyoming	No	Yes–for fish and Wyoming toad	Yes–alter design for big game crossings	No

FIGURE 1 Fine mesh fence and culvert for small mammals in Europe.

from 2 × 2 cm (0.78 in.) to 4 × 4 cm (1.57 in.) buried 20 to 40 cm (7.87–15.75 in.) with a height extending from the ground of from 0.5 to 1 m (1.64–3.28 ft). Specific application of this type of fencing depends on the target species. For reptiles and amphibians, the upper edge of the finer mesh is bent over at a 90-degree angle to provide a lip to prevent animals from climbing over the fence. In Waterton Park, Canada, a temporary silt barrier type fence is used to direct frogs into polyvinyl chloride (PVC) drop traps so that volunteers can move them across the highway to a pond during the few-week-long migration period. Europeans use a PVC barrier (Figure 2) with an angled lip to keep reptiles and amphibians off the highways. Another application for reptiles and amphibians in Europe is a fabricated galvanized steel rail with a barrier lip along the upper edge (Figure 3).

FIGURE 2 Plastic barrier with angled lip used for reptiles and amphibians in Europe.

California used a unique fencing application for desert tortoise approximately 6 km (3.7 mi) east of Kramer Junction on Highway 58 in San Bernardino County. A finer [1.27 cm (0.5 in.)] mesh section of wire fence, approximately 50.8 cm (20 in.) in height, was installed along the bottom of a typical 1.22-m (4-ft) right-of-way fence. The finer mesh fence was buried approximately 15 cm (5.9 in.) to prevent animals from going under. This portion of the fence was held in place using three strands of wire. The fencing application was done on an approximately 35.42-km (22-mi) section of four-lane highway. The fencing angled into the road at a series of culverts and bridges that were constructed for wildlife connectivity (Figure 4).

FIGURE 3 Galvanized steel barrier with lip used for reptiles and amphibians in Europe.

FIGURE 4 Tortoise fencing along Highway 58 in California for Desert Tortoise.

Another factor associated with fencing is the aspect of wildlife being trapped between the fences should they find a way to enter the rights-of-way under, over, or around the fence ends. Because fencing is not totally exclusionary, Bissonette and Hammer (2000) studied two highway sites in Utah to compare the use of one-way gates and earthen ramps. They found that earthen ramps were used from 8 to 11 times more than one-way gates.

Another fencing application that may prove useful in site-specific applications is the ElectoBrad fence (electric fence) that was researched for deer exclusion in test plots in Michigan (Rogers et al. 1999).

Fencing is also being used for a variety of other animals from turtles and the Houston toad to black bear and grizzly bears (Table 3). Irrespective of the species, fencing without provisions for movement across the road can cause disruption of connectivity resulting in isolation of populations. This can be especially problematic for species with low populations, where the possibility of extinction can result (Shaffer and Samson 1985).

As mentioned previously, the problem associated with fencing is that it is a barrier to wildlife movement such that when used over large stretches of highway, connectivity for wildlife movement across highways needs to be provided. The following are some of the methods that are being used to provide connectivity.

Modified Drainage Culverts

The Netherlands is a leader in modifying extant drainage culverts to accommodate wildlife (Bekker 1998). Animals are able to move through the culverts on shelves and floating docks or through wildlife tunnels built parallel to the wet culvert. These structures are proving effective for small mammals and amphibians (Veenbass and Brandjies 1997). Montana is successfully using similar designs on US-93 south of Lolo for small mammals (Foresman 2002).

Modified culverts were tried on US-98 in Texas for ocelots and bobcats (Hewitt et al. 1998). Existing culverts were modified with a 0.46 m wide × 0.30 m high (18 in. × 12 in.) elevated concrete walkway to allow animals to move through even when water was present. However, ocelots were not shown to use the culverts. This was largely attributed to the low population in the area. More recently, Tewes and Hughes (2002) studied the ocelots along transportation corridors in southern Texas by looking at roadkill and habitat features to help determine locations for future crossings and develop management strategies.

Other applications of modified culverts include California reporting success in decreasing beavers blocking culverts with debris by having a central "sacrificial" culvert with other culverts placed on both sides but at a higher elevation for drainage and connectivity. The beavers attempt to block the lower culvert, and the adjacent culverts at higher elevation remain open. Beaver-exclusion devices, including fencing, perforated pipe, or a combination of the two have been successfully used throughout the United States to reduce impounding of water behind road fills and for wetland mitigation and habitat preservation. For an example go to: http://fund.org/library/documentviewer. asp?ID = 81&table=documents or http://www.dnr.state.wi.us/org/water /fhp/waterway/beaver.PDF

Drainage Culverts

Table 3 reports that a number of states are using culverts in different applications for a variety of species. Florida, Montana, New Hampshire, Texas, and Wisconsin are using culverts for reptiles and amphibians. Nebraska and South Dakota are using them for turtles.

These dual-purpose culverts are proving successful in accommodating both terrestrial and aquatic organisms depending on water levels in the area of the culverts. When placed at the proper elevation, they can serve both types of organisms. They are typically used where highway causeways or fill sections transverse wetlands with fluctuating water levels such as wet prairies and marsh. They are also used on intermittent streams and floodplain areas that may inundate during wet periods. Aquatic species such amphibians and fish use them when they are wet and terrestrial species including reptiles and small mammals use them when they are dry. If sized properly, everything from small aquatic organisms to larger mammals such as deer and bear will use them.

This sort of application is proving successful for a wide range of terrestrial and aquatic species on Payne's Prairie, a wet prairie near Gainesville, Florida. A 1.1-m (3.5-ft) concrete wall with a 15.2-cm (6-in.) lip at the top keeps reptiles and amphibians from getting onto the highway for nearly a 3.22-km (2-mi) stretch of US-441 in central Florida. A series of wet/dry culverts allows wildlife to move safely under the highway. Sand track stations, live traps, and infrared cameras have been used to monitor the wide variety of animals, from reptiles and amphibians to small mammals using the culverts (USGS 1999).

A modification resulted in the establishment of two amphibian tunnels approximately 61 m (200 ft) apart on Henry Street in Amherst, Massachusetts, that were researched by Jackson and Tyning (1989) and Jackson (1996).

The Dutch are using concrete pipes, metal pipes, or rectangular concrete tunnels approximately 0.4 to 2.0 m (1.31–6.56 ft) in diameter in conjunction with fine mesh fencing for reptiles and amphibians as well as other small mammals (*Wildlife Ecology* . . . 2002).

Pictures of the Payne's Prairie wall, Massachusetts amphibian tunnels, Dutch structures, and wildlife using the culverts mentioned above, as well as other projects around the world can be seen at http://www.fhwa.dot.gov/environment/wildlifecrossings. However, few states report formally researching the success of these structures.

Stream Culverts and Bridges

Like drainage culverts in upland areas, oversized culverts can be designed and placed at the proper elevation over waterways to provide passage for a large number of aquatic and terrestrial species. The use of the natural stream bottom rather than a concrete or metal bottom is best. By providing shallow water or even dry edges along the stream edge in the culvert or bridge, the greatest number of species can move through the these structures.

Given sufficient height, these culverts can even allow larger mammals, such as deer, bear, and other species that ordinarily follow riparian corridors for movement, to pass safely under roads. A wide variety of designs are possible depending on the site-specific construction environment—concrete box culverts, and round, oval, and elliptical pipe culverts. By providing substrate and cover on the inside of the culvert, similar to that of the exposed stream, the utility of the culvert for a larger group of species can be improved. Proper sizing of the culvert depends on site-specific considerations and hydraulics, but including the natural streambed and as much adjacent upland as possible proves most successful.

A number of states report using specialized culverts and bridges in streams for uninterrupted or improved fish passage (Table 3). In Washington, there are 4,463 sites where state highways cross fish-bearing streams. Of these locations, more than 500 "problem sites" were identified. These were sites where the drop of the culvert's outfall was too high, exiting water velocities were too great, or water depth was too shallow for adequate upstream fish passage. The state transportation agency is fixing these culverts using a "Priority Index System," which considers potential habitat improvements. These efforts have been documented by Carey and Wagner (1996).

Oregon has a similar program to retrofit culverts to increase the value and accessibility of upstream habitat. The resource and sensitive areas for Oregon's salmon are being mapped (Carson et al. 2002). Chase (1998) describes the Oregon regional approach to recovery as provided for in the Oregon DOT.

Planning efforts, best management practices, and mitigation for transportation projects in the Pacific Northwest were examined by Corkran and Findley (2002). They looked at several projects in Oregon and Washington and describe fisheries issues, approaches used, and lessons learned from these projects.

Stream restoration is also becoming a part of transportation projects. Harman and Jennings (2002) describe restoration projects in North Carolina that used the natural channel in the design technique. The projects were to improve water quality and habitat, reduce stream bank erosion, and enhance floodplain functions. Enhancements to streams were provided during Maine Turnpike construction for two high-quality trout stream crossings to improve productive habitat and the carrying capacity of the streams. Log flow deflectors were provided to increase the depth and velocity of the main channel, create pools, scour fine sediments, and divert water flow from eroding banks. Submerged woody debris and boulders were placed to provide additional habitat. Log bank undercut structures were provided to stabilize stream banks (Farrell and Simmons 2002).

Fish passage structures in urban streams are also becoming better understood. Hegberg et al. (2002A and B) presented approaches to hydrologic and resource issues as well as hydraulic design and analysis. Recommendations for evaluation of target fish species characteristics, site-specific base flow hydrology, and hydraulics of structures are provided. They also present a list of procedures for design of passages.

To address the specifics of culvert design and placement the Pacific Northwest National Laboratory in the state of Washington has begun culvert testing for juvenile salmonid passage (Pearson et al. 2002). Full-scale models will be used to look at hydraulic conditions (velocity, turbulence, and water depth) associated with various culvert designs under various slopes and flow regimes.

States are also considering freshwater mussels in the construction of bridges and culverts. Savidge (1998) describes erosion control measures, elimination of direct drainage from bridges, and structural features on several projects in North Carolina that were the result of protected mussel species. Reutter and Patrick (2002) report on measures taken for mussels in a bridge replacement on the Allegheny River 80.5 km (50 mi) north of Pittsburgh, Pennsylvania. The assessment included a construction/demolition options evaluation, hydraulic and hydrologic analyses, and the development and implementation of a mussel relocation program with subsequent monitoring of success.

Wildlife Underpass Bridges and Dry Culverts

Many states are also using culverts of varying size in uplands areas for a wide variety of wildlife species from small mammals to ungulates (Table 3). Upland culverts are one of the most frequently used structures for wildlife crossings and have proven successful for accommodating a wide variety of species. Both pipe culverts and box culverts are proving effective—mainly for small animals. California is using culverts for San Joaquin kit fox. Illinois, Kansas, Montana, New Hampshire, New Jersey, Oregon, Texas, Utah, and Virginia are using culverts for other small mammals. Arkansas, Colorado, Wyoming, Utah, Michigan, Maine, Washington, and Kansas report using larger culverts for deer and other wildlife. Small culvert sizes such as 1.22 m × 1.22 m (4 ft × 4 ft) in Arkansas and 2.13 m × 2.44 m (7 ft × 8 ft) to 2.44 m × 3.66 m (8 ft × 12 ft) in Colorado indicate that the states believe they can have success with these sizes. Again, there is a lack of formal research as the states experiment with these designs. Culvert sizes as small as 1.22 m x 1.22 m (4 ft × 4 ft) in Arkansas

FIGURE 5 Box culvert being used by wildlife in Banff National Park.

FIGURE 6 Infrared camera set-up in Banff National Park to monitor use of structures.

up to 2.44 m × 7.32 m (8 ft × 24 ft) in Florida were reported in the survey of the states

An extensive research project addressing the use of dry drainage culverts was conducted by Clevenger and Waltho (2000). Banff National Park had used a variety of culvert sizes for small and medium-sized mammals (Figure 5). These researchers used infrared triggered cameras (Figure 6), track beds, and snow tracking to research 24 of these structures during the winter of 1999. They found that passage was positively correlated with traffic density, road width, road clearance, and culvert length. They also found that all species with the exception of coyotes and shrews preferred small culverts with low openness ratios. There appeared to be some evidence of predation at crossings so the thought was that the smaller culverts provided comfort to the prey species. Weasels and shrews preferred culverts with nearby cover. The researchers felt that drainage culverts could be used to mitigate the harmful effects of high-speed roads and recommended frequently placed culverts [150–300 m (492.13–984.25 ft)] of varying size be placed in close proximity to shrub or tree cover.

Boarman and Sazaki (1996) reported that desert tortoise and other vertebrates in California's western Mojave Desert are using culverts of varying construction and size (Figure 7). In 1990, the California Department of Transportation (Caltrans) erected tortoise-barrier fencing along both sides of Highway 58 from a point approximately 6 km (3.72 mi) east of Kramer Junction. The fence consists of 60-cm (23.62-in.) wide, 1.3-cm (0.51-in.) mesh hardware cloth buried to 15 cm (5.9 in.) beneath ground level that extends 45 cm (17.71 in.) above the ground (Boarman et al. 1997). The fence angles into culverts and bridges spaced approximately every kilometer along the route. The culverts are made of 0.9 to 1.5 m (2.95–4.92 ft) corrugated steel pipe; 1.4 m (4.59 ft) diameter reinforced concrete pipe, or 3 to 3.6 m (9.84–11.8 ft) by 1.8 to 3 m (5.90–9.84 ft) reinforced concrete boxes. The culverts were 33 to 66 m (108.27–216.54 ft) in length. Figures 7 and 8 show pipe and box culverts used on Highway 58. Three bridges (Figure 9) that cross natural washes were also fenced to provide connectivity. With a four-laning project on Highway 58, there are now approximately 26 crossing opportunities for wildlife, which range from approximately 1 m (3.28 ft) ribbed pipe culverts to 61 m (200 ft) bridges that are approximately 2 m (6.56 ft) high in the 35.42 km (22 mi) project.

FIGURE 7 Box culvert used by desert tortoise along Highway 58 in California.

Culverts varying in size from 1.5 to 10 m (4.92–32.81 ft) in diameter were used successfully in New South Wales, Australia, for a large group of terrestrial mammals and reptiles (Norman et al. 1998).

FIGURE 8 Pipe culvert for desert tortoise on Highway 58 in California.

FIGURE 9 Bridge overdry wash used by wildlife on Highway 58 in California.

FIGURE 10 Goat bridge underpass on Highway 2 near Glacier National Park.

Wildlife underpasses are bridges and/or large culverts over dry land and sometimes land and water, constructed expressly to facilitate wildlife movement in important corridor areas. The length and height of these large culverts or bridges varies with the wildlife expected to use them.

Twenty-three of the responding states reported using underpasses for wildlife (Table 3). Some species being addressed in the responses included bobcat and coyote in San Bernardino, California; deer in most states; and goats at Glacier National Park, Montana (Figure 9). Singer and Doherty (1985) studied the use of the two structures in Glacier National Park: Goat Bridge [8 m (26.24 ft) high × 23 m (75.46 ft) wide × 11 m (35.80 ft) long] and Snowslide Gulch Bridge [3 m high × 3 m wide (9.84 ft × 9.84 ft) × 11 m (35.80 ft) long]. Figure 10 shows the Goat Bridge and Figure 11 shows the Snowslide Gulch Bridge. They found that goats were crossing and making it safely to the mineral lick located on the Flathead River.

FIGURE 11 Snowslide gulch bridge for goats on Highway 2 near Glacier National Park, Montana (three views).

Significant provisions were made for wildlife on Highway 241, a toll road in southern California. Wildlife underpass bridges (Figure 12) that varied in length, bridge extensions, and viaducts (Figure 13) over rivers and dry streambeds were used to provide connectivity to the adjacent private, federal, and state lands. The bridges, several hundred feet long, traverse topographic features that allow for both wildlife and occasional human access for utility maintenance. Unfortunately, land-use planning has allowed for development in several areas along the corridor thereby compromising the integrity of adjacent wildlife habitat (Figure 14).

FIGURE 12 Wildlife underpass on Highway 241 in southern California.

FIGURE 13 Viaduct on Highway 241 in southern California.

FIGURE 14 California structures suitable for wildlife use but precluded by adjacent development.

On Highway 71 in southern California, large pipe culverts (Figure 15) were used as wildlife underpasses to provide wildlife connectivity to habitat in the Prado Flood Control Basin. The successful use of these structures by wildlife led Caltrans to include bridge spans in lieu of culverts in planned upgrades for the facility.

Wildlife underpasses of varying designs were used in Banff National Park in Canada. The underpasses varied from 25.6 to 67.5 m (83.99–221.46 ft) in length, 4.2 to 13.4 m (13.78–43.96 ft) in width, and 2.5 to 4.0 m (8.20–13.12 ft) in height (Figure 16). These underpasses have been used successfully for a variety of animals, including elk, deer, coyote, wolf, black bear, grizzly bear, and cougar (Clevenger 1998; Clevenger and Waltho 1999, 2000). A more detailed discussion of the crossings used in Banff can be found in the case study in chapter 10.

FIGURE 15 Large pipe culvert being used by wildlife under Highway 71 in southern California.

FIGURE 16 Large pipe culvert being used by a variety of wildlife in Banff National Park, Alberta.

FIGURE 17 Pre-cast segment construction of box culvert wildlife underpass in Florida.

Florida used 2.44-m (8-ft) high and 7.32-m (24-ft) wide box culverts for a variety of species in central and south Florida. Depending on the remoteness of the area of use, these concrete box culverts can be cast in place or pre-cast (Figure 17) for shipment to the site. Fencing associated with these crossings was 3.04 m (10 ft) in height with three strands of barbed wire on an outrigger. A wide variety of species use the culverts, including the Florida panther and black bear (Land and Lotz 1996; Roof and Wooding 1996).

Florida has also used 36.58 m (120 ft) bridges with a 2.44 m (8 ft) height in the Big Cypress Preserve area for movement of wildlife under I-75. The crossings have been used by a wide variety of wildlife including the Florida panther and black bear (Foster and Humphery 1995; Evink 1996; Land and Lotz 1996). A more detailed discussion of Florida wildlife crossings is contained in the case study in chapter 10.

New Jersey built a structure of similar size under Route 31 near Clinton that is approximately 2.44 m (8 ft) high and 6.08 m (20 ft) wide and 36.28 m (119 ft) long. It is a combination crossing that is also used by pedestrians in a park. The structure was built using 25 pre-cast, post-tensioned, elements.

Early research on the use of culverts was mainly for ungulates and indicated some success with small box culverts for certain species. Mule deer seem to be more reluctant to use small box culverts than their white-tailed cousins (Reed et al. 1975; Ford 1980; Ward 1982). However, after an acclimation period, they are using them.

Wyoming is conducting research on a wildlife crossing on US-30 through Nugget Canyon between Kemmerer and Cokeville. The crossing is the result of the Nugget Canyon Wildlife Migration Project Act passed by the Wyoming State Legislature to mitigate deer/vehicle collisions in the area. A concrete box underpass with dimensions 6.08 m (20 ft) wide, 9.12 m (30 ft) long, and approximately 3.35 m (11 ft) high was constructed after other measures mentioned in the Non-Structural Section of this report had failed. Wildlife movement was monitored using an infrared video system with two lenses mounted at each end of the crossing. Light-emitting diode (LED) lights were used to improve image quality. Two sets of infrared scope activated the system that recorded to a VCR. A Trailmaster TM 1500 infrared sensor recorded the time and date of animal use. Approximately 2,000 animals (elk, mule deer, and antelope) have used the crossing. The plan is to modify the dimensions of the crossing in the spring of 2002 to determine the dimensions needed for mule deer use for future crossing designs. Other locations have been identified that may warrant wildlife crossings in the future (Gordon 2002B).

Phillips et al. (2002) studied the use of an underpass on I-70 at Mud Springs Gulch near Vail, Colorado. The box culvert structure constructed in 1970 is 3.05 m (10 ft) high, 3.05 m (10 ft) wide, and 30.5 m (100 ft) long. Subsequently, a pedestrian/cyclist path was constructed adjacent to I-70 with an elevated bridge in the area of the underpass. The researchers found that highway traffic and the presence of humans at the crossing disturbed the deer attempting to use the crossing. A temporary screen that was installed to block the view of human presence helped reduce disturbance to the deer. The result was a recommendation for a permanent screen. The research also indicates that mule deer will use a crossing of this small size.

Austin and Garland (2002) researched wildlife use of a double box culvert on Vermont State Highway 289 in Essex. The crossing has one box for a small stream and another box with higher bottom elevation for wildlife movement. Each box is 3.05 m wide (10 ft), 3.96 m high (13 ft), and 97.54 m long (320 ft). There is a 1.22 m (4 ft) fence along the highway in the area of the underpass. The underpass was monitored using Trailmaster 550 passive infrared monitors with Trailmaster TM35-1, a 35mm camera, and track plots. Raccoon, mink, weasel, and skunk were found to be using the structure; however, deer that were in the area did not.

North Carolina is constructing three underpasses for black bears at a new location, US-64 near the Outer Banks in Washington County. The dimensions will be approximately 38 m (124.64 ft) wide, 2.4 to 3.0 m (8–10 ft) high, and approximately 100 m (328 ft) long. The locations of the underpasses were determined by studies conducted by the North Carolina Wildlife Resources Commission in 1999. They used track counts, ditch crossings, and infrared cameras to determine locations (Scheick and Jones 1999). To estimate population density and determine genetic relatedness, the University of Tennessee has been collecting pre-construction information with radio-collared bears and analyzing DNA samples from hair collected at 140 barbed-wire hair traps. They also used infrared cameras to measure activity in the areas near planned crossings. The pre-construction study was completed in June 2001 and post-construction study will start after completion of the highway in 2004 (van Manen et al. 2002).

Extended Bridges and Existing Structures

One of the most successful and cost-effective means of providing for wildlife movement down riparian corridors is the extended bridge. Twenty-four of the responding states reported using extended bridges for wildlife movement and wetland protection (Table 3). Providing adequate area for both water movement with associated organisms and dry habitat for terrestrial species movement has proven successful. Again, the characteristics of the area need to be considered when trying to determine the appropriate length of the bridge. In cases where there is an important corridor for movement of rare or protected wildlife species, bridging the entire floodplain may be necessary. At the other end of the spectrum, where the floodplain is being used by habitat-limited species, a combination of smaller structures and fences may be possible. An important consideration when choosing a combination of bridge and fill is what reptile and amphibian species will likely move up the fill slope on to the road. Standard fencing will not stop this movement so that very expensive barrier walls and associated guard rails may be necessary to prevent significant kills of these species during periods of the year when they are moving around in large groups. Another consideration is the cost of mitigation for wetland takings by opting for a fill section. By the time the costs of shorter bridges or culverts, fill acquisition, barrier walls for reptiles and amphibians, guardrails, and fencing are factored in, along with the cost of wetland mitigation, the cost of a more substantial bridge, preferred for habitat connectivity, may already have been approached.

Singleton and Lehmkuhl (1999) researched existing bridges and culverts along 48.30 km (30 mi) of highway from Snoqualmie Pass to the town of Cle Elum in Washington. They mapped 58 culverts and 31 bridges and underpasses along the I-90 study area. Thirty structures (24 culverts and 6 bridges) were monitored using automatic cameras, track plates, and tracking beds. They found that reptiles, amphibians, and small mammals were using the structures.

Haas and Lyren (2000) monitored existing structures on Highway 71 between Euclid Avenue and Highway 91 east of Los Angeles, California, with remotely triggered cameras and track/scat surveys. They also radio collared 4 bobcats and 53 coyotes to monitor movement. They concluded that, although small mammals were using some existing structures, larger underpasses were needed for mule deer. They made further recommendations on some specific sites for underpass improvements.

Viaducts

Viaducts are a potential solution for the entire spectrum of species moving through an area. Long bridges such as those found over wetlands, rivers, and variable topography and geology are viaducts. Typically, this approach is most cost-effective where there is topographic relief sufficient to make bridging necessary for a significant span of a waterway, canyon, or valley. As a result most viaducts are located in mountainous areas. They are very effective because wildlife naturally use spanned lands for movement. Most existing viaducts were constructed because it was the best or most esthetic way to cross a valley or ravine from an engineering standpoint rather than to accommodate wildlife. However, their consideration and design for wildlife is increasing, especially in Europe.

Figure 18 shows one of three viaducts [593 m (1945.04 ft), 160 m (524.8 ft), and 265 m (869.20 ft in length] used in Slovenia on the Ljubljana–Trieste highway. This viaduct is being successfully used by brown bear, wolf, and a number of ungulates (Kobler and Adamic 1999).

FIGURE 18 Viaduct on the Ljubljana–Trieste Highway in Slovenia.

FIGURE 19 Viaduct on Highway 241 in southern California.

None of the states responding to the questionnaire reported using this concept for wildlife connectivity. Although there are numerous viaducts in the United States and Europe, wildlife movement was not the primary motive in their development. However, wildlife connectivity could be one of multiple considerations resulting in a viaduct. Several viaduct-length bridges traverse rivers and floodplains on the Highway 241 toll road in southern California (Figure 19). The curves of the picturesque Linn Cove viaduct on the Blue Ridge Parkway in North Carolina hug the winding contours of the underlying mountain. This project was completed in 1983 at a cost of almost $10 million, with multiple environmental considerations in mind. Regardless of the ultimate reasons for design, viaducts can help provide important corridors for wildlife movement.

Wildlife Overpasses

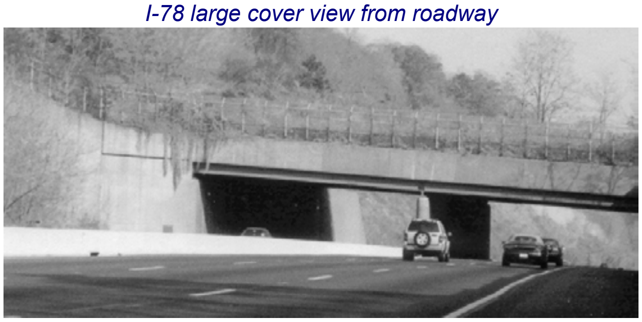
Although wildlife overpasses are largely a European phenomenon (Berris 1997; Keller and Pfister 1997), there are now a few U.S. structures. Florida, Hawaii, New Jersey, and Utah reported overpasses being used by wildlife.

The New Jersey overpasses, among the first in the United States, were completed in 1985 at a cost of $12 million. The two overpasses were designed to provide connectivity across I-78 (a six-lane highway) at an approximately 2-mile stretch that crossed the Watchung Reservation in Union County. Figure 20 shows one of the vegetated overpasses [91.46 m (300 ft) wide]. The other [61 m (200 ft) wide] has pavement as well as vegetation. At the time of construction, the deer herd in the Watchung Reservation was small and there was great concern about mortality on the highway. Although no formal research has been conducted, deer have been observed using the crossings and the health of the local population indicates the success of the overpasses. Currently, the deer population is on the increase; however, local development has encroached on the reservation such that the deer are considered a nuisance by local landowners.

The Utah overpass was constructed principally for deer. The Florida overpass on I-75 in Marion County just north of County Road 484 is a multi-use overpass designed to accommodate a recreational and equestrian trail, as well as for wildlife use [see the Florida case study (chapter 10) for further details].

Two overpasses were built over the Trans-Canada Highway in Banff National Park and are being used by a variety of wildlife (see the case study, chapter 10).

I-78 large cover view from roadway



Both covers viewed from I-78

FIGURE 20 Overpass being used by deer and other wildlife in New Jersey.

Montana (US-93) and Connecticut (Route 6) are currently planning wildlife overpasses (Table 3).

Wildlife overpasses are used extensively in Europe and vary in width from 3.4 m (11.15 ft) to 870 m (2,853.6 ft). Pfister et al. (1997) conducted research on five wildlife overpasses on the Stockach–Uberlingen section of German highway B31 (Figure 21) and looked at 12 other overpasses in Germany, The Netherlands, France, and Switzerland. They also did a follow-up study looking at other overpasses (Pfister et al. 1999) using the same infrared video camera technology. The research looked at large mammals, small mammals, and flightless insects, such as ground beetles, grasshoppers, ground spiders, and diurnal butterflies. When there is suitable habitat at and leading to the overpasses, it was found that the overpasses were effective for a wide variety of animals including invertebrates. The conclusions included the observation that structures at least 60 m (196.8 ft) wide were more effective than overpasses narrower than 50 m (164 ft), especially for larger mammals. It was noted that animal behavior on the overpasses was more normal on the wider structures.

FIGURE 21 Vegetated overpass in Europe approximately 50 m wide.

Other Structural and Non-Structural Measures for Wildlife

Signage is a common approach to informing motorists when they are entering an area where the danger of wildlife collision is high. Romin and Bissonete (1996) report that most states have tried deer warning signs, hazing, reduced speed limits, and public awareness campaigns, but few states have conducted research to determine the effectiveness of these techniques.

The Swiss have used a series of solar-powered, battery-operated, motion sensors to determine animal presence that trigger low-voltage, LED-illuminated warning signs that reduce the posted speed limit to 40 km/h and alert motorists to the presence of approaching wildlife (Figure 22). The installation of these measures was very successful in reducing deer mortality on the referenced country road. The location on the road was also adjacent to a large wildlife overpass over a major nearby freeway.

FIGURE 22 Swiss warning sign that illuminates when animals are present near the highway.

Utah and Georgia examined warning devices (whistles) on cars, but these did not prove effective (Romin and Dalton 1992). Europeans have also found ultrasound and road lighting to be ineffective in reducing wildlife mortality (*Wildlife Ecology* . . . 2002). Utah tried interception feeding, placing food plots in areas away from the highway. These proved effective only during the portions of the year when mule deer were concentrated (Wood and Wolfe 1988).

Deer reflectors have been tried in many different areas of the world. Pafco and Kovach (1996) reported dramatic reductions in deer/vehicle accidents in the rural coniferous forest, central hardwoods, and farmland habitats in rural Minnesota. However, two other sites with steep slopes were apparent failures. A California study on SR-36 east of Chester resulted in no statistical difference in the mean of deer killed whether or not the reflectors were in operation (Ford and Villa 1993). Molenaar and Henkens (1998) completed a literature review of research conducted on reflectors and determined that there was no conclusive evidence that the reflectors worked. However, additional research may be needed on this approach.

As part of an effort to reduce deer collisions, Wyoming tried traditional deer signing, an infrared sensing device that activates a flashing light system to warn motorists of deer presence, and reflectors in the area of a gap in 11.27 km (7 mi) of 2.43-m (8-ft) high deer fence on US-30 in Nugget Canyon. None of the measures was found effective and this caused the Wyoming DOT to move on to the structural alternative that is reported in the Wildlife Underpass Section of this report (Gordon et al. 2001; Gordon 2002A).

Florida reported installing PVC pipe approximately 3 m (9.84 ft) in height perpendicular to the railing on the San Sebastian Bridge to keep bird flight patterns above the elevation of traffic. The poles were spaced approximately 3.7 m (12 ft). The rationale was to keep those birds hovering over the bridge from dropping down into traffic crossing the bridge. The technique has been found to reduce bird kills on the bridge (Egensteiner et al. 1998).

HABITAT TECHNIQUES

Twenty-six states indicated that they use habitat restoration or preservation as mitigation for impacts to habitat or wildlife other than wetland impacts. One of the larger projects is Colorado's shortgrass prairie effort, described in the programmatic agreement discussions earlier in this chapter. Florida has approximately 688 hectares (1,700 acres) of upland mitigation bank, which is used to offset project impacts for 27 state and federally listed species in a 13-county service area. The FHWA reimburses the Florida DOT when credits are used for specific transportation projects. A trust fund was established with the Florida Fish and Wildlife Conservation Commission for perpetual management and maintenance of the habitat for listed species. Improvements that result in higher listed species populations result in increasing available credit. An inventory is taken every 5 years to document population status.

California, in partnership with a group of public and private organizations, purchased habitat in the Coal Canyon area of Puente–Chino Hills to provide a corridor of habitat to help implement a Natural Communities Conservation Planning effort that includes important natural areas such as the Cleveland National Forest, Tecate Cypress Preserve, Camp Pendleton, Santa Rosa Plateau, Santa Margarita River, Starr Ranch, Irvine Company Reserves, Chino Hills State Park, Prado Basin, Tonner Canyon, Schabarum Regional Park, and Powder Canyon. These are some of the last remaining natural areas in southern California. The corridor is constricted in the area of the Riverside Freeway (SR-91) such that Caltrans participated in an outright habitat purchase and plans to decommission the Coal Canyon interchange and use the existing interchange bridge as a wildlife underpass. Plans include fencing to guide wildlife to the bridge and removal of pavement to provide a corridor under the interchange bridge. This project demonstrates a significant commitment of resources for environmental enhancement.

The following are some other state habitat mitigation activities:

- Georgia has purchased habitat for wood stork foraging and gopher tortoise/indigo snake mitigation.
- Iowa has purchased prairie and woodland habitats.

- Kentucky has purchased habitat for endangered plants.
- Kansas has planted trees and native grasses and undertaken stream meander and riffles restoration.
- In Maine, preservation and restoration are emerging as the major options for reducing habitat impacts.
- Minnesota has done prairie and native grass restoration.
- Montana uses stream and riparian corridor restoration for listed species conservation measures.
- Nebraska has used conservation easements to protect whooping crane roosting habitat.
- New Hampshire has preserved habitat tracts in important wildlife corridors.
- Ohio has done preservation or restoration to a limited degree, but not commonly.
- Oregon has undertaken stream bank restoration.
- Texas has used conservation easements and one-fee simple purchase with management plans for endangered plants.
- Utah uses county Habitat Conservation Plans for funding habitat for desert tortoise and Utah prairie dogs.
- Washington uses habitat mitigation to a limited degree where part of an overall package of mitigation, but not typically for listed species. The state has also funded research and developed rare plant management plans.
- Wisconsin legislature has prohibited habitat acquistion as mitigation, but allows the DOT to place money in an existing stewardship program.
- Wyoming has provided land for big game habitat preservation.
- Idaho has purchased winter range for deer and habitat for plants.

Maintenance of these habitat mitigation efforts is discussed in chapter 8.

PROGRAMMATIC AGREEMENTS

Programmatic agreements are a relatively new approach to resolving wildlife impacts. Reviewing impacts at the program level makes a lot of sense, because it speaks to the overall impact of highways in a given area to specific environmental issues. The survey of states revealed that 22 had entered into programmatic agreements principally for wetland mitigation. Programmatic agreements are also becoming a part of state streamlining efforts.

Colorado's Shortgrass Prairie Initiative

In April 2001, the Colorado DOT (CDOT) entered into a Memorandum of Agreement (MOA) with the FHWA, FWS, the Colorado Department of Natural Resources (DNR), Colorado DNR Division of Wildlife (CDOW), and the Nature Conservancy (TNC) "to effect regional conservation of declining species on Colorado's Eastern Plains by providing proactive advance conservation of priority habitats for multiple species and that will allow CDOT and FHWA to address compliance with the Endangered Species Act for listed species and for declining species that may become listed." The MOA was based on the CDOT 20-year plan for improvements on Colorado's Eastern Plains. With the help of the Colorado Natural Heritage Program the parties arrived at an estimate of the collective impacts to declining species from the proposed transportation projects. A technical Conservation Site Identification Panel headed by TNC and CDOW will evaluate and recommend areas of real property interest from willing sellers for large-scale conservation/mitigation that CDOT will present to the FHWA and FWS for approval for purchase by CDOT. The FHWA will reimburse the state for mitigation credits as they are used on future projects. The project aims to preserve approximately 6070.5 to 8094 hectares (15,000–20,000 acres) or more of shortgrass prairie habitat over the next 2 years, protecting approximately 25 target species, including mountain plovers, black-tailed prairie dogs, burrowing owls, swift foxes, box turtles, ferruginous hawks, and numerous secondary species. In Colorado, only 40% of prairie land remains, and much of that is degraded from fragmentation and overuse. The CDOW will "own and manage the conservation areas in accordance with the purpose for which it was acquired."

It is the purpose of the MOA to provide for conservation of the important habitats in Colorado's Eastern Plains while advancing the transportation goals contained in the CDOT 20-year plan. For CDOT, the MOA reduces mitigation costs and Section 7 (ESA) consultation times and makes project timelines more predictable.

Additionally, Colorado has entered into a programmatic agreement on the Canada lynx. A standard methodology for impact assessment and mitigation design was developed. By following programmatic standards, CDOT will ensure that the FWS evaluates projects on a consistent, predictable basis. A number of project types with low probability of involvement were excluded from lynx-specific mitigation measures (Barnum 1999).

Other State Initiatives

The following are programmatic activities of other states:

- Alaska is developing an agreement on fish passage criteria and Essential Fish Habitat using agreements for species and sensitive areas where management needs coordination for species and habitat.

- Connecticut uses U.S. Army Corps of Engineers (USACE) Highway Methodology, but has found that it does not work to resolve ecological issues.
- Georgia is working on guidance for the Clean Water Act Section 404 permitting process and threatened and endangered species.
- Kentucky has a wetland banking MOA and property transfer agreement for wetland mitigation property.
- Minnesota has a project streamlining agreement with other state agencies.
- Mississippi has a wetland banking agreement with the USACE.
- Montana developed an agreement for a state and federal interagency research technical committee and has a MOA with the state universities related to research and with state and federal agencies "Concerning Wildlife Connectivity and Highway Projects."
- New Jersey has an agreement for wetland mitigation banking.
- Oregon has a programmatic Biological Assessment for culvert retrofit for fish passage; emergency maintenance of mudslides, bridge replacement, and tree removal.
- Texas is working on an agreement for mitigation of listed plants.
- Utah is working on a programmatic agreement for all projects with little or no listed species involvement.
- Washington has a programmatic agreement in place for the Olympic Region and is looking at statewide application for salmon.
- Wisconsin has an agreement with their DNR on how to resolve issues on how to handle transportation impacts. It covers many issues including endangered species, erosion control, and stormwater runoff. The state also uses Habitat Conservation Plans in working with the FWS and their DNR.
- South Dakota established a wetland bank in 1988.
- Idaho has an MOA for wetland banking.
- California has a programmatic agreement in place on the kit fox, red-legged frog, and salmonids and is at work on one for the desert tortoise.

CHAPTER EIGHT

MAINTENANCE PROGRAMS FOR WILDLIFE MITIGATION

MAINTENANCE OF STRUCTURES

Maintenance of wildlife features can easily be overlooked in the planning, documentation, design, and construction of wildlife structures. However, it can be critically important to the long-term success of these features. Therefore, planning and budgeting for maintenance is important. Attention to the lowest maintenance design will minimize the costs of upkeep, while ensuring that the structures remain effective for wildlife movement.

An emerging area for maintenance related to wildlife concerns bats in bridges. Keeley and Tuttle (1996) describe the use of highway bridges and culverts as bat habitats and provide guidance for maintenance and demolition of bridges occupied by bats. They report that some states, such as Texas, are managing bridges for bats with great success. Maintenance personnel must be aware that some species of bats are listed as threatened or endangered; therefore, it is usually necessary to involve environmental professionals when dealing with bats in bridges.

Culverts

Materials used in modern culvert construction (concrete and metal with protective coatings) and the actual design (corrugated) can result in a structure with a long life span and potentially little maintenance. Common problems associated with perpetually wet culverts are erosion and deposition of sediments because of poor design and/or placement of the culvert. Improperly sized culverts often lead to heightened water velocities in and around these structures and require frequent maintenance because of scour, soil erosion, and sedimentation. Culverts located at improper elevations or in changing watershed conditions can have similar problems with erosion if the culvert is placed too high in relation to the stream. The erosion often results in a pool far enough below the culvert outfall that organisms find it impossible to move upstream through the culvert. These are referred to as “perched” culverts. On the other hand, culverts placed too low will be in constant need of maintenance as a result of sedimentation, thereby reducing the culvert’s hydrologic effectiveness. Several states have developed manuals to address the associated problems of with culvert maintenance (*Fish Passage . . .* 1999; Robison et al. 1999). The most common problem with the maintenance of ordinarily dry culverts in upland areas is the control of vegetation in keeping the structure open and accessible. Around the mouth of small pipe culverts deposition of soil as a result of wind and rain can decrease its effectiveness for wildlife movement.

Underpasses

Because wildlife underpasses are essentially bridges over land and water, maintenance personnel can expect routine structural inspection and maintenance activities as for any bridge structure. Slope maintenance around these crossings is often problematic because of the need to maintain a built-up fill section for an elevation that provides for a smooth transition into the bridge while also maintaining suitable conditions for animal movement under the bridge. Slope stabilization with headwalls, riprap, reinforced earth, or vegetation can greatly reduce maintenance frequency, expense, and disturbance to the wildlife underpass. Many underpasses are large enough that maintenance of the cross-sectional opening is not as problematic as it can be in some drainage culverts. It is important that cover for animals be a consideration in the maintenance plan for the structure. If organisms sensitive to the need for cover are to use the structure, maintenance of sufficient cover will be required. Research from Europe has indicated that cover, such as rows of debris under the crossing, can facilitate small mammal and reptile/amphibian movement under the crossing.

To assure visibility of the crossings for animals, vegetation control is the primary maintenance function for these structures. Therefore, it may be necessary to size structures so that mowers can move through the underpass and the area in and around the structure. Graffiti and vandalism are also maintenance problems in areas that have access to humans.

Overpasses

Overpasses for wildlife are so recent in the United States that good information about their maintenance is not available. In Europe, maintenance on overpasses is performed for native vegetation and even wetland systems, similar to that for adjacent roadside communities. Various structures for wildlife cover, including large rocks and stumps, are also maintained on European overpasses. With the exception of planting and maintenance of native vegetation, Europeans do little else to maintain their wildlife overpasses. In Canada, one innovative measure being used in Banff National

Park involves the placement of piles of used Christmas trees to provide cover for habitat and movement of small animals across the overpasses.

Fencing Maintenance

Fence maintenance can be one of the most expensive activities for wildlife mitigation techniques. Run-off-the-road vehicles and falling trees often damage fences and unless quickly repaired animals will find their way through these breeches and on to the rights-of-way. Vegetative growth along fences can also present a maintenance problem. Spraying with herbicides seems to be the most popular maintenance measure, although this can present problems in particularly sensitive aquatic areas and areas with listed protected plants.

HABITAT AND RIGHT-OF-WAY MAINTENANCE

Fourteen states report maintaining their rights-of-way to promote use by wildlife and 11 states maintain the use of rights-of-way by wildlife to reduce their predisposition to mortality by motor vehicles. The following are what states managing for wildlife or habitat are doing:

- Alaska maintains rights-of-way to keep moose from being hit.
- Arkansas provides a transition zone between the intensely managed areas and adjacent natural areas.
- Colorado does aggressive mowing to discourage deer use.
- Florida manages rights-of-way for threatened and endangered plants and to eliminate exotic plants.
- Kansas delays mowing until after pheasant nesting.
- Maine maintenance personnel place signage and habitat manipulations for wildlife.
- New Hampshire uses fencing to keep beavers from clogging culverts.
- Ohio delays mowing for nesting birds and also maintains some plantings in stream and wetland mitigation sites.
- Oregon is mapping all rights-of-way with development of management plans being the end result.
- Washington is delaying mowing for upland nesting birds and emphasizes the use of native plants on roadsides.
- Wisconsin is managing the mowing schedule for the Karner blue butterfly as part of a Habitat Conservation Plan.
- South Dakota is managing mowing to allow for the nesting success of upland birds.

Schutt (2002) advocates the setting of regional ecological goals for roadside maintenance that look outside of the right-of-way to determine meaningful ecological issues, which are then translated into a management program on the highway. This would include the use of native plants to emulate native ecosystems along the roadsides that in turn reduce maintenance requirements. Harper-Lore (2002) supports similar vegetation management goals, especially in areas with native grasslands.

Sanz et al. (2002) reported that by wise landscape integration of transportation projects the chances of roadkill can be reduced. They researched landscape features in relation to two freeways in Navarra in the northern part of Spain and looked at wildlife mortality for medium- and large-sized mammals along the highways. The conclusions of the research provided a number of guidelines for viewing landscapes in relation to transportation facilities to address wildlife mortality issues.

Hyman and Vary (1999) conducted a synthesis study of best management practices for environmental issues related to highway and street maintenance. In the area of vegetation management, they reported that use of vegetation that does not attract wildlife, clear-cutting of roadsides to create better visibility, and the use of remote feeding areas were techniques to keep wildlife off of highways. Other environmental aspects of maintenance activities that may seem less directly related to wildlife are also covered in the report including winter operations (deicing), pavement and shoulder work, paint stripping, hazardous waste management, and noise abatement.

Andres (1995) studied the disposal of animal carcasses and reported that in most states it is a maintenance responsibility. The disposal of animal carcasses is regulated in approximately one-half the surveyed states. The typical requirement was to bury the carcasses on-site or at a discrete location nearby. Other disposal methods mentioned were (1) pulling the animal off the road to decompose, (2) taking the carcass to a rendering plant, (3) disposing of the carcass at a landfill, and (4) salvaging the meat. The report also covers cleaning of beaver dams, culverts, and stream channels as wildlife-related maintenance activities.

The maintenance of unpaved roads can be important to the protection of adjacent water bodies. Sheehy (2002) describes a new technique being used for reconditioning and stabilizing of unpaved roads to reduce road maintenance and decrease impacts to fisheries habitat. The process uses a Mobile In Place Processor that grinds up the surface of aggregate or native soil roads and adds a binder, typically calcium chloride, and then compacts the surface. Preliminary studies indicate that roads treated in this manner require less maintenance and do not washboard, rut, pothole, ravel, or generate dust. Additionally, surface erosion is significantly reduced, which results in less sediment into adjacent water bodies.

MAINTENANCE AND MANAGEMENT OF CREATED, MODIFIED, OR RESTORED HABITAT

Most state DOTs try to find a land management agency to provide maintenance for mitigation/conservation habitats. Two states seek to perform mitigation (modification or restoration) on public lands that are already being managed by a resource agency. Universities, conservation groups, resource agencies, and even private groups where it was consistent with the objectives of the mitigation have become involved in maintenance of habitat by taking possession or easement of land from the state DOTs. Few transportation departments are maintaining habitat except for wetland mitigation sites. Texas and Florida are allowed to provide funding instead of mitigation. Habitat management is delegated to the agencies taking the land, as is the case for the upland mitigation bank in Florida (see case history).

Venner (2001A) reviewed regulatory guidance on the establishment and maintenance of compensatory mitigation projects as provided in the USACE Regulatory Guidance Letter (RGL) No. 01-1. The guidance (1) establishes requirements for a mitigation plan, (2) provides direction for factors affecting mitigation, (3) rectifies past overreliance on on-site mitigation, (4) emphasizes watershed considerations, and (5) provides context for "no net loss" by requiring consideration of other critical elements of the aquatic environment. As a result of numerous comments from the public, resource agencies, and the FHWA, the USACE is expected to revise RGL 01-1 for reissue in 2002. The requirements in the guidance are too extensive for full coverage. Those faced with addressing these issues should refer to Venner's report, the RGL, and any ensuing changes made to the RGL.

Monitoring Requirements

In most cases, when a state uses a habitat strategy as a conservation or mitigation measure, the maintenance plans for these habitats contain a monitoring requirement. These requirements vary in length and design. Basically, the states are being required to maintain sites to varying performance levels (usually a percent survival of desired species and exotic/invasives free) for some period of time (commonly 3 to 5 years). Specific management plans including funding can also be a requirement.

Smiley (2002) reported on the importance of a mitigation monitoring program. The purpose of a monitoring program is to (1) specify recommended mitigation and ensure that it is included in the final design process; (2) monitor the implementation of the mitigation through design, construction, and operation; (3) resolve issues that are contingent on the outcome of design as it progresses to more detailed stages; and (4) report on progress toward implementation of mitigation measures to responsible parties.

CHAPTER NINE

FUNDING

The key to funding for wildlife features on transportation projects is to identify the need early in the planning process such that adequate funding is anticipated at the project development, design, construction, and maintenance phases.

TRANSPORTATION EQUITY ACT FOR THE 21ST CENTURY

Project Funds

States reported that, for the most part, environmental costs were being anticipated early enough in the work program to fund wildlife mitigation needs. Most felt that the funding situation was improving as a result of ongoing consultation with the resource agencies. A few states indicated that they still were getting unanticipated mitigation requirements that were not budgeted on a few projects but, generally, the states are programming the money as regular project funds.

The states also reported that they are not using funds from other projects to cover unanticipated mitigation costs for a given project. Utah had a unique situation with the Legacy Nature Preserve, which was mitigation for the Legacy Highway project. Additional funds were needed for the Preserve that would otherwise have been spent on other projects. Because many of the states are operating mitigation banks, they have available credits that have already been funded when the banks were established.

Bond and Toll Funds

States are funding wildlife features on toll roads. Florida is using tolls from Alligator Alley (I-75) to pay for wildlife measures built on the project. Another example is Highway 241 near the Cleveland National Forest in southern California, where crossings and bridge extensions have been provided for wildlife on this toll road.

Enhancement Funds

Environmental mitigation of runoff pollution, provision of wildlife connectivity, soil erosion controls, detention and sediment basins, river clean-ups, and wildlife underpasses are qualifying items under the enhancement funding provided for in TEA-21. Although the FHWA provides guidance and ensures compliance, states are responsible for selecting projects for these funds. Most states were aware of this provision in TEA-21, but enhancement funds in most states were either being passed on to local governments for projects or used for other qualifying activities such as recreation trails, main street beautification, and historic restoration.

A few states have used transportation enhancement funds for wildlife. Florida used enhancement funds for the overpass on I-75 (see case study) and California used them for Coal Canyon corridor habitat preservation. For wildlife features, several states mentioned that they had more success in using other funding sources than enhancement funds. Other states mentioned that wildlife agencies are now becoming aware of their ability to compete for these funds so they expect greater use of them in the future.

Safety Funds

States are also using safety funds to support deer collision mitigation and other wildlife-related safety studies.

OTHER FUNDING SOURCES

Public/Private Partnerships

The only reported public/private partnerships for wildlife are a few instances of jointly funded wildlife research that may have applicability to transportation activities. There are opportunities for partnerships with land trusts, conservation groups, and even the insurance industry in the funding of project-related land acquisition and research activities. FDOT partnered with TNC to purchase the upland mitigation bank mentioned in chapter 7. Caltrans partnered with a number of private and public organizations to purchase the Coal Canyon Corridor, also mentioned in chapter 7.

Other State and Federal Programs

Several states are proactively funding wildlife mitigation measures because of FHWA reluctance to pay for mitigation until it is used on a specific project. This was true of the upland mitigation bank in Florida and the short grass prairie initiative in Colorado. The responding states did not report any other federal agency program involvement in their wildlife activities, although several states have used federal grant funding for research; for example, Washington's use of EPA funds to study wetland mitigation. However, the majority of wildlife research is being done with assistance from FHWA research funds.

California has two other funding sources that have been used for wildlife-related transportation activities. The first is the state's environmental enhancements program (EEM 84-71), which has been used cooperatively on transportation projects for habitat acquisition. The second is CALFED, a fish and wildlife funding source that, among other things, can also be used for purposes of habitat acquisition and/or improvement related to transportation projects. Partnerships are common under this type of funding arrangement.

Other examples include Kentucky, which has a legislatively established fund dedicated to project mitigation with flexibility to increase it if needed and Washington, which has an Advance Environmental Mitigation Revolving Account (SB5313) that was funded by the legislature for advanced mitigation of fish habitat, fish passage, wetlands, and flood management.

CHAPTER TEN

CASE STUDIES

The following case studies are presented to illustrate a few areas where the interactions between roads and wildlife are being addressed in large-scale activities to protect both wildlife and motorist safety.

FLORIDA CASE STUDY

FDOT initiatives to address wildlife interactions began with the Alligator Alley project. To resolve the need for an interstate connector between the coasts in south Florida it was decided that SR-84 (Alligator Alley), then a substandard two-lane highway, would be upgraded to interstate standards. The alignment would connect Naples to Ft. Lauderdale, crossing numerous ecologically important areas of Florida—the Fakahatchee Strand State Preserve, Florida Panther National Wildlife Refuge, Big Cypress National Park, and Everglades National Park. At the time, this was the last remaining habitat for the endangered Florida panther, whose population had dwindled to 30–50 animals. Consultation with state and federal wildlife officials under Section 7 of the ESA resulted in the construction of 23 wildlife crossings—36.58 m (120 ft) wide and 2.44 m (8 ft) high (Figure 23)—and 13 bridge extensions—12.19 m (40 ft) extension over dry land. Approximately 64.37 km (40 mi) of the highway in the area of the crossings was fenced with 3.05-m (10-ft) chain-link fence with an outrigger with three strands of barbed wire. The fence design was the result of consultation with experts managing captive cougars and bears. It was felt that the barbed wire would discourage these animals from crossing the fence. A study conducted by the University of Florida under contract with the FDOT concluded that the Florida panther and many other animal species were using the structures to safely cross under the highway (Foster and Humphrey 1995). No Florida panthers or black bears have been killed on Alligator Alley in the project area since completion of the Interstate.

FDOT also participated in the purchase of important habitat for the Florida panther by obtaining the four sections of land around the interchange at SR-29 and joining with the Florida Department of Environmental Protection in the fee simple purchase of lands for the National Panther Refuge. This was accomplished by combining access rights funds with state Conservation and Recreational Lands purchase funds to buy land adjacent to the highway for the refuge.

The Alligator Alley project was so successful that when Florida panther and black bear continued being killed on SR-29, which ran perpendicular to Alligator Alley, DOT and the Florida Panther Technical Advisory Committee developed a program of wildlife crossings for that facility. The plan calls for six wildlife crossings at strategic locations on SR-29 where it crosses the Florida Panther National Wildlife Refuge, Fakahatchee Strand State Preserve, and Big Cypress National Park. To date, four of these crossings have been constructed. Three crossings are 2.4-m (8-ft) high and 7.3-m (24-ft) long box culverts, while one of the crossings is a 36.58 m (120 ft) bridge similar to those on I-75 (Alligator Alley). Because of the high cost of the bridges on Alligator Alley the alternative box culvert design (Figure 24) was approved for research purposes on this facility. The fencing used in this area was identical to the application on Alligator Alley and the fences are connected at the SR-29 interchange with I-75 (Alligator Alley). Subsequent research indicates that the Florida panther as well as black bear and other wildlife that use the 36.58 m (120 ft) bridge design on Alligator Alley were regularly using the box culvert crossings on SR-29 (Land and Lotz 1996).

FIGURE 23 One of 23 wildlife underpasses on I-75 (Alligator Alley) in southern Florida.

FIGURE 24 Box culvert underpass used on SR-29 in southern Florida.

With Florida's rapid development, it became clear that there were many potential problem areas for wildlife interactions with roadways. For example, the Florida black bear was being killed at numerous locations around the state. Therefore, the Florida Fish and Wildlife Conservation Commission (FFWCC) gathered biological and roadkill information and published a report on the particularly dangerous locations for bears (Gilbert 1996). This information was used to locate crossings on SR-46 in Lake County. The area was an important corridor for bears between the Ocala National Forest and Wekiva State Park. Land had been purchased by the state to provide a connector for wildlife between these public lands and the highway transecting this corridor. Increasing traffic levels because of urban growth from the Orlando area made the highway unsafe for both motorists and wildlife. Therefore, in 1994, a box culvert design, 7.2 m (24 ft) long and 2.4 m (8 ft) high, with 3.05-m (10-ft) chain-link fence and barbed wire outrigger similar to those used on SR-29 were constructed in the area of increased bear kills. Research conducted by the FFWCC biologists (Roof and Wooding 1996) indicates that the crossing design is working for bears and other animals in the area and subsequently another crossing is planned for this area of highway.

Given the indications of a statewide problem from the FFWCC report on bears, the FDOT contracted the University of Florida to study connectivity needs on a statewide scale. Smith (1999) completed a study that used a rule-based GIS model. Factors for prioritizing relative impact of roads included chronic roadkill sites, focal species hot spots, riparian corridors, greenway linkages, strategic habitat conservation areas, existing and proposed conservation lands, and known or predicted movement/migration routes. The model indicated that significant areas of highway were within nationally and regionally significant conservation areas and riparian corridors. Another activity of the study was identifying existing structures that wildlife might use in these areas. Additionally, projects in the work program in the subject areas were identified for wildlife feature planning purposes. A number of existing structures and future road projects were identified that present the opportunity to improve connectivity. The FDOT is expected to use these priority ecological interface zones to program mitigation measures both in planned highway projects and, where necessary, as individual projects to protect wildlife and motorists while restoring landscape level connectivity.

One priority area that is being addressed is US-1 on Big Pine Key. This area is habitat for the endangered Key deer and reduction of mortality on the highways is important to population management (Calvo and Silvey 1996). Crossings at two locations are presently being designed and constructed for US-1.

Another area identified by the GIS modeling was Payne's Prairie State Preserve, which is a unique wet prairie managed by the Florida Department of Environmental Protection. Thousands of reptiles and amphibians were being killed annually on U.S. Highway 441 (Smith 1995). A wildlife barrier wall [0.91 m (3 ft) high] and culvert underpass system was designed to keep reptiles and amphibians off the highway and allow them to move under the highway. A preconstruction study was completed that documented extensive wildlife mortality (3,365 animals) between August 1998 and August 1999. The post-construction research is ongoing.

Florida will continue to use the GIS model results to implement strategies to remedy wildlife impacts identified during the statewide study at the program and project level. Additionally, statewide habitat connectivity needs that were identified will aid resource agencies in Florida in protecting the lands important to the future of wildlife movement in Florida.

In 2001, in response to multiple needs in a state-owned conservation corridor that crossed I-75 in Marion County just north of County Road 484, Florida constructed an overpass with Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) enhancement funds. The 16-m (52.5-ft) wide overpass was designed to accommodate both recreation/equestrian and potential wildlife movement in the corridor. The overpass allows safe passage over a busy Interstate highway where traffic levels approach approximately 50,000 vehicles per day. Vegetation planted on the overpass will protect wildlife from traffic noise and vehicle headlights as the animals pass over at night. Florida Department of Environmental Protection biologists in the area are monitoring use of the overpass.

In coastal situations lighting can be a problem for turtle hatchlings. In response, FDOT constructed a section of coastal highway with lighting imbedded into the pavement as part of an ongoing study of motorist safety and the effect on turtle hatchlings. Sea Turtle Lighting Zone standards are being developed by state and local officials and may influence FDOT lighting standards.

Florida has also developed a 697.98-hectare (1,700-acre) upland mitigation park for the conservation of 23 state and federally listed species. Acre credits are based on the wildlife population on the property and can be used in a 23-county service area. The FHWA reimburses for credits when they are used on projects.

BANFF CASE STUDY

The Banff story has had international ramifications. Since 1980, Parks Canada has been in the process of four-laning (twinning as they call it) the Trans-Canada Highway. The Trans-Canada Highway is the major east–west corridor for motor vehicles across Canada and traffic levels continue to increase. In addition, Banff National Park is one of the gems of the Canadian park system, with nearly 4 million people entering the park each year (Leeson 1996). By the summer of 1992, the levels of traffic had so deteriorated that passing was impossible, maximum speeds were below 80 km/h (49.71 mi/h), and time delays exceeded 75%. With environmental protection as a paramount priority, Parks Canada developed a phased approach to addressing environmental concerns.

In the first two phases, approximately 16% of the budget to twin 31 km (19.25 mi) of the highway was devoted to environmental features. These features included 10 wildlife crossings each with a 2.4-m (8-ft) high fence that included one-way gates that allowed for animals caught between the fences to exit the roadway corridor. In the third phase, approximately 30% of the budget was devoted to environmental features. In this 18 km (11.18 mi) section of the highway, two overpasses (Figure 25) and 13 underpasses were constructed and the 2.4-m (8-ft) high fence was continued. Figure 26 depicts several of the underpasses used in Banff National Park. Parks Canada constructed a combination of pipe culverts, box culverts, and open-span bridges of varying size and design. The two overpasses built for this section are approximately 50 m (164 ft) wide.

FIGURE 25 Large overpass used by wildlife in Banff National Park, Alberta.

FIGURE 26 Underpass in Banff National Park, Alberta.

There remains one more phase to complete the twinning through Banff National Park, which will involve 30 km (18.64 mi) of highway. This final phase awaits the budget and the results of research to help Parks Canada make decisions about what needs to be done. Wisely, Parks Canada began an extensive research effort to scientifically document the effectiveness of the existing 23 wildlife underpasses and 2 overpasses on approximately 49 km (30.45 mi) of the Trans-Canada Highway. This was an important decision because this is one of the longest stretches of highway in the world with features undertaken to provide wildlife connectivity.

The Banff research on road effects on wildlife began in November 1996. Therefore, recent published results represent nearly 5 years of research effort on the effectiveness of mitigation measures and incidence of road-related mortality in Banff National Park. To describe the unprecedented success of this research, the following is a modified summary of results taken from the most recent progress report (Clevenger 2001):

- There have been a total of 26,279 through-passes by wildlife at the 11 (phases I and II) underpasses since November 1996. Elk were the most frequently detected species at the crossing structures, followed by deer, coyotes, and sheep. Among large carnivores, wolves used the structures 1,190 times, cougars 517 times, black bears 380 times, and grizzly bears 14 times.
- There have been 5,515 passages by wildlife at the 13 (phase IIIA) crossing structures since November 1997. Among large carnivores, cougars used the structures 149 times, black bears 127 times, wolves 100 times, and grizzly bears 16 times.
- On average deer used the phase IIIA wildlife overpasses 12 times more than the IIIA underpasses, whereas elk used the overpasses 3 times more than underpasses. Since June 2000, moose used the phase IIIA crossing structures seven times (six times on overpasses and once on an underpass). All carnivores except cougars have used both overpasses. Since 2000, wolves have used the two overpasses as a group (i.e., between two and seven individuals) five times.
- In the 50 months of monitoring more than 31,794 individual wildlife passes have been detected at the 24 crossing structures.
- There was a general pattern of increased use at phase IIIA overpasses for all large carnivore species during the first 3 years of monitoring. Increased annual passage frequencies were particularly dramatic in grizzly bears, wolves, and cougars during the third year of monitoring (i.e., 4 to 25 times greater than the average use during the first 2 years).
- Cougars use of the underpasses has gone from relatively low levels and seasonal use to moderate, year-round use. Wolf use of underpasses has varied

geographically by pack, depending on wolf pack size and adaptation to underpasses. Elk use of underpasses has not changed geographically, but the frequency of use decreased substantially in 2000. Deer use of underpasses has not changed geographically and the amount of use has increased slightly each of the successive 4 years.

- Researchers found that for many small- and medium-sized mammals drainage culverts can mitigate harmful effects of busy transportation corridors and provide a vital habitat linkage. To maximize across road connectivity for meso-fauna, future road construction schemes should include frequently spaced culverts of mixed-size classes and have abundant vegetative cover present near culvert entrances.
- Since January 1997, a total of 237 animals were reported killed on the Trans-Canada Highway in Banff, Yoho, and Kootenay national parks; 143 (60%) were ungulates and 94 (40%) were carnivores. Carnivore mortalities consisted of coyotes (56%), black bears (28%), wolves (11%), and cougars (4%).
- A review of road mortality data of large carnivores in Banff National Park from 1981 to the present showed that 48 large carnivores (black bear, wolf, cougar, and wolverine) have been killed. For wolves (80% of 20), black bears (52% of 23), and all large carnivores combined (65% of 48) mortality was highest on unmitigated, unfenced Trans-Canada Highway.
- Four years of road-kill surveys covered a total of 49 994 km (31,064.83 mi). A total of 824 animals (60 identified species) were collected from 827 different road sites. These included 354 mammals (23 species), 312 birds (35 species), and 158 amphibians (2 species). Mammals accounted for 43% of the kills, birds 38%, and amphibians 19%. Along the Trans-Canada Highway birds were the most common road-killed taxa, accounting for 43% of all mortality, mammals were second accounting for 37%, and amphibians third with 20%. On the Bow Valley Parkway, mammals were the most frequently killed at 56%, followed by birds at 28%, and amphibians 16%. Road-kill indices were highest for mammals on the Bow Valley Parkway, with 8.3 roadkills/1000 km (621.37 mi) sampled as opposed to 6.2 roadkills/1000 km on the Trans-Canada Highway.
- Researchers developed three different but spatially explicit habitat models to identify linkage areas across transportation corridors. One model was based on empirical data and the other two models were based on expert information developed in a multi-criteria, decision-making process. We used the empirical model as a yardstick to measure the accuracy of the expert-based models. Our tests showed the expert literature-based model most closely approximated the empirical model, both in the results of statistical tests and the description of the cross-highway habitat linkages. Our empirical and expert models represent useful tools for resource and transportation planners charged with determining the location of mitigation passages for wildlife when baseline information is lacking and when time constraints do not allow for preconstruction data collection.
- Researchers developed a GIS approach to modeling animal movements across transportation corridors. The work consisted of three steps: (1) the creation of high-resolution, regional-habitat suitability models for four large mammal species, black bear, grizzly bear, moose, and elk; (2) developing a regional-scale movement component to the models; and (3) nested within step 2, constructing local-scale movement models of high spatial resolution. Recommendations regarding the location of potential mitigation based on the intersection of simulated pathways with transportation corridors and other human infrastructure are the result of this exercise. The full results from this work are being prepared as a separate report to Parks Canada in May 2001.

The Banff projects are some of the most successful for wildlife connectivity. The long-term research of the effectiveness of the measures taken to provide connectivity also has world-wide importance. Information on the progress of wildlife activities in Banff National Park can be obtained at www.hsctch-twinning.ca.

US-93 MONTANA PLANNING CASE STUDY

This study involves US Highway 93 between Evaro and Polson in Missoula and Lake Counties, Montana. This 90.6-km (56.3-mi) project includes social, economic, and environmental complexity. It affects important areas of habitat with listed species, wetlands of national significance, public lands [Section 4(f)], cultural and historical resources, lands of the Confederated Salish and Kootenai Tribes, and public safety. A final Environmental Impact Study was published in 1996, but the Record of Decision contained exceptions. The existing alignment was selected for improvement, but the FHWA deferred making a decision on lane configuration until agreement was reached on a number of issues including design features and mitigation measures. Among the issues that needed resolution were environmental concerns unique to different areas of the study region, concerns about wildlife and habitat, traffic and safety, access control, corridor preservation, and area economics. An environmental re-evaluation of the project was processed for US-93 from Evaro to Polson and right-of-way acquisition is underway as well as some project features. The area in the Ninepipe/Ronan segment presents special considerations and as a result a Supplemental Environmental Impact Statement is being processed. Some changes included a new listing of endangered species, increased traffic, and a heightened awareness of the extensive cultural and environmental conditions along the corridor.

An extensive coordination process lead to an MOA between the Montana DOT, the FHWA, and the Confederated Salish and Kootenai Tribes that will allow for the completion of the environmental process, as well as lane configuration and design concepts (FHWA et al. 2000). Agreement was reached on a number of design features, environmental mitigation, and measures that increase vehicular safety, reduce congestion, respect culturally significant areas, allow animals safe passage through the corridor, and maintain and nurture the spirit of the Indian lands. The significance of the MOA cannot be overstated as the complexity of the project had brought the process to a standstill. The process continues with environmental analysis, design, funding procurement, a public involvement process, resolution of right-of-way issues, and eventually the construction of the project features. Design and alignment concepts included in the MOA consider the landscapes along the corridor, provide for fish and wildlife crossings structures (culverts, underpasses, overpasses, and viaduct concepts), fencing concepts for wildlife, and typical section concepts to maintain the character of the corridor. The MOA also contains Design Guidelines and Recommendations, a Traffic Operational and Safety Analysis Report, a Wildlife Crossing Handbook, and a Design Components Handbook that details alternatives for consideration by multi-interest interdisciplinary technical teams during the design process. The significance of this effort will be tested as the projects move forward. However, the level of planning and coordination that has brought this very complex project to this point will help guide the resolution of the multitude of decisions that remain.

CHAPTER ELEVEN

CONCLUSIONS

Habitat and wildlife issues are becoming an increasingly important part of transportation planning, project development, construction, and maintenance. This is the result of growth impacts on native populations to the point that many ecosystems are diminished to critical levels. In some areas, any further degradation can lead to environmental problems that impact the quality of life and life support systems. Native habitats and wildlife are part of the quality-of-life factor and the life support systems. At the same time, the need by the American public for mobility continues to grow, with the automobile being the primary transportation mode of choice.

The transportation industry has the opportunity to significantly contribute to the quality of the environment in many areas of the country by intelligent planning and implementation of transportation programs and projects. This can be achieved by making habitat and wildlife considerations a more recognized part of the planning process. The policy and regulatory direction to make this happen is already in place. The FHWA has provided clear policy and guidance to meet the intent of the National Environmental Policy Act, which requires consideration of environmental impacts, including those to native habitats and the associated wildlife. Consideration of other regulatory mandates at the local, state, and federal levels requiring consideration of habitat and wildlife is a normal part of the highway development process. Many states have begun successful efforts to address these issues on significant projects. Initiatives such as streamlining and context-sensitive design are daily improving the way that many states are doing business. Consideration of habitat and wildlife early in the process can help bring about real progress toward addressing environmental and other issues. Transportation departments are finding that if they make a genuine effort to accommodate habitat and wildlife considerations, the result can be reduced time for approvals at the state and federal levels.

The effects of placing a transportation facility in natural environments are becoming better understood. The potential for impacts is the most studied area of the topic. However, little research has been done to document the impacts from built facilities of sufficient duration of time to actually quantify the impacts. The states, through necessity, have developed their own evaluation approaches and mitigation strategies that vary in quality and acceptability. Standard methods for evaluation, mitigation, and post-construction study are needed by the states.

These techniques need to be developed in a partnership with the environmental resource agencies to guarantee regulatory acceptability. Technologies such as geographic information systems and computer sciences are beginning to play a role in helping transportation and resource agency scientists address habitat and wildlife issues. However, there is considerable room for the improvement of both technology and methods to address transportation-specific situations. Several states have made significant commitments to addressing these issues with the development of methodologies for evaluation and measures of compensation. However, there is need for further research that develops these methodologies and documents the long-term success of mitigation measures. This is especially true in the area of secondary and cumulative impacts—one of the most poorly understood consequences of the development of the transportation system.

Research needs are recognized in *Conference Proceedings No. 28: Environmental Research Needs in Transportation: Report of a Conference* (Transportation Research Board, The National Academies, Washington, D.C.). Research is identified for methodologies to evaluate secondary and cumulative impacts, the barrier effect of highway features, the relationship of highways to needed landscape linkages for wildlife, the effectiveness of aquatic and terrestrial structures for wildlife over long periods of time, the impacts of invasive species, the potential of deer density reduction measures to improve motorist safety, and the importance of ecologically sensitive transportation corridor rights-of-way management.

Additionally, training is also needed to give the states the specific expertise to address these often-complicated and technical issues. Presently, there are few training opportunities for transportation or regulatory personnel that cover habitat and wildlife aspects in relation to the transportation industry. Specific courses are needed that detail the evaluation process, discuss mitigation possibilities, and document methodologies for the study of the resulting impacts to the natural environment and associated wildlife.

Several states are addressing habitat and wildlife issues with structural and habitat conservation measures. The most commonly used approach is sizing drainage structures such that wildlife can also pass through the structure. This is often done with bridges along riparian corridors. Although this type of structure may be adequate where aquatic systems are present, other types of structures are required where there is a need for terrestrial connectivity. Culverts and even small bridges are being used as wildlife underpasses. However, little research has been done to document the effectiveness of these structures so that determination of sizing and location of structures is often done with incomplete information. Research on cost-effective underpass structures for various types of wildlife is needed to aid transportation agencies in addressing connectivity. Overpasses (bridges over the highway for wildlife movement) have been used to a limited degree in the United States, but are widely used in Canada and Europe. These structures have proven to be very effective for the entire ecological community from plants to insects to wildlife. Research done in Europe indicates that overpasses are warranted on ecologically sensitive corridors on public lands as the most complete answer for connectivity.

While connectivity is one issue related to transportation facilities, the taking or degradation of habitat is also occurring. Some of the most successful strategies for dealing with these impacts have been programmatic approaches that address more than single project impacts and strive to preserve entire ecosystems. Several states have developed agreements that are proving to be ecologically sound while expediting the transportation approval process. Programmatic approaches to mitigation should be pursued in the future because they address the immediate impacts of transportation facilities and also accommodate consideration of secondary and cumulative impacts.

Maintenance forces are beginning to play a role in ecological considerations through more environmentally sound rights-of-way management for plants and animals. There is great potential in what maintenance can additionally do in providing for wildlife connectivity through better sizing of drainage structures for aquatic connectivity. Fencing of highways and placing of culverts for wildlife connectivity is being done by maintenance in Europe. Through coordination with transportation and resource agency environmental staff, maintenance personnel could provide similar assistance in the United States to provide for wildlife considerations and increase motorist safety.

Funding of habitat- and wildlife-related activities is provided for in the Transportation Equity Act for the 21st Century, but it is up to the individual states to use the funding mechanisms provided in the bill. Available funds are often used for other priorities rather than addressing habitat- and wildlife-related environmental impacts.

In conclusion, habitat and wildlife relationships to transportation facilities are an emerging science where the potential impacts have been identified, but not quantified. Scientific research in this area has been limited while an aggressive transportation program is being carried out across the United States. This is presenting problems in documentation and regulatory processes to the extent that the Congress is asking for streamlining measures in carrying out the transportation programs. Good sound scientific methodologies at all stages would go far toward expediting the process. Much coordinated research needs to be considered if an environmentally sound transportation program is to result. Investment is needed to improve the methodologies for

- Documentation of impacts,
- Mitigation strategies,
- Long-term connectivity,
- Effectiveness studies,
- Programmatic approaches to addressing impacts, and
- Better coordination processes.

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DEFINITIONS

Amphibian—Cold-blooded vertebrates (frogs, toads, and salamanders) consisting of gilled aquatic larvae and air-breathing adults.

Anthropogenic—Generated and maintained, or at least strongly influenced, by human activities.

Average daily traffic (ADT)—vehicles per day.

Avoidance—Avoidance by not developing infrastructure ultimate answer to fragmentation. Adapting an alignment of infrastructure to minimize the spatial occupation of the road. Measures aimed at vulnerable areas by prevention of bisection or physical disturbance.

Biodiversity—Variability among living organisms from all sources; terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part. This includes diversity within species, between species, and of ecosystems, as well as of the processes linking ecosystems and species.

Biota—All organisms in a community or area.

Biotope—Area inhabited by a distinct community of plants and animals.

Buffer zone—Vegetated land that is intended to screen ecosystems from impacts such as pollution or disturbance.

Categorical exclusion—Category of actions that do not individually or cumulatively have a significant effect on the environment and that have been found to have no such effect in procedures adopted by a federal agency in implementation of these regulations and for which, therefore, neither an environmental assessment nor an environmental impact statement is required.

Community (biotic) —Assemblage of interacting species living in a given location at a given time.

Compensatory measure—Measure or action taken to address a residual adverse effect that cannot be entirely mitigated.

Conformity—Act or instance of conforming to air quality standards.

Connectivity—Quality or condition of structural landscape features being connected, enabling access between places via a continuous route of passage.

Core areas—Areas of habitat large enough to support wildlife populations; source populations.

Corridor—Tract of land connecting two or more areas.

Critical habitat—Areas of important habitat for endangered species that have been formally designated by the U.S. Fish and Wildlife Service.

Cumulative impacts—Accumulated impacts of a number of projects or actions.

Demographic—Relating to the dynamic balance of a population especially with regards to density and capacity for expansion or decline.

Dispersal—Process or result of the spreading of organisms from one place to another.

Ecoduct—Structure built over a road or railway to connect habitats on either side. The surface is covered with soil or other natural material that allows the establishment of vegetation.

Ecological corridor—Landscape structures of various size, shape, and vegetation that maintain, establish, or re-establish natural landscape connectivity throughout the ecological network.

Ecological network—System of ecological corridors, habitat core areas, and buffer zones surrounding corridors and core areas providing a network of habitat needed for the successful protection of biological diversity at the landscape level.

Ecosystem—Dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit.

Ecotone—Transition zone between two habitats.

Ecotope—Distinct area with a recognizable set of land attributes such as soil, vegetation, water, or anthropogenic influences. The ecotope concept describes the smallest mappable land unit that builds up the mosaic of the landscape.

Edge effect—Change in character introduced when forest is cleared, thereby causing a perimeter where influences of the surroundings prevent development of interior environmental conditions.

Endangered Species Recovery Plan (ESRP)—Plan developed by the U.S. Fish and Wildlife Service in coordination and cooperation with other interests to provide for the recovery of an endangered species.

Enhancement—Improving the quality of habitat.

Environment (natural and built)—Complex of physical, chemical, and biotic factors (e.g., climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival.

Environmental assessment—Concise public document that serves to: (1) briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact; (2) aid an agency's compliance with the National Environmental Policy Act when no environmental impact statement is necessary; and (3) facilitate preparation of a statement when one is necessary. It shall include brief discussions of the need for the proposal, of alternatives as required by section 102(2)(E), of the environmental impacts of the proposed action and alternatives, and a listing of the agencies and persons consulted.

Environmental impact statement (EIS)—Detailed written statement.

Evolution—Changing genetic process whereby organisms change through time.

Extent—Largest scale at which an organism responds to patchiness. The extent of an analysis is set by the limits of the study area or sampling period. Anything that falls outside the limits will be detected and analyzed.

Extinction—Loss of the last individual of a species.

Fauna—Animal life.

Filter effect—Road barrier impact has a different effect on different species and may even vary between sexes or age categories. Thus, the road may act as a filter, inhibiting the movement of certain species or individuals.

Finding of no significant impact (FONSI)—Document presenting the reasons why an action will not have a significant effect on the human environment (interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment) and for which an environmental impact statement therefore will not be prepared.

Flora—Plant or bacterial life.

Fragmentation—Fragmentation is the splitting of natural habitats with the occurrence of specific plant and animal species into smaller and more isolated units.

Genetics—Study of genes and their influence on organisms.

Geographic information systems (GIS)—Diversity of remotely sensed information documenting the geographic character of an area.

Grain—Finest level of resolution of a data set.

Habitat—Species-specific concept of the area in which a plant or animal species find all necessary resources to live and reproduce.

Hazardous substances—Any material that can have an adverse impact at the biological level.

Heterogeneity—Quality or state of being dissimilar or diverse.

Hierarchy theory—Hierarchy theory considers a system to be composed of a number of subsystems and contributing itself to a higher level system. This implies that the mechanisms underlying ecological phenomena expressed at a given level should be sought at the next lower level in the hierarchy. For instance, levels in natural hierarchy are, e.g., cells, organs, individuals, populations, communities, and ecosystems.

Impact, effect, consequence—Impact is the immediate response of an organ, organism, species, or property to an external factor. This response may have an effect on the species or condition that may give consequences to the population or species community on a longer time scale. For instance, the impact of traffic noise on birds may reduce the capability of identifying and distinguishing other birds' voices. This may effect their social interactions and breeding success, with the possible consequence of local extinction.

Indicator—Quantitative variable, usually with target value representing an objective, which symbolizes environmental or other impacts of transport infrastructure plans (including ordinal scales, e.g., low, medium, high).

Indicator species—Species indicative of (1) some environmental or historical influence or (2) a community or habitat type.

Indices—Device that serves to indicate a value or quantity.

Infrastructure—System of communications and services within an area or country.

Interstate—Between states.

Intrastate—Within a state.

Landscape—Total spatial and visual entity of human living space integrating the geological, biological, and human-made (anthropogenic) environment.

Landscape diversity—Formal expression of the numerous relations existing in a given period between the individual or a society and a topographically defined territory, the appearance of which is the result of the action, over time, of natural and human factors and a combination of both.

Land-use planning—Activity aiming at predetermining the future acting of society by deciding on the temporal and spatial usage of land and water.

Linkage areas—Corridors of habitat that provide connectivity to other areas of habitat.

Mesofauna—Fauna of an intermediate size such as small mammals.

Metapopulation—Set of local populations within some larger area, where typically migration from one local population to at least some other patches is possible to recolonize areas where local populations occasionally went extinct. The metapopulations may have a higher persistence than the single local population.

Minimization—Efforts to reduce impacts by alternative actions.

Mitigation—Action designed and taken to reduce the severity of or eliminate an adverse impact.

Multi-modal—Pertaining to more than one mode of transportation.

Network—Interconnected system of corridors.

Nonattainment area—Area that does not meet (attain) air quality standards.

Nonpoint source pollution—Pollution from diverse inputs rather than one point.

Patchiness—Irregular in appearance, makeup, size, or quality.

Population—Functional group of individuals that interbreed within a given, often arbitrarily chosen, area.

Programmatic agreement—Agreement that covers multiple projects or aspects of projects.

Region—Embraces several landscapes or ecosystems that share some qualitative criteria in, e.g., topography, fauna, vegetation, climate, or urbanization.

Retrofit—Improvements on an existing facility.

Restoration—Process of returning something to an earlier condition or position. Ecological restoration involves a series of measures and activities undertaken to return a degraded ecosystem to a former healthier state.

Riparian habitat—Habitat situated by a riverbank or other body of water.

Scale—Spatial and temporal dimensions of objects, patterns, and processes. Scale is an inherent property of nature, but also intimately associated with observation, analysis, and processing. Scale has two basic properties—grain and extent. Changing the scale in an analysis means changing the resolution and may invoke a new pattern as other hierarchical levels of organization are entered.

Scenic by-ways—Formally designated highway of scenic or ecological importance with an approved management plan that ensures continued compatibility of the facility with the scenic designation.

Secondary impact—Impact that occurs later in time than the initial impact of an action.

Significant—Having or likely to have a negative influence or effect of noticeable or measurable amount.

Source (sink habitats and populations)—Areas where populations of a given species can reach a positive balance between births and deaths and thus act as a source of emigrating individuals. Sink habitats, on the other hand, do not support a species' life history, as birth-death ratio will be below unity. Sink populations are thus dependent on the immigration from source populations.

Spatial—Related to space.

State Implementation Plan (SIP)—Transportation plans must conform to national ambient air quality standards as spelled out in an SIP.

Stewardship—Actions that protect and enhance the natural environment.

Streamlining—Administrative process of shortening evaluation and approval of transportation projects.

Succession—Natural process whereby organisms and habitats change over time.

Taxa—Category in the classification of living organisms. Taxa in the Linnean system are kingdom, phylum, class, order, family, genus, and species.

Temporal—Dealing with time.

Transition zone—Areas of habitat where species of defined or distinct adjacent communities mix and thereby are not classified as either adjacent community.

Transportation Implementation Plan (TIP)—Transportation program developed by state and metropolitan transportation agencies.

Underpass—Structure, including the approaches, that allows one route to pass under another route or obstacle.

Viaduct—Long elevated bridge over a valley and/or water body, supported on pilings that carries a highway or railroad over the lower area.

Wetlands—Land and/or area containing high levels of soil moisture or completely submerged in water for either part or the whole of the year.

Wildlife—Wild animals, plants, and bacteria as a collective body.

Wildlife corridor—Vegetated feature that links to other wildlife areas and may act as an interconnecting route for the movement of animals between different areas needed during their life cycle or to facilitate dispersal of animals and plants by providing access to new or replacement sites. It may also increase the overall extent of habitat for animals with large range requirements and, in urban and agricultural areas, may constitute the main remaining wildlife habitats.

ACRONYMS

CEQ—Council on Environmental Quality

CFR—Code of Federal Regulations

DOA—U.S. Department of the Army

DOI—U.S. Department of the Interior

DOT—Department of transportation

EIS—Environmental impact statement

EPA—Environmental Protection Agency

EPS—Environmental Policy Statement

ESA—Endangered Species Act

ESBA—Endangered Species Biological Assessment

FHPM—Federal-Aid Highway Program Manual

FWPCA—Federal Water Pollution Control Act

FWS—U.S. Fish and Wildlife Service

GIS—Geographic information system

GPS—Global Positioning System

HEP—Habitat Evaluation Procedure

MPO—Metropolitan planning organization

NMFS—National Marine Fisheries Service

NPDES—National Pollution Discharge Elimination System

NPS—National Park Service

P.L.—Public Law

RCRA—Resource Conservation and Recovery Act

SIP—State Implementation Plan

STAT.—Statute

STP—Surface Transportation Program

TEA-21—Transportation Equity Act for the 21st Century

USACE—U.S. Army Corps of Engineers

U.S.C.—United States Code

USCG—U.S. Coast Guard

USFS—U.S. Forest Service

APPENDIX A

Questionnaire Responses

Section I: Law, Policy, Procedure, and Process

1. *Does your state have mandates for addressing ecological impacts above and beyond existing federal laws and regulations?*

Law	Yes	26	No	9
Planning requirements	Yes	11	No	24
Policies	Yes	17	No	18
Procedures	Yes	18	No	17
Court decisions	Yes	4	No	31
Other	Yes	5	No	30

2. *Are your state resource agencies a normal part of coordination when trying to address federal regulations on a project? Yes 34 No 1 Which federal environmental regulations do you most commonly encounter in your transportation projects?*

Further comments? Alaska – NEPA & Wetlands. **Arkansas –** Section 404 and Migratory Bird Treaty Act. **California** ESA, CWA section 10 and 404, CZMA Act as well as Executive Orders promulgated through FHWA. **Connecticut –** 401 Water Quality Certificates, Section 404, Essential Fish Habitat **Florida –** Section 401 & 401, NEPA, ESA and CZMA. **Georgia –** NEPA, CWA, ESA, Clean Air Act and Fish & Wildlife Coordination Act. **Hawaii –** Section 7 ESA. **Illinois –** Section 404 of CWA. **Iowa –** NEPA, CWA 404, ESA, Section 106. **Kansas –** Section 404, CWA and ESA. **Kentucky –** CWA, ESA, NEPA and coordination with Kentucky State Nature Preserves Commission (state heritage agency) and KDFWR. **Maine –** NEPA, ESA, Rivers and Harbors Act of 1899, CWA, Magnuson-Stevens Act, Pittman-Robertson Act. **Maryland –** NEPA, ESA, Sec 106, Sec 404, Sec 418. **Michigan –** CWA, Sections 401 & 404; EO 11988 & 11990; ESA **Minnesota –** NEPA, NPDES, Section 4(f), Section 6(f), CWA Section 404, AQ, FHWA Noise, ESA, Wild & Scenic Rivers. **Mississippi –** CWA, ESA, Section 106, Section 4(f). **Montana –** CWA Section 404 and 402 (Stormwater Erosion Control), ESA. **Missouri –** NEPA, ESA, CWA and Section 106. **Nebraska –** CWA Section 401 & 404, ESA, Historic Preservation Act. **Nevada –** ESA, CWA Section 404. **New Hampshire –** CWA, CAA, NEPA, Section 4(f), RCRA/CERCLA and Fish and Wildlife Coordination Act. **New Jersey –** CWA 404 & 401, NEPA, ESA. **New York –** CWA Section 404 and 10; ESA, Migratory Bird Treaty Act (MBTA); National Pollution Discharge Elimination System (NPDES) NEPA. **Ohio –** NEPA, Fish and Wildlife Coordination Act, CWA Section 401, 404 and NPDES, ESA. **Oregon –** ESA, Clean Water Act, CZMA. **Texas –** ESA and Fish & Wildlife Coordination. **Utah –** ESA, CWA, Section 4f and 6f, NEPA. **Virginia –** Federal Aid Policy Guide 23 CFR 772 Procedures for Abatement of Highway Traffic Noise and Construction Noise; Transportation Equity Act for the 21st Century (TEA-21) Public Law No. 105-178 (air quality provisions); National Environmental Policy Act (NEPA), Public Law No. 91-190 (public provisions); Clean Air Act Amendments of 1990, Public Law No. 101-549; Transportation Conformity Rule, 40 CFR Parts 51 and 93; Statewide Transportation Planning Regulations, 23 CFR Part 450. Highway Beautification Act of 1965, 23 USC Section 131 et seq. and 23 CFR Part 750, Section 33.1-351 et seq. – Code of Virginia, 24 VAC 30-120-10 et seq.; Americans with Disabilities Act; Scenic Rivers Act of 1990; Protection of Historic Properties, 26 CFR Part 800; Federal Aid Highway Act of 1987, Section 123(f); Regulations Promulgated Pursuant to the Resource Conservation and Recovery Act of 1976 (as amended); National Emission Standards for Hazardous Air Pollutants (NESHAP) Promulgated Pursuant to the Clean Air Act of 1970 (as amended), Virginia Occupational Safety and Health Standards, (regulations promulgated pursuant to the Occupation Safety and Health Act (OASHA) (as amended)); Regulations Promulgated Pursuant to the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) of 1980 (as amended) by the Superfund Amendments and Reauthorization Act (SARA) of 1986; Regulations Promulgated Pursuant to the Federal Water Pollution Control Act of 1972 (as amended) by the Clean Water Act of 1977 and the Oil Pollution Act of 1990; Federal Endangered Species Act – December 1973, as amended, 16 USC 1531; Nationwide (programmatic) Section 4(f) Evaluations and Approvals for Federally-Aided Highway Projects with Minor Involvement with Public Parks, Recreation Lands, Wildlife and Waterfowl Refuges and Historic Sites – December 23, 1986 – 49 USC 303; Farmland Protection Policy Act of 1981, 7 USC 4201–4209; Section 6(f) of the Land and Water Conservation Act of 1965, 16 USC 4601 – 8(f); Federal Highway Administration Regulations Governing the Preparation of Environmental Documents, 23 CFR 771; Section 4(f) of the U.S. Department of

Transportation Act of 1966, 49 USC 303; National Environmental Policy Act of 1969, as amended, September 13, 1992, 42 USC 4321-4347; Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act – November 29, 1978, 40 CFR 1500-1508; Federal Highway Administration Letters of Approval of VDOT Programmatic Categorical Exclusions, 23 CFR 771.117 and Agreement approved May 21, 1998; Federal Actions to address Environmental Justice in Low Income Populations and Minority Populations, Executive Order 12898 – Guidance 6640.23; Environmental Impacts and Related Procedures, Constructive use – April 1, 1991 – 23 CFR 771.135; Coastal Zone Act Reauthorization Amendments of 1990 – Section 6217, Coastal Resources Management Program – October 1987, Federal Coastal Zone Management Act of 1972, P. L. 92-583, as amended; U.S. Army Corps of Engineers' Regional Permit 14, Letter of Permission 1 – revised August 1998, Section 404 of the Clean Water Act, as amended – 33 USC 1344, Section 10 of the Rivers and Harbors Act of 1899 – 33 USC 403; Revised Nationwide Permits – December 13, 1996, Norfolk District Corps of Engineers' Regional Conditions – December 24, 1996, Section 404 of the Clean Water Act – 33 USC 1344, Section 10 of the Rivers and Harbors Act of 1899 – USC 403; Department of Environmental Quality Conditions on Corps of Engineers' Nationwide 7, 16, 17 and 26 Permits – January 1997, Section 401 of the Clean Water Act, as amended – 33 USC 1341; National Pollutant Discharge Elimination System for Stormwater Discharge under 40 CFR – Part 122. This federal requirement requires that the state implement regulations; U.S. Army Corps of Engineers' Wetland Mitigation Site Monitoring Requirements – revised April 1989, Section 404 of the Clean Water Act, as amended – 33 USC 1344, Section 10 of the Rivers and Harbors Act of 1899 – 33 USC 403; Endangered Species Act of 1973, as amended, 16 USC 1531 et seq., Virginia Endangered Species Act, Title 29.1, Sections 291.-563-570 – Code of Virginia, Virginia Endangered Plant and Insect Species Act, Section 3.1-1020-1030 – Code of Virginia. **Washington –** ESA, the Clean Water Act section 404 and the NPDS permits, MSA and Migratory Bird Treaty Act. **Wisconsin –** Clean Air Act and the Clean Water Act, Endangered Species Act. **Wyoming –** NEPA, CWA Section 404 & 401, ESA and Migratory Bird Treaty Act. **South Carolina –** CWA 401 & 404. **South Dakota –** CWA 404 & 401, SHPO.

3. *Is mitigation a normal part of resolving wildlife and habitat issues as part of the state and federal coordination process? Yes 33 No 2*
If yes, has it been in response to public or agency input during project development? Yes 30 No 5

4. *Where coordination has not resulted in satisfactory resolution of issues, have administrative or legal actions resulted in project features to resolve wildlife or habitat issues? Yes 9 No 26 Is there an arbitration process to resolve project ecological issues in your state? Yes 8 No 27*

5. *Has your department had projects where the Class of Action determination resulted in the need for an EA/FONSI or EIS because of ecological considerations on the project? Yes 26 No 9*

6. *Do you feel that existing state and federal policy and procedure give you the means to justify project features for ecological considerations? Yes 26 No 9*

Section II: Types of Effects

7. *Is your state doing new alignment projects? Yes 33 No 2 If yes, has habitat fragmentation been an issue on these projects? Yes 30 No 5 Or, taking of habitat? Yes 32 No 3*

8. *What types of organisms has your department encountered which resulted in mitigation measures?*

Reptiles	Yes 24	No 11
Amphibians	Yes 20	No 15
Birds	Yes 32	No 3
Small mammals	Yes 21	No 14
Carnivores	Yes 13	No 22
Other	Yes 23	No 12

Were any of these listed species? Yes 32 No 3

9. *Have you encountered federally designated "critical habitat" on projects? Yes 15 No 20 If yes, did it result in mitigation? Yes 11 No 4*

Section III: Analytical Tools

10. *Do you use GIS for ecological analysis? Yes 27 No 8 Do you use remote sensing equipment? Yes 17 No 18*

11. *Are any of the following plans used when trying to determine the present and future land use of an area?*

Natural resource management plans	Yes	28	No	7
Habitat and/or species management plans	Yes	29	No	6
Threatened or endangered species recovery plans	Yes	29	No	6
Local comprehensive plans	Yes	27	No	8
Local conservation plans	Yes	21	No	14
Other planning initiatives	Yes	12	No	23

12. *Are secondary and cumulative impacts a part of your analysis for habitat and wildlife? Yes 32 No 3*

13. *Do other state and federal agencies provide information that is helpful in the analytical process? Yes 33 No 2 Do you provide financial support to other agencies for personnel or resources to conduct studies or reviews? Yes 26 No 9*

14. What analytical tools do you use in habitat and wildlife analysis that you feel would be useful to other states?

Please provide references or methodology. ***Alaska –*** *No suggestions. Depend on professional judgment a lot. Many of the analytical tools in the lower 48 don't work in Alaska. We have agreed with agencies to use a rapid wetlands assessment (HGM), but haven't used it yet.* ***Connecticut –*** *We rely chiefly on education and experience of our staff.* ***Florida*** *– Using a model (Smith) to determine state-wide wildlife connectivity needs.* ***Iowa –*** *Mitigation monitoring protocol developed by IDOT.* ***Kansas –*** *Wildlife Habitat Assessment (Kansas Dept. of Wildlife Protection).* ***Kentucky –*** *GIS/GPS Arcview, Database sharing and HGM assessments for wetlands.* ***Michigan*** *– WET II.* ***Montana –*** *Montana Wetland Field Evaluation Form developed by MDT for functional assessment of wetlands impacted by projects.* ***Missouri –*** *Use of GIS with agency agreements and financial support of ecological data layers.* ***New Jersey –*** *Mostly based on professional judgment of on-site habitat conditions.* ***New York –*** *NY Dept. of Environmental Conservation, Natural Heritage Program "red flag" maps (hard copy and GIS) for location and attributes on threatened and endangered species and critical habitats.* ***Utah –*** *Wildlife/vehicle collision frequency analysis on our major highways. Data are currently being collected from UDOT carcass removal consultant's data kept by the UDOT regional offices, Utah Division of Wildlife Resources data where available and other sources as they are identified.* ***Washington*** *– We have developed a GIS arc view tool which is provided to the environmental folks which has all the NWI wetland maps, stream maps, USGS maps, assorted fish, wildlife, and plant data from USFWS and WDFW, culvert barrier data, etc. These maps are all in a user-friendly system application that all the environmental folks have on their computer so that they can determine what kind of environmental constraints each project may have. We have many field survey methods that are specific to local species/habitats, particularly for USFS survey & manage species. WSDOT has developed a rapid method for wetland functions characterization particularly useful for linear projects. Copies are available from Paul Wagner (360) 705-7406.* ***Wisconsin –*** *Tools used include ArcGIS (ESRI product) in conjunction with GPS.*

15. *Does your agency provide training on ecological assessment techniques? Yes 16 No 19*

Section IV: Conservation/Mitigation Measures

16. *Has your department entered into any programmatic agreements or approaches to resolving ecological issues? Yes 25 No 10*

17. *Has your department used habitat preservation or restoration as mitigation for impacts to habitats other than wetlands? Yes 30 No 5 Comments?*

18. *Has your department used structural measures as mitigation or part of a project to conserve wildlife?*

bridge extensions	Yes 25	No 10
wildlife underpasses	Yes 22	No 13
wildlife overpasses	Yes 7	No 28
culverts	Yes 30	No 5
fencing	Yes 28	No 7
other	Yes 10	No 25

19. *Has your department constructed structural features for wildlife as a separate project independent of a highway improvement project? Yes 9 No 25*

20. *Are ecological measures taken as mitigation or conservation measures routinely researched to determine the effectiveness of the measures? Yes 18 No 17*

Section V: Maintenance

21. *Do your maintenance forces maintain rights-of-way to accommodate wildlife? Yes 15 No 20 Maintain the rights-of-way to discourage the use by wildlife? Yes 13 No 23*

22. *Do other agencies maintain habitat restored or set aside (purchased or deeded) as mitigation or conservation measures for your department's project impacts? Yes 19 No 16 Does your agency contribute financial support to these activities? Yes 10 No 24*

Section VI: Funding Sources

23. *Have ecological factors been anticipated early enough in project planning to result in adequate funding being included in the project budget to cover needed features? Yes 27 No 8*

24. *Has the need for ecological features on a project resulted in capturing funds from other projects? Yes 6 No 29 Resulted in unanticipated bonding for funds? Yes 0 No 35 Additional tolls for funds? Yes 1 No 34*

25. *Have enhancement funds been used for ecological (wildlife) features or studies as provided for in TEA-21? Yes 12 No 23 Were you aware that these features qualified for enhancement funds? Yes 32 No 3*

26. *Have federal grant or research funds been used to study the effectiveness of ecological measures? Yes 18 No 17*

APPENDIX B

List of Survey Respondents

Alaska Department of Transportation
Statewide Design and Engineering Services

Arkansas State Highway and Transportation Department
Environmental Division

California Department of Transportation
Environmental Program

Colorado Department of Transportation
Office of Environmental Services

Connecticut Department of Transportation
Office of Environmental Planning

Florida Department of Transportation
Environmental Management Office

Georgia Department of Transportation
Office of Environment/Location

Hawaii State Department of Transportation
Highways Division, Planning Branch

Idaho Transportation Department
Bureau of Design and Environment

Illinois Department of Transportation
Bureau of Design and Environment

Iowa Department of Transportation
Planning and Programming Division–Environmental

Kansas Department of Transportation
Environmental Services Section

Kentucky Transportation Cabinet
Division of Environmental Analysis

Maine Department of Transportation
Environmental Office

Maryland State Highway Administration
Project Planning Division

Michigan Department of Transportation
Project Planning Division

Minnesota Department of Transportation
Environmental Development Unit

Mississippi Department of Transportation
Environmental Division

Missouri Department of Transportation
Preliminary Studies Division

Montana Department of Transportation
Environmental Services and Construction

Nebraska Department of Roads
Project Development Division

Nevada Department of Transportation
Environmental Services Division

New Hampshire Department of Transportation
Bureau of Environment

New Jersey Department of Transportation
Bureau of Environmental Services

New York State Department of Transportation
Environmental Analysis Bureau

Ohio Department of Transportation
Office of Environmental Services

Oregon Department of Transportation
Environmental Services/Project Support Section

South Carolina Department of Transportation
Environmental Management Office

South Dakota Department of Transportation
Office of Project Development

Texas Department of Transportation
Division of Environmental Affairs

Utah Department of Transportation
Environmental Division

Virginia Department of Transportation
Environmental Division

Washington Department of Transportation
Environmental Affairs Office

Wisconsin Department of Transportation
Bureau of Environment

Wyoming Department of Transportation
Environmental Services Branch

APPENDIX C

Major Federal Regulations Relevant to Wildlife and the Environment

National Environmental Policy Act (NEPA)—NEPA requires the consideration of environmental factors including wildlife through a systemic interdisciplinary approach before committing to a course of action. The act applies to all FHWA actions. The act is the basis for the documentation of social, economic, and environmental impacts for all FHWA actions. The procedures for implementing NEPA are set forth in Council for Environmental Quality regulations and 23 CFR 771. Coordination with the appropriate federal, state, and local agencies is required.

Section 7A1 of the Endangered Species Act of 1973, as amended—The goal of the Endangered Species Act is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved," thereby conserving the associated species of fish, wildlife, and plants facing extinction. The act covers any action that is likely to "take" individuals or jeopardize continued existence of such endangered/threatened species or result in destruction or modification of federally designated "critical habitat." The act requires consultation on federal actions with the secretary of the interior or commerce, as appropriate. Responsible agencies include the Department of Interior (DOI), Fish and Wildlife Service (FWS), Department of Commerce (DOC), and the National Marine Fisheries Service (NMFS), as appropriate.

Federal Water Pollution Control Act (1972), as amended by the Clean Water Act (1977 and 1987)—The legislation was passed to restore and maintain the chemical, physical, and biological integrity of the nation's waters through prevention, reduction, and elimination of pollution. The act is applicable to any discharge of a pollutant into waters of the United States. The act requires obtaining a permit for dredge or fill material from the U.S. Army Corps of Engineers (USACE) or state agency, as appropriate, under Section 404. Permits for all other discharges are to be acquired from the Environmental Protection Agency (EPA) or appropriate state agency (Section 402). The act provides for Phase 1 of the National Pollution Discharge Elimination System by issuance of permits for municipal separate storm sewers serving large (over 250,000) or medium (over 100,000) population areas. For stormwater discharges associated with industrial activities (activities including construction sites of greater than 5 acres), a water quality certification is required from the State Water Resource Agency (Section 401). Furthermore, all projects shall be consistent with the state Non-Point Source Pollution Management Program (Section 319) of the Clean Water Act. Protection of aquatic resources is a benefit of this act. Responsibility for administering the provisions of the act is with the USACE, EPA, designated state Water Quality Control Agency, or designated state Non-Point Source Pollution Agency.

Rivers and Harbors Act of 1899—The act is designed to protect navigable waters in the United States. Any construction affecting navigable waters (over, under, or in) and any obstruction, excavation, or filling is covered. Applicant must obtain approval of plans for construction, dumping, and dredging permits (Sec. 10), as well as bridge permits (Sec. 9). The act also protects important estuarine and marine habitats. USACE, U.S. Coast Guard, EPA, and state agencies each have responsibilities to administer.

Emergency Wetlands Resources Act of 1986—This act was passed to promote the conservation of wetlands in the United States in order to maintain the public benefits they provide. It applies to all projects that may impact wetlands. The act requires the preparation of a national wetlands conservation plan, which assumes priority with respect to federal and state acquisition. It also provides direction for the national wetlands inventory of the Fish and Wildlife Service (FWS), thereby providing policy, regulatory, and project level guidance for projects involving wetlands and associated wildlife. The requirements of the act are administered by the FWS.

Native American Coordination—The White House Memorandum for the Heads of Executive Departments and Agencies issued by President Clinton in 1994 requires that the heads of executive departments and agencies operate on a government-to-government basis with federally recognized tribal governments. This action greatly underscored the concept of tribes as sovereign nations that is recognized by the Constitution, affirmed by Congress in treaty and statute, and enforced through the courts by precedents. Because the Indian religions and cultural heritage are closely aligned with the natural environment and wildlife the following acts can come into play during the coordination process:

- American Indian Religious Freedom Act (PL 95-341);
- Antiquities Act (PL 209);
- Archaeological Resources Protection Act (PL 96-95);
- National Historic Preservation Act (PL 89-665);
- Native American Graves Protection and Repatriation Act (PL 101-601);
- Executive Order 11593, Protection and Enhancement of the Cultural Environment; and
- Executive Order 13007, Indian Sacred Sites.

The ancestral links to the environment and sacred nature of sites around the country lead to protection of these areas, which are often also important from a habitat and wildlife standpoint. The Native American reverence for the environment and all things living can lead to interesting coordination challenges, which directly relate to wildlife (see case history on US-93, Montana).

Transportation Equity Act for the 21st Century (TEA-21): Congestion Mitigation and Air Quality Improvement Program—Provisions to improve air quality have ramifications in relation to habitat degradation and associated wildlife impacts. They also are related to global warming. These provisions of the bill were designed to assist nonattainment (do not meet standards for local area) and maintenance areas in the reduction of transportation-related emissions. The provisions apply to transportation programs or projects that are likely to contribute to the attainment or maintenance of the national air quality standards in nonattainment areas and areas redesignated to maintenance. The project sponsor (transit operator, municipal office, etc.) develops a formal proposal to improve air quality. This is submitted to the metropolitan planning organization(s) (MPO) and the state for evaluation and approval. The project is then included in the Transportation Improvement Plan (TIP) and approved as eligible by the FTA and FHWA in consultation with the EPA.

Transportation Equity Act for the 21st Century: *National Scenic Byways Program*—These provisions allow for identification and development of those special scenic byways that offer outstanding scenic, historic, natural, cultural, recreational, or archaeological values. Any public road or highway that meets the criteria can be included as a Scenic Byway or an All-American Road. Nominations may originate from any local government, private group, or individual, but must come through the states. The secretary of transportation makes final designations. The FHWA is the administering agency.

Transportation Equity Act for the 21st Century: Transportation Enhancement Activities—This provision provides funds for Transportation Enhancement activities, such as the study and prevention of wildlife mortality. Funds are to be used in all areas except roads classified as local or rural minor collectors, unless such roads are on a federal-aid highway system. Annually, 10% of State Transportation Program funds are apportioned to each state for Transportation Enhancement Activities. The FHWA administers these provisions of the act.

Transportation Equity Act for the 21st Century: National Recreational Trails Fund—These funds are meant to establish a program that allocates funds to the states to provide and maintain recreational trails and trail-related projects. Trails and trail-related projects that are identified in, or further a specific goal of, a trail plan included or referenced in a statewide comprehensive outdoor recreation plan, as required by the Land and Water Conservation Fund Act qualify for these funds. The project sponsor applies to the state, and the FHWA approves spending for the project. The state may be a project sponsor. Assured access to funds is given for motorized, nonmotorized, and discretionary recreation uses. States shall give preference to projects with diversified uses, such as multiple-use trails for human and wildlife use. These trails can often provide corridors for wildlife. (See overpass example in Florida case study.) The FHWA administers this program.

Section 4(f) of the Department of Transportation Act—This section of the act requires the preservation of publicly owned parklands, waterfowl and wildlife refuges, and significant historic sites. There is a specific finding required for significant publicly owned parklands, recreation areas, wildlife and waterfowl refuges, and all significant historic sites “used” for a highway project. This specific finding requires that (1) the selected alternatives must avoid protected areas, unless not feasible or prudent, and (2) the project includes all possible planning to minimize harm. Coordination with the DOI, Department of Agriculture (DOA), Housing and Urban Development, state, or local agencies having jurisdiction and state historic preservation officer (for historic sites) is required.

Fish and Wildlife Coordination Act—This act calls for the conservation, maintenance, and management of wildlife resources for any project that involves impoundment (surface area of 10 acres or more), diversion, channel deepening, or other modification of a stream or other body of water or the transfer of property by federal agencies to state agencies for wildlife conservation purposes. Coordination with the FWS and state fish and wildlife agency is required early in project development. DOI (FWS) and the state fish and wildlife agencies are responsible for administering the act. Coordination is required when dealing with fish and wildlife.

Migratory Bird Treaty Act—The goal of this act is to protect most common wild birds found in the United States. The act makes it unlawful for anyone to kill, capture, collect, possess, buy, sell, trade, ship, import, or export any migratory bird, egg, or nest. Indirect killing of birds by destroying their nests and eggs is covered by the act; therefore, construction in nesting areas can constitute a taking. The FWS reviews and comments on the effects of a proposal that could kill birds, even indirectly. The act is administered by the DOI (FWS) and state fish and wildlife agencies. Coordination is required when projects involve migratory bird habitat.

Marine Protection Research and Sanctuaries Act of 1972, as amended—This act regulates dumping of material into

U.S. ocean waters. Any transportation of materials and dumping into the open sea is covered under this act. The act requires application for a permit in accordance with procedures. The responsible agencies are the EPA and the USACE if there are dredge materials. In this instance the relationship to wildlife comes when demolition materials are disposed of in marine waters or used as artificial reefs.

Wilderness Act—The intent of this act is to preserve and protect wilderness areas in their natural condition for use and enjoyment by present and future generations. All lands designated by Congress as part of the wilderness system are covered by the act. Modifications or adjustments of wilderness boundaries require application to Congress by either the secretary of the interior or the secretary of agriculture, as appropriate. The act is administered by the DOA [U.S. Forest Service (USFS)], DOI [FWS, National Park Service (NPS)], and Bureau of Land Management and state agencies. The relationship here is that wilderness areas are without roads so avoidance is required.

Wild and Scenic Rivers Act—This act was passed to preserve and protect wild and scenic rivers and the immediate environments for the benefit of present and future generations. Wild and scenic rivers provide some of the most pristine aquatic and fisheries habitats remaining in this country and require special consideration. All projects that affect designated and potential wild, scenic, and recreational rivers, and/or immediate environments require coordination by submitting project proposals and reports to DOI (NPS), DOA (USFS), and responsible state agencies.

Coastal Barrier Resources Act (COBRA), as amended; Great Lakes Coastal Barrier Act of 1988—This legislation intends to minimize the loss of human life, wasteful expenditures of federal revenues, and the damage to fish, wildlife, and other natural resources by designating a coastal barrier resources system of units needing protection. The coastal environments constitute important habitats that support unique wildlife. Agencies consult maps that depict the boundaries of each coastal barrier unit and coordinate early with the FWS regional director if the project crosses or is in close proximity to a unit. Exemptions for certain actions are possible. Coordination with DOI (FWS) is required.

Coastal Zone Management Act of 1972—The intent of the act is to preserve, protect, develop, and, where possible, restore and enhance resources of the coastal zone. Similar to COBRA, this act is meant to protect limited coastal habitats and associated wildlife. All projects significantly affecting areas under the control of the State Coastal Zone Management Agency for which the DOC approves a plan are covered by the act. Coordination is required to ensure that projects comply with federal consistency regulations, management measures, and the appropriate approved state plans for the Coastal Zone Management Programs. The Coastal Zone State Management Agency and the DOC [Office of Coastal Zone Management (OCZM)], the National Oceanic and Atmospheric Administration (NOAA), and the EPA administer the provisions.

Coastal Zone Management Act Reauthorization Amendments of 1990—These amendments require the management of nonpoint source pollution for activities located in coastal zones. These amendments help protect estuarine and marine habitats and species. All developmental activities located in coastal zone areas will be subject to nonpoint source control measures developed by the state Coastal Zone Agency. Coordination is necessary to ensure that projects comply with state CZM plans for controlling nonpoint sources. The state CZM Agencies, NOAA (OCZM), and the EPA administer the provisions of the amendments.

Clean Air Act (as amended), Transportation Conformity Rule—The intention of the act is to ensure that transportation plans, programs, and projects conform to the state's air quality implementation plans. Nonattainment and maintenance areas are identified using quality standards. The act requires that transportation plans, programs, and projects must conform to State Implementation Plans (SIPs) that provide for attainment of the national ambient air quality standards. All of the clean air provisions have ramifications in habitat quality and global warming impacts to wildlife. The FTA, EPA, MPOs, state departments of transportation, and state and local air quality control agencies work to ensure attainment of air quality standards.

Clean Air Act (as amended), Sanctions—The amendments restrict federal funding and approvals for highway projects in states that fail to submit or implement an adequate State Implementation Plan (SIP) in nonattainment areas 24 months after EPA has identified an SIP deficiency. The provisions may be applied statewide under separate rulemaking after the EPA finds that a state failed to submit or implement an SIP, that the SIP is incomplete, or disapproves of an SIP. Unless deficiencies are corrected within 18 months, 2:1 offset sanctions are applied. Six months later highway sanctions are applied. The EPA administers this act.

Land and Water Conservation Fund Act (*Section 6(f)*)—The act intends to preserve, develop, and assure the quality and quantity of outdoor recreation resources for present and future generations. The act applies to all projects that impact recreational lands purchased or improved with federal land and water conservation funds. The relationship to wildlife is the importance of these recreational lands as habitat. The secretary of the interior must approve any conversion of property acquired or developed with funding assistance under this act to activities other than public, outdoor recreation use. The DOI and state agencies administer.

National Trails System Act—This act provides for outdoor recreation needs and encourages outdoor recreation. Projects affecting national scenic or historic trails designated by Congress, and the lands through which such trails pass, require coordination. National recreation trails and side or connecting trails are proposed by local sponsors and approved by the DOI and DOA. The first step is to apply for right-of-way easements from the secretary of interior or the secretary of agriculture, as appropriate. Next, the applicant ensures that potential trail properties are made available for use as recreational and scenic trails. Similar to the trails provisions in TEA-21, these lands can serve multiple functions including wildlife habitat and corridors. DOI (NPS) and Agriculture (USFS) administer the trail system, but other federal land management agencies may apply for designation.

Magnuson–Stevens Fishery Conservation and Management Act (*Essential Fish Habitat*)—This act provides for essential fish habitat protection. Essential fish habitats are those waters and substrates necessary for spawning, breeding, feeding, or growth to maturity (all life stages) for marine, estuarine, and anadromous species. Waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate. The act is administered by the NMFS of NOAA.

Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976—This act provides for the recovery, recycling, and environmentally safe disposal of solid wastes. It applies to all projects that involve the recycling or disposal of solid wastes. Solid wastes will be disposed of according to the rules for specific waste involved. Proper disposal of solid wastes is important to terrestrial and aquatic habitats and their associated wildlife. Additionally, recycling prevents further resource extraction in wildlife habitat. The EPA administers the provisions of this act.

Resource Conservation and Recovery Act of 1976, as amended—The act protects human health and environments important to wildlife by prohibiting open dumping and requiring the management of solid wastes. It regulates treatment, storage, transportation, and disposal of hazardous waste. Any project that takes right-of-way containing a hazardous waste is covered. Coordination with EPA or state agency on remedial action is required. The EPA or state agency approved by the EPA has jurisdiction.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended—This act provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous waste disposal sites. The benefits to wildlife are prevention of exposure to hazardous substances in terrestrial and aquatic environments. Any project that might take right-of-way containing a hazardous substance is covered. The aim is to avoid hazardous waste sites, if possible. The EPA or state agency approved by the EPA has jurisdiction.

Federal Insecticide, Fungicide, and Rodenticide Act—This act calls for the control of the application of pesticides to provide greater protection to man and the environment. All activities that necessitate use of restricted pesticides are covered. This act requires the environmentally sound use of chemicals on highway rights-of-way by transportation maintenance crews, which helps protect habitat and wildlife. “Restricted use” pesticides require applicator certification. The EPA administers the act.

Executive Order 12898: Environmental Justice—Projects should avoid federal actions that cause disproportionately high and adverse impacts on minority and low-income populations with respect to human health and the environment. All federal programs and projects are covered. Environmental justice goals apply when looking at transportation alternatives, which can involve wildlife at the expense of minority and low-income populations. Because these minority and low-income populations often live in rural areas the relationship is more prevalent than is immediately obvious. The procedures are set forth in the department of transportation (DOT) Final Environmental Justice Strategy and DOT order dated April 15, 1997. The FHWA headquarters and field offices are charged with administering the executive order.

Executive Order 11990: Protection of Wetlands DOT Order 5660.1A—This executive order requires the avoidance of direct or indirect support of new construction in wetlands wherever there is a practicable alternative. Federally undertaken, financed, or assisted construction and improvements in or with significant impacts on wetlands are covered. The executive order requires evaluation and mitigation of impacts on wetlands. It has obvious benefits to wetland wildlife habitat. A specific finding is required in the final environmental document. The DOI (FWS), EPA, USACE, NMFS, and state agencies have regulatory responsibility.

Executive Order 11988: Floodplain Management, as amended by Executive Order 12148, DOT Order 5650.2—The intent is to avoid the long- and short-term adverse impacts associated with the occupancy and modification of floodplains, and to restore and preserve the natural and beneficial values served by floodplains. Floodplains are important wildlife habitat. All construction of federal or federally aided buildings, structures, roads, or facilities, which encroach upon or affect the base floodplain, requires the following: (1) assessment of floodplain hazards and (2) specific finding required in final environmental document for significant encroachments. The Federal Emergency Management Agency and state and local agencies administer.

Federal Statute—Economic, social, and environmental effects: 23 U.S.C. 109(h), (P.L. 91-605), 23 U.S.C. 128. 23 CFR 771-772—This statute was passed to ensure that possible adverse economic, social, and environmental effects of proposed highway projects and project locations are fully considered and that final decisions on highway projects are made in the best overall public interest. It is applicable to the planning and development of proposed projects on any federal-aid highway system for which the FHWA approves the plans, specifications, and cost estimates or has the responsibility for approving a program. Identification of economic, social, and environmental effects; consideration of alternative courses of action; involvement of other agencies and the public; and a systematic interdisciplinary approach are required. The report required by Section 128 may be used as the NEPA compliance document. Appropriate federal, state, and local agencies have jurisdiction.

Public hearings: 23 U.S.C. 128. 23 CFR 771.111(h)—This law ensures adequate opportunity for public hearings on the effects of alternative project locations and major design features, as well as the consistency of the project with local planning goals and objectives. Public hearings or hearing opportunities are required for projects described in each state's FHWA-approved public involvement procedures. Public hearings or opportunities for hearings during the consideration of highway location and design proposals are conducted as described in the state's FHWA-approved, public involvement procedures. States must certify to the FHWA that such hearings or the opportunities for them have been held and must submit a hearing transcript to the FHWA. Appropriate federal, state, and local agencies administer.

Wildflowers, 23 U.S.C. 319(B), (P.L. 100-17). 23 CFR 752—This statute is meant to encourage the use of native wildflowers in highway landscaping. Native wildflowers are to be planted on any landscaping project undertaken on the federal-aid highway system. At least one-quarter of 1% of funds expended on a landscaping project must be used to plant native wildflowers on that project. The FHWA state, division, and regional contacts work with state transportation agencies on these programs.

Noise Standards: 23 U.S.C. 109(i), (P.L. 91-605), (P.L. 93-87). 23 CFR 772—This law promulgates noise standards for highway traffic. All federally funded projects for the construction of a highway on a new location, or the physical alteration of an existing highway, which significantly changes either the vertical or horizontal alignment or increases the number of through-traffic lanes require the following: (1) noise impact analysis, (2) analysis of mitigation measures, and (3) the incorporation of reasonable and feasible noise abatement measures to reduce or eliminate noise impact. Although noise standards are aimed at human receptors, reduced noise could also positively affect wildlife. The FHWA administers this law.

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Advisers to the Nation on Science, Engineering, and Medicine

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