U.S. Fish & Wildlife Service

Roadway Design Guidelines

Prepared By
FWS Pacific Region, NWRS Branch of Transportation
Portland, Oregon

Alex Schwartz, PLA
Landscape Architect
Alex_Schwartz@fws.gov
503/736 4723

Contributors
Jeff Holm - Chief, R1 Branch of Transportation, Refuge Roads Coordinator R1 & R8
Mike Marxen - Chief, R1 Branch of Visitor Services and Communication
Peter Field - Western Federal Lands, Federal Highway Administration

Special Thanks
Steve Suder - National Coordinator, Refuge Transportation Program, FWS
Charles Houghten - Chief, R1 Division of Planning, Visitor Services and Transportation
Doug Staller - Refuge Manager, Necedah NWR, FWS, R3
Sandra Jacobson - Wildlife Biologist, Pacific Southwest Research Station, U.S. Forest Service
Florian Schulz and Emil Herrera - Florian Schulz Photography (visionsofthewild.com)
Patrick Stark - Visual Information Assistant, R1 Visitor Services and Communications

Consultant Team
SvR Design Company
Tom von Schrader, PE
Nate Cormier, RLA
Justin Martin, ASLA

Quatrefoil, Inc.
Brian Bainnson, ASLA

Cover: A Great Blue Heron flies off with its catch at William L. Finley NWR in Oregon. Roadways on National Wildlife Refuges provide opportunities for wildlife viewing and photography, two of the Big Six activities supported by the National Wildlife Refuge System.

Photo: George Gentry, USFWS

Purpose

The U.S. Fish & Wildlife Service (FWS) is the world's premier conservation agency, managing over 150 million acres of wildlife habitat on National Wildlife Refuges alone. FWS is in a unique position to demonstrate the land ethic so deeply interwoven in the rich fabric of our national heritage.

This guide highlights state of the art ecological, planning, design and engineering considerations for roadway projects that heed both the significant benefits and impacts these projects present. Roadway projects on FWS managed lands should conform to planning and design criteria that have been established to support the FWS mission. This document provides such criteria in the form of guidelines. These guidelines are summarized in a table of contents that serves as a project checklist.

The Roadway Design Guidelines are a wayfinding tool intended to facilitate dialog and decision making among project teams. The guidelines have been crafted to support the interdisciplinary team typically involved with decision making regarding a roadway project: Project Leaders, Project Managers, and technical experts from various disciplines.

This document includes 30 individual project planning and design guidelines, organized around 6 major themes. The project checklist serves as an overview of these guidelines, and has been provided as a tool to assist in project planning, design and implementation.

In the pages that follow you will find information and resources that will be useful in your work on roadway projects. Using these guidelines is not an end in itself. Rather, the guidelines are a starting point from which to explore solutions to implement a roadway project of the highest standard. Every guideline begins with a brief discussion of the intent for presenting a particular topic, followed by supporting principles central to honoring the guideline, as well as associated metrics. Selected resources are provided to gain a deeper understanding of the topic.

Brian Bainnson

Eva Paredes/USFWS

Visitor contact facilities are often located in close proximity to roadways like this one at McNary National Wildlife Refuge (NWR) (top). Bison herd as viewed from roadway at the National Bison Range (bottom).

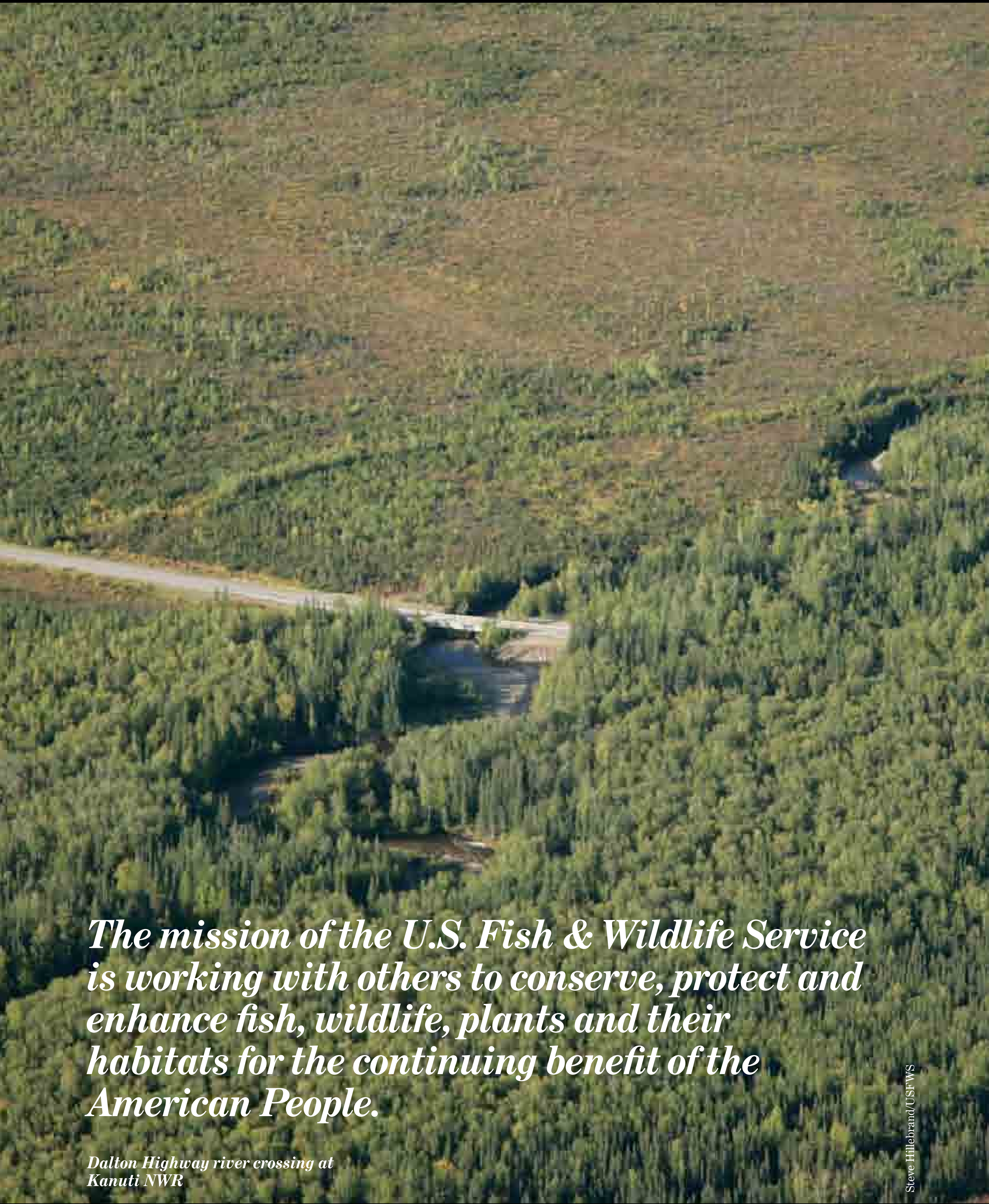
More Than Just A Road

A 'roadway' as referred to in these guidelines encompasses not only the suite of typical improvements associated with a vehicle-focused transportation project, but also related facilities such as parking, overlooks and the zone of ecological impacts from a road. These can be summarized as follows:

- **Typical transportation improvements** extend from the centerline of an existing or proposed road outward and include associated infrastructure components, such as paving, utilities, grading, drainage and planting.
- **Other facilities and infrastructure** commonly associated with vehicular transportation, include parking, visitor contact facilities, and pullouts.
- **Ecological connections and impacts** beyond the edge of the physical road or right of way, such as habitat fragmentation, habitat disturbance, pollution and aquatic and terrestrial species conflicts.

Moving Ahead for Progress in the 21st Century

Effective October 1, 2012, the existing Refuge Roads Program funded through previous Federal transportation authorizations is now called the FWS Transportation Program within the new Federal Lands Transportation Program. These new program details are described in the new transportation legislation called Moving Ahead for Progress in the 21 st Century (MAP-21). While still applicable to all refuge roads, these guidelines are generally applicable to all FWS transportation infrastructure and future improvements performed on this system of facilities and assets.



The mission of the U.S. Fish & Wildlife Service is working with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American People.

Dalton Highway river crossing at Kanuti NWR

Steve Hillebrand/USFWS

Project Checklist

LE – Landscape Ecology

- [ ] LE-1 Improve habitat connectivity
- [ ] LE-2 Reduce impacts to wildlife and habitat
- [ ] LE-3 Understand hydrologic processes of regional landscape
- [ ] LE-4 Respond to intrinsic qualities of regional landscape
- [ ] LE-5 Address climate change

PC – Planning Context

- [ ] PC-1 Review relevant planning, policy and regulatory information
- [ ] PC-2 Define level of service for the project
- [ ] PC-3 Evaluate multiple siting and alignment alternatives
- [ ] PC-4 Assess full costs and impacts of transportation system
- [ ] PC-5 Communicate with team and stakeholders

DE – Design and Engineering

- [ ] DE-1 Preserve and restore native vegetation and other natural resources
- [ ] DE-2 Consider and plan for invasive species management
- [ ] DE-3 Minimize cut and fill to fit with existing landscape
- [ ] DE-4 Consider road geometries for lower speeds, safety and alertness
- [ ] DE-5 Consider construction impacts and best practices
- [ ] DE-6 Consider range and sources of materials for sustainable construction
- [ ] DE-7 Consider maintenance

OP – Organism Passage

- [ ] OP-1 Develop your corridor plan for crossing
- [ ] OP-2 Provide and enhance aquatic organism crossings
- [ ] OP-3 Provide and enhance terrestrial wildlife crossings
- [ ] OP-4 Evaluate the need for wildlife fencing and other guiding features
- [ ] OP-5 Consider warning and safety systems for drivers

SM – Stormwater Management

- [ ] SM-1 Buffer habitat from polluted runoff
- [ ] SM-2 Protect habitat from erosive flows and flooding
- [ ] SM-3 Monitor and maintain stormwater facilities
- [ ] SM-4 Promote stewardship of aquatic resources

VE – Visitor Experience

- [ ] VE-1 Preserve and highlight scenic value
- [ ] VE-2 Promote and facilitate multiple modes of transportation
- [ ] VE-3 Comply with accessibility standards and guidelines
- [ ] VE-4 Facilitate compatible wildlife dependent recreation and education

Highway through Siletz Bay NWR provides travelers with visual access to the Refuge. The highway affects habitat connectivity and the landscape's hydrology.

David Pitkin/USFWS

Landscape Ecology

Landscape Ecology
Overview

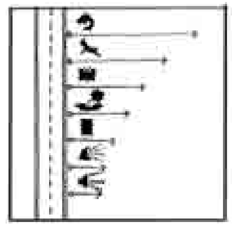
Pattern and Process
Roads and ecological function are intrinsically intertwined. Roadways on FWS managed lands in particular are frequently located in areas of high ecological importance.

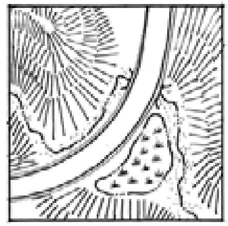
This section, Landscape Ecology, is intended to help you consider the broad-scale environmental impacts of your decisions regarding roadways and transportation infrastructure. It addresses a range of issues, providing you with a set of tools for decision-making.

Any new roadway construction or improvements to existing roadways on FWS managed lands requires unique treatment, consistent with the mission of the Service and supported by a detailed understanding of refuge management goals. Improvements need to be made in a manner consistent with applicable laws such as the Migratory Bird Treaty Act (MBTA), Fish and Wildlife Coordination Act (FWCA), Bald and Golden Eagle Protection Act (BGEPA) and Endangered Species Act (ESA). While the guidelines in this section cover principles which are, in general, applicable across a broad range of environments, take time to consider the guidelines and their specific implications within the unique bioregional context in which your projects will occur.

Research in the field of road ecology demonstrates that the multitude of adverse impacts of roads on landscapes, and the healthy function of the natural systems they traverse, are reduced by designing for slower travel speeds and lower traffic volume.

A significant component of a roadway project may be to remove roads from ecologically sensitive areas and restore those areas.





Landscape Ecology 101

Landscape ecology is the study of the relationship between spatial pattern and ecological processes on a wide variety of landscape scales and organizational levels. Some key landscape ecology concepts are:

Patch - Distinct area of a particular habitat or landscape type. Key considerations include size, number, location, and composition/contents. Small patches have a higher edge-to-interior ratio; some species thrive on edges, while others strictly prefer the qualities of a patch interior.

Edge - The shape, width, straightness, and other qualities of habitat or patch edges affects their performance and utility for various species.

Connectivity - This depends on distance, as well as other factors that may promote or inhibit movement between patches. A roadway may seem relatively narrow, but constitute a greater barrier than a broad field for some species.

Mosaic - The bigger picture that includes the various patches and the matrix that contains them (e.g. areas of remnant woodland and wetlands, within a matrix of agricultural fields). Key elements include scale, grain (coarseness), patch diversity, and degree of fragmentation.

Roads form a **network**, which may be viewed as a **matrix** that contains a variety of habitat patches. They significantly affect connectivity, creating abrupt and harsh edge conditions, whose effects (such as light, noise, air quality, temperature, hydrology) can extend well into the adjacent habitat patches.

LE-1 Improve Habitat Connectivity

Intent
Roadways should be examined for their potential to impact habitat connectivity. Wherever possible such impacts should be minimized and/or mitigated. When a contiguous habitat area is bisected by a roadway, abrupt edge conditions are created. Such habitat fragmentation is generally undesirable. Hydrologic and soil community connectivity are also affected. Native plantings and other restoration activities associated with roadway improvements can be designed to support multiple habitat objectives, including buffering patch interiors and mitigating roadway impacts. In rare instances, roadway corridors may also serve as habitat connectors, linking otherwise fragmented communities.

Principles
- Identify and prioritize habitat restoration and connectivity opportunities at the landscape scale
- Review state habitat connectivity plans as well as applicable recovery plans for listed species
- Consider impacts and footprint of the entire roadway as defined in these guidelines
- Develop partnerships among land management agencies and the local FWS Ecological Services (ES) office
- Partner with neighbors
- Identify opportunities for individual projects to minimize impacts to wildlife and restore habitat connectivity

Metrics
- Trends in species mortality, avoidance, low population survival, sensitive or endangered species populations
- Decreased wildlife-vehicle collisions and/or roadway avoidance
- Distance between habitat patches
- Distribution of species/population along and across roadway

Resources
Overview of road ecology and guidelines for ecological road planning and design.

Forman, Richard, et al. 2003. Road Ecology: Science and Solutions.

Graphic explanations of landscape ecology principles.

Dramstad, Olson, and Forman. 1996. Landscape Ecology Principles in Landscape Architecture and Land-Use Planning.

Discussion of positive and negative impacts of roadways on adjacent vegetation.

Forman, Richard. 2002. "Roadsides and Vegetation." In Proceedings of the International Conference on Ecology and Transportation, Keystone, CO, September 24-28, 2001.

Roadway design guidelines from applied ecology and experiential perspective.

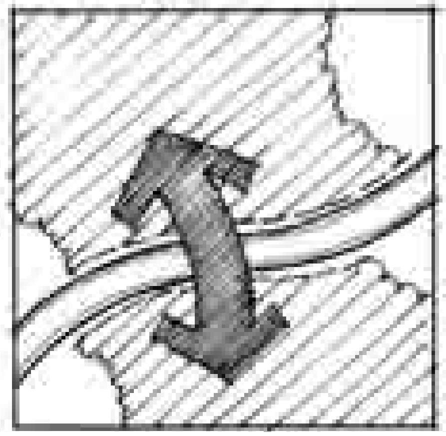
Jones, Grant R., et al. 2007. Applying Visual Resource Assessment for Highway Planning (pp.130-139) and Road Alignment (pp.330-341). In Landscape Architecture Graphic Standards.

Effects of roadways on wildlife (see also entire February 2000 Conservation Biology issue).

Trombulak, Stephen and Christopher Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities.

Wildlife conservation and planning efforts among the western states.

Western Governors' Wildlife Council. http://www.westgov.org/. Resources include the Wildlife Corridors Initiative Report (2008) and Wildlife Sensitivity Maps.

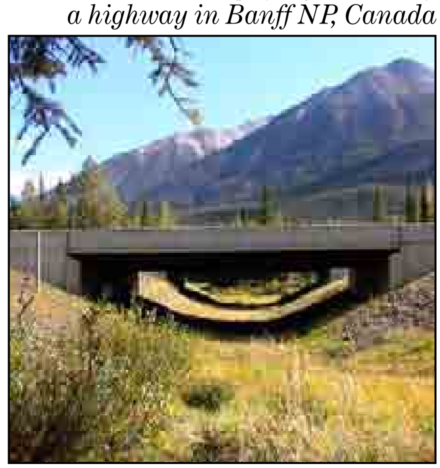


Habitat connectivity is disrupted along any road corridor

Habitat Connectivity

Habitat connectivity is a term commonly used in landscape ecology to describe the degree of connection between nearby or adjacent habitat areas. Distinct habitat areas are frequently referred to as 'habitat patches'. If the connection between these patches is not good, the resultant fragmentation can lead to loss of diversity within a given population of a species and potentially local extinction of that species from one or both patches. Even for fairly mobile species, a roadway can present a significant barrier to movement between patches.

Terrestrial under-crossing facilitates wildlife movement across a landscape fragmented by a highway in Banff NP, Canada



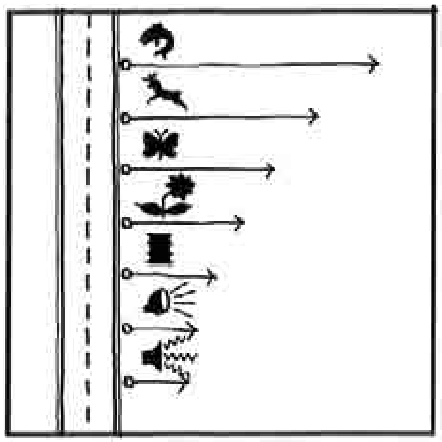
Patricia White/Flickr.com

LE-2 Reduce Impacts to Wildlife and Habitat

Intent

Roads have a significant impact on wildlife populations and habitat. Roads can directly impact wildlife through mortality (e.g. wildlife-vehicle collisions), roadway avoidance, habitat loss and habitat fragmentation. Wildlife-vehicle collisions are a safety concern for motorists. Traffic volume and roadway type directly relate to the severity of wildlife impacts. Roadkill data alone is not an accurate indicator of roadway impacts to wildlife, due to avoidance behavior and other issues. Mortality and avoidance are two species-dependent outcomes that may result from the barrier effect a roadway has on wildlife. In addition, maintenance practices, in combination with abundant edge habitat, can attract certain species of wildlife to a roadway, increasing the potential for conflict.

Consider roadway alignment, design, construction, and future maintenance methods that create the least detrimental impact to wildlife and habitats. Section OP (Organism Passage) discusses terrestrial and aquatic organism passage in more detail.



Impacts to wildlife and habitat extend outward from the roadway in various degrees, creating the 'road-effect zone'.

Principles

- Identify and limit the 'road-effect zone' and determine the potential exposure of ESA listed species and critical habitat to road effects within that zone. Minimize adverse effects to ESA listed species and critical habitat, and ensure any such effects are addressed through the ESA section 7 compliance process, as appropriate.
- Design for lower speeds, in order to minimize disturbance
- Consider management techniques to minimize disturbance to wildlife on auto tour routes
- Examine how road alters wildlife use patterns
- Examine how future effects on wildlife could make a project compatible (or not) with management goals
- Consider effects of noise, light and chemical pollution on habitats and wildlife

Metrics

- Reduction of wildlife-vehicle collisions
- Health of wildlife populations with habitats fragmented by or in proximity to roadways
- Road density (landscape ecology metric, see Definitions)
- Mesh size (landscape ecology metric, see Definitions)

Resources

Overview of road ecology, guidelines for ecological road planning and design. See especially discussion of road-effect zones, pp. 306-16.

Forman, Richard, et al. 2003. Road Ecology: Science and Solutions.

Latest information on road ecology as it relates to mitigating interactions between roads and wildlife.

Beckmann, J. P., et al. 2010. Safe Passages.

Identifying & prioritizing habitat connectivity zones, and guidelines for design solutions.

FHWA. 2008. Best Practices Manual, Wildlife Vehicle Collision Reduction Study (Report to Congress).

Effects of roadways on wildlife (see also entire February 2000 Conservation Biology issue).

Trombulak, Stephen and Christopher Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities.

Buffer design guidelines.

Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Access at: http://www.unl.edu/nac/bufferguidelines/

See also:

Section OP - Organism Passage

Roadways have significant impacts on both individuals and populations.

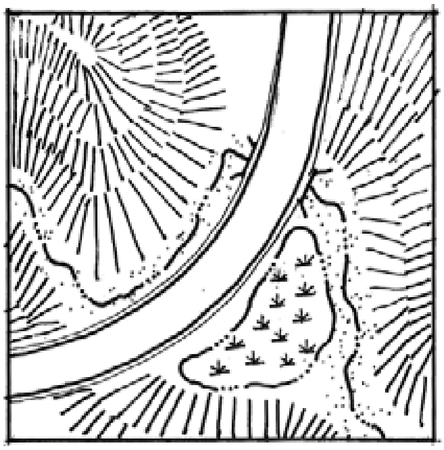
Mac Danzig Photography

Florian Schulz

LE-3 Understand Hydrologic Processes of Regional Landscape

Intent

Roadways can have dramatic impacts on hydrology at local, regional, and watershed scales. Disturbance to local hydrology is one negative impact to habitat caused by roadways. Impervious surfaces have a cumulative effect across a watershed, altering its hydrology and often creating detrimental consequences for wildlife. In some cases, the effects of a roadway on hydrology may be desired as part of a field station's approach to habitat management. Project teams should consider carefully how a roadway will impact local hydrology, or conversely how hydrologic processes can inform design decisions. Roadway improvements might support FWS management goals by addressing known issues and/or restoring historic hydrologic processes.



Roadways disrupt natural hydrology.

Principles

- Consider how road design may protect hydrologic processes
- Consider how to adapt an existing roadway for greater permeability
- Consider what effects the roadway might have on subsurface flows, water tables, and nearby aquifers, as well as how these elements affect construction options and feasibility
- Consider balance between restoring to pre-development conditions and maintaining historic alterations to hydrology
- Consider how development and roadway work will support current hydrologic and habitat management goals

Metrics

- Hydrologic modeling showing potential changes from roadways
- Stream flow data
- Changes in species composition (invasives vs. natives)

Resources

General reference on road ecology. See in particular overview of roadway effects on hydrology in Chapter 7.

Forman, Richard, et al. 2003. Road Ecology: Science and Solutions. Island Press. Washington D.C.

Guidelines that address hydrology impacts of roadways.

Smith, Stacy (Idaho Technology Transfer Center, Univ. of Idaho). 2005. BMP Handbook: Best Management Practices for Idaho Rural Road Maintenance.

Design guidelines for low-use roads, focusing largely on hydrology.

Weaver, William and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

Roadway design guidance for lower impact to hydrology.

Dashiell and Lancaster. Undated. Road Design Guidelines for Low Impact to Hydrology. Five Counties Salmonid Conservation Program. Weaverville, CA.

Guidebook on design and best practices for providing aquatic organism passage.

USDA Forest Service. 2008. Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings.

See also:

Section SM - Stormwater Management

Roads both affect and are affected by hydrology. Floodwaters wash out a road at Flint Hills NWR (top); levee road at Blackwater NWR (bottom).

Eva Paredes/USFWS

Leon Reed/Flickr.com

LE-4 Respond to Intrinsic Qualities of Regional Landscapes

Intent

Every landscape has a rich natural and cultural history, a distinct composition of flora and fauna, unique weather, drainage patterns and views. Such intrinsic qualities contribute to each location's "sense of place," or context, which should be a guiding factor in work there. A contextual approach should be taken when planning and designing all roadways on FWS lands, and should be used for such decisions as road alignment and location of visitor facilities. Consider local vernacular architecture and land management traditions (e.g. local historic and sustainable agricultural practices), aesthetic issues such as viewsheds and practical issues such as seasonal access to recreational opportunities.

Principles

- Consider Context Sensitive Solutions (CSS) for general design guidelines and engage a landscape architect
- Develop benchmarking tools for ecological performance
- Consider what local land use traditions are consistent with FWS goals and management activities
- Respond to visual appearance of regional landforms, vegetation, and other natural features
- Review historic land use patterns and cultural practices
- Consider visitor experience and potential educational and interpretive benefits of road and visitor facility designs

Metrics

- Visitor satisfaction
- Ecological literacy of visitors
- Documentation of visual analysis (visual resource assessment) process (see Resources below)

Resources

Context-sensitive highway planning and design case study.

Kentucky Transportation Center. Undated. Context-Sensitive Design Case Study No. 1: Paris Pike - Kentucky.

Performance metrics for CSS design.

TransTech Mgmt., Oldham Historic Properties Inc., and Parsons Brinckerhoff Quade & Douglas for National Cooperative Highway Research Program. 2004. Performance Measures for Context Sensitive Solutions - A Guidebook for State DOT's.

Items to address or consider.

ODOT. 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Roadway design guidelines from applied ecology and experiential perspective.

Jones, Grant R., et al. 2007. Applying Visual Resource Assessment for Highway Planning (pp.130-139), and Road Alignment (pp.330-341). In Landscape Architecture Graphic Standards. Available at: http://www.jonesandjones.com/news/publications.html.

Guidelines for visual and context considerations for roadway design.

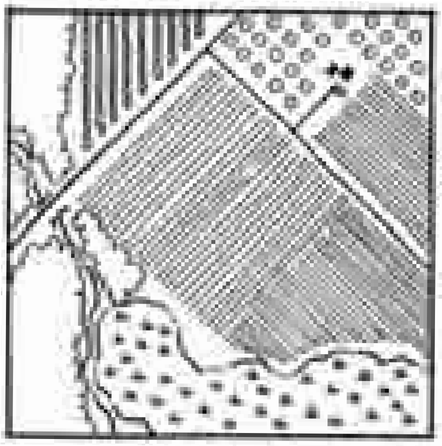
USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

Transportation Research Board of The National Academies. 2002. A Guide to Best Practices for Achieving Context Sensitive Solutions (NCHRP Report 480).

Regional design guidelines.

New Mexico Department of Transportation. 2006. Architectural and Visual Quality Design Guidelines for Context Sensitive Design and Context Sensitive Solutions.

Nevada Department of Transportation. 2002. Pattern and Palette of Place: A Landscape and Aesthetic Master Plan for the Nevada State Highway System.



Historic land use patterns and natural features can help drive design.

Context Sensitive Solutions

The term Context Sensitive Solutions (CSS) refers to a decision-making process used by roadway designers and transportation engineers that accounts for many factors of a site's context—from topography and geology to cultural history and the intended users—during the planning, design, and maintenance of transportation facilities. Landscape architects played a leading role in developing this concept and are valuable team members for their expertise in determining how a project can appropriately respond to its context. Fundamental landscape architecture capabilities include identifying and expressing in built form the intrinsic qualities of a project's regional landscape.

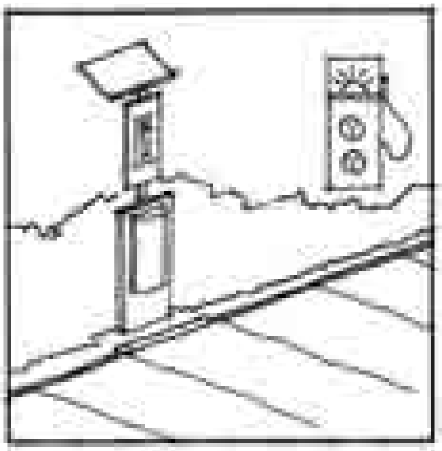
Leota Butte overlook at Ouray NWR provides an excellent landscape view.

Eva Paredes/USFWS

LE-5 Address Climate Change

Intent

Responding to climate change is a growing imperative for land managers and natural resource professionals, as well as the transportation and infrastructure sectors. Roadways on FWS managed lands may be particularly impacted because many are often in or near tidal zones, wetlands and floodplains. Factors to consider include how might roadways and visitor facilities be planned to reduce vehicle miles traveled (for visitors and staff); how will the roadways likely be impacted by changing weather and hydrologic patterns; and how might roadways be designed in a resilient and multifunctional manner that serves not only transportation, but perhaps other purposes such as protecting valuable facilities or habitat.



Facilitate greener transportation options.

Principles

- Provide alternative modes and means of access to FWS managed lands
- Consider potential climate change impacts when making decisions on location, scale and design life of infrastructure investments
- Consider construction materials and methods that have lower carbon footprints and climate impacts consistent with FWS and Department of the Interior (DOI) policies
- Use climate change research to inform transportation planning efforts at the landscape scale

Metrics

- Regional trends in weather-related damage and maintenance needs
- Vehicle miles traveled (VMT) on FWS roadways and associated greenhouse gas emissions
- Transportation modes used by visitors to reach and use FWS facilities
- Reports and data from the Emergency Relief for Federally Owned Roads (ERFO) program

Resources

Overview of transportation industry connection with climate change.

Transportation Research Board. 1997. Toward A Sustainable Future: Addressing the Long-Term Effects of Motor Vehicle Transportation on Climate and Ecology (SR 251).

Potential climate impacts of transportation sector and work towards reducing them.

Sperling, Daniel and Deborah Gordon. 2008. Two Billion Cars: Transforming a Culture. In: TR News, No. 259 (Nov-Dec).

Overview of general impacts of climate change on transportation infrastructure.

Transportation Research Board. 2008. Potential Impacts of Climate Change on US Transportation (TRB Report 290).

Regionally specific climate change impact information.

Climate Impacts Group. 2009. The Washington Climate Change Impacts Assessment.

Information, resources and organizations relating to sustainable transportation systems.

Green Highways Partnership. http://www.greenhighwayspartnership.org.

Assistance with emergencies and data on federally owned roads.

Emergency Relief for Federally Owned Roads (ERFO). http://flh.fhwa.dot.gov/programs/erfo/.

Official FWS climate change information and strategy.

http://www.fws.gov/home/climatechange/.

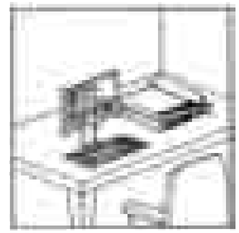
Climate change will impact roads on FWS managed lands. Road damage due to flooding at Arrowwood NWR (top); washed out bridge at Flint Hills NWR (bottom).

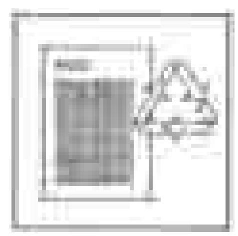
Eva Paredes/USFWS

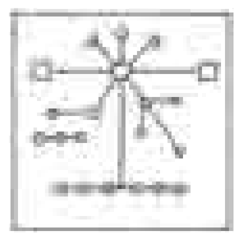
Eva Paredes/USFWS

Planning Context

Planning Context
Overview







Planning the Process
Guidelines in this section are intended to help you consider a roadway project in a broad context before advancing to the specifics of site design and engineering presented in sections DE, OP, SM and VE of these guidelines. It is important to consider how a particular project fits into the region's infrastructure, management and public access priorities, and how it might be most compatible with the conservation of listed species, the recovery function of critical habitat, and/or the conservation of FWS trust resources. Consider how the access a roadway enables and the impacts a roadway creates will fit into the management goals for the FWS managed lands it serves. The planning process can also help ensure that all applicable laws (e.g., FWCA, ESA, etc.) are appropriately addressed.

This section will help guide you to resources that will aid with or inform the planning process, as well as relevant documents that should be reviewed. It also serves as a reminder for project elements that are sometimes overlooked, such as developing a communications plan that addresses both internal and external communications about the project. Information regarding project prioritization, selection, and delivery is discussed in the Region's Long Range Transportation Plan (LRTP). Contact your Refuge Roads/FWS Transportation Coordinator for more information.

Selected project phases where the Roadway Design Guidelines are used by the project team

- Project identification and establishment
- Project scoping meeting(s)
- Establishing goals for the project
- Establishing scope, schedule, and budget for the project
- Establishing roles and responsibilities for the project
- Preliminary / schematic design phase
- Completed project assessment and monitoring

* Contact your Refuge Roads/FWS Transportation Coordinator for more information regarding how projects are planned and delivered in the region.

PC-1 Review Relevant Planning, Policy and Regulatory Information

Intent
Take advantage of lessons learned and research in relevant fields. Reviewing relevant background information ensures your project team is considering the most advanced and applicable contextual information related to a specific project. Consider what applicable legal and FWS policy requirements your project must respond to in order to be successful.

Principles
- Review local, regional and state transportation plans to determine how efforts by other agencies may inform your project planning and design
- Contact GIS staff to initiate data gathering and discuss mapping and analysis needs
- Review your Comprehensive Conservation Plan (CCP) and step down plan sections on transportation planning
- Conduct survey work and geotechnical investigations
- Review the Regional Long Range Transportation Plan (LRTP)
- Review existing asset management data and any asset management plans
- Review requirements of NEPA as well as other applicable state and local regulations
- Address ESA requirements as applicable
- Ensure consistency with applicable environmental laws such the FWCA, MBTA, and BGEPA.

Metrics
- List of related documents or case studies reviewed
- Concurrence from project team and stakeholders that relevant information has been reviewed and is ready to be applied to future phases of work

Resources
Overview of various systems of performance metrics.

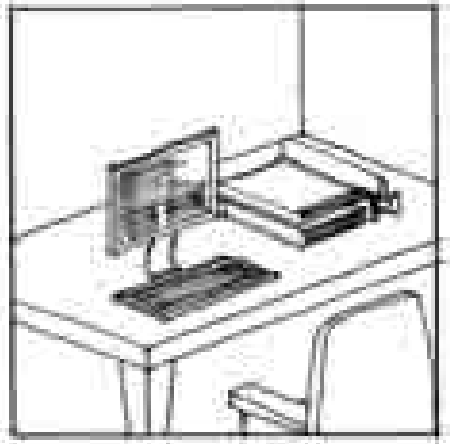
AASHTO. 2008. Guidelines For Environmental Performance Measures. NCHRP 25-25, Task 23. Prepared by Cambridge Systematics, Inc. Cambridge, MA.

NEPA information for EPA Region 10 (Pacific NW).

http://yosemite.epa.gov/R10/ECOCOMM.NSF/webpage/national+environmental+policy+act.

Guidelines for developing projects that work for local communities.

WSDOT. 2003. Building Projects that Build Communities: Recommended Best Practices.



Use in-house and online resources to find relevant case studies and up-to-date regulatory requirements.

Documents are shared and discussed during a project kickoff meeting at Umatilla NWR (top); a multidisciplinary team reviews resource documents during a project meeting in the Regional Office (bottom).

USFWS

Brian Bainnson

PC-2 Define Level of Service for the Project

Intent

Your project team should identify what level of service (LOS) will be provided by roadways. This will help to adequately size facilities and ensure facility compatibility with current and anticipated demand. Designing for an appropriate LOS helps avoid over-building facilities, which can be costly. Plan to balance roadway improvements with wildlife conservation and habitat maintenance goals. Good phasing plans and cost estimates should be developed, keeping in mind that these may change over time, in response to changing visitor patterns, management priorities, or adjacent land use.

Principles

- Develop performance based, rather than prescriptive, goals and objectives
- Avoid unnecessarily over-designing facilities
- Consider utilizing partnerships and alternative transportation to accommodate special events that generate traffic or atypical demands on roadways
- Determine jurisdiction
- Decide whether roadways should enable more direct access to facilities or amenities
- Balance needs with resources and intended capacity and vehicle or user types
- Decide if and how it may be appropriate to promote lower design speeds
- Consider seasonal and multi-modal issues
- Examine case studies for other similar facilities in order to “right size” your facility for current and anticipated demands
- Consider Intelligent Transportation Systems (ITS) or other means of sharing traveler information to distribute traffic, inform visitors of seasonal closures and provide more trip planning
- Consider how the roadway can serve as a link to communities – gateways, access, etc.

Metrics

- Visitor use statistics (vehicle and trailhead)
- Visitor satisfaction
- Traffic and parking violations
- Traffic or congestion statistics
- Existing parking and roadway capacity

Resources

Design recommendations for various road types.

National Park Service. 1984. Park Road Standards.

Design recommendations for various road types.

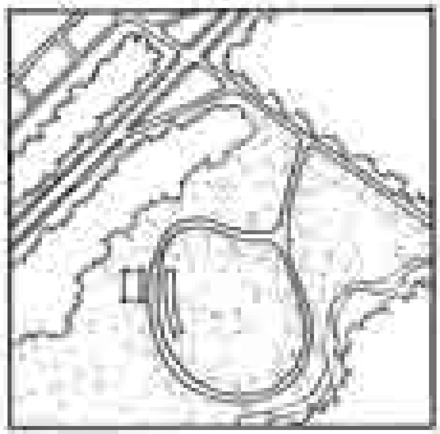
USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

Regional guidelines for roadside development.

ODOT. 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Public involvement may help clarify visitor needs.

Peaks, Harold E. and Sandra Hayes. 1999. “Building Roads in Sync With Community Values.” In Public Roads (Mar./Apr. 1999).

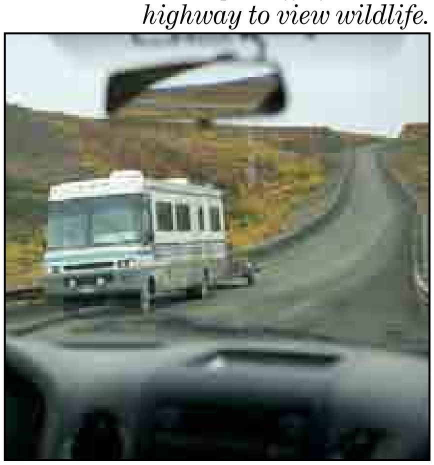


Determine the intended vehicles and traffic volumes for the roadway.

Level of Service

The term Level of Service (LOS) is commonly used among transportation planners to refer to the number of vehicles served. However users of these guidelines should also consider the term to include other elements, such as types of users, seasonality of use and modes of transportation that a particular roadway serves. Multimodal access refers to the ability of a transportation facility to provide access via a variety of modes, such as car, bicycle, public transit or walking. In keeping with the FWS mission, consider where it is possible and appropriate to provide multimodal access to FWS facilities, and whether the scale and type of roadway is in line with local management objectives.

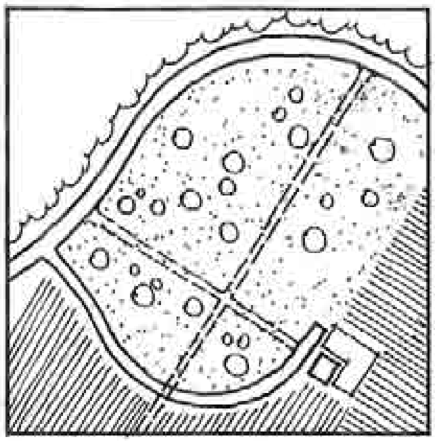
Wide gravel shoulder allows visitors to pull off of a 2-lane highway to view wildlife.



USFWS

PC-3 Evaluate Multiple Siting and Alignment Alternatives

Intent
Project teams should explore multiple design alternatives for roadway projects. A systematic alternatives evaluation process can be effectively used to arrive at a preferred alternative for further development. Alternatives development can reveal opportunities for projects to enhance visitor experience, protect wildlife, reduce ecological impacts to landscapes, minimize habitat fragmentation and provide alternative transportation methods. Reviewing a suite of alternatives will ensure that roadway decisions are compatible with the Service's mission and are made using the best possible information. The evaluation of alternatives will also support your NEPA process.



Explore and assess the effects of alternative road alignments.

Principles
- Determine if a roadway or road improvement is necessary
- Consider whether the roadway is in the right place
- Consider physical elements (e.g. hydrology), ecological effects (e.g. habitat fragmentation) as well as experiential factors (e.g. views, openness, arrival experience)
- Consider appropriateness of existing alignments versus potential alternatives
- Consider benefits or drawbacks of decommissioning existing facilities
- Determine how and when vehicles and people will move through the FWS managed lands
- Consider alternative modes of travel and potential for facility conversion, such as road to trail, trail in lieu of road, etc.
- Determine whether funding is tied to existing facilities

Metrics
- Comparison of road density for options considered
- Analysis of potential habitat fragmentation (e.g. vegetation or habitat mapping, wildlife tracking)

Resources
Case Studies.

Conboy Lake NWR, Visitor Experience Site Plan. Evaluated multiple vehicular and pedestrian circulation routes at HQ site. Contact Alex Schwartz, Project Manager (503/736 4723) for more information.

Umatilla NWR, McCormack Unit, Quarters Area Site Plan. Evaluated multiple roadway realignment concepts in conjunction with a new bunk house and residence. Contact Alex Schwartz, Project Manager.

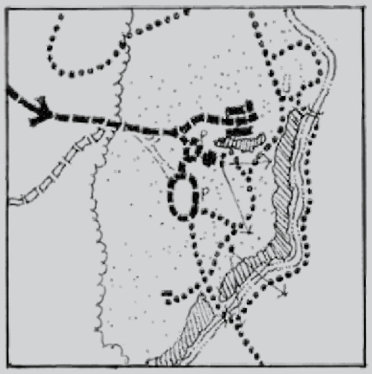
Roadway design guidelines using applied ecology and experience.

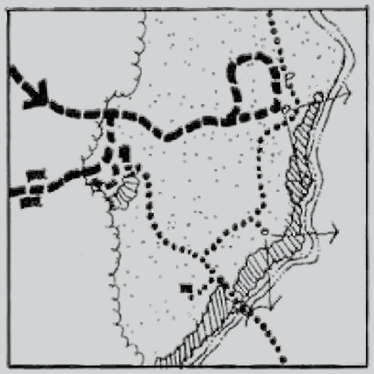
Jones, Grant R., et al. 2007. Applying Visual Resource Assessment for Highway Planning (pp.130-139) and Road Alignment (pp.330-341).

A decommissioned roadway is restored with native vegetation.

SvR Design

Evaluate Alternatives



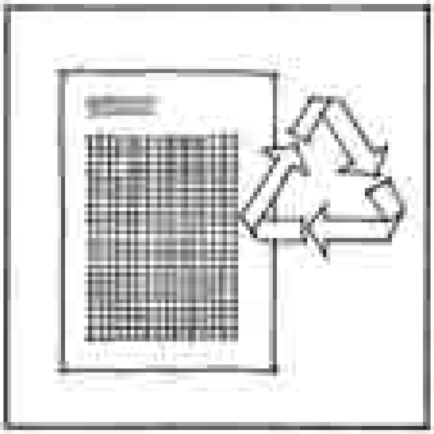


Conceptual site planning at Conboy Lake NWR evaluated three different alternatives for roadways on the site.

PC-4 Assess Full Costs and Impacts of Transportation System

Intent

Examine the full suite of costs associated with a roadway project in addition to the traditional design and construction costs. Consider the environmental impacts of the construction process and materials used, as well as future maintenance needs and costs. Projects that make sense in the near-term may not be environmentally beneficial or economically tractable in the long-term. Consider both environmental and monetary costs. Check resources for assigning monetary value to environmental costs.



Examine the characteristics of materials used in a project, including embodied energy and recyclability.

Principles

- Environmental impacts should be considered
- Evaluate the embodied energy of materials used
- Minimize externalization of environmental impacts through emissions and materials used
- Include comparison of costs of facilities for alternative modes of transportation in analysis
- Consider projected maintenance costs (often 65% of life cycle cost of an asset)

Metrics

- Carbon footprint (or ecological footprint)
- Vehicle miles traveled
- Long-term maintenance costs
- Life of pavement and other materials
- Greenroads rating system
- Life cycle costing (of total costs for construction and maintenance of a proposed transportation alternative)

Resources

Overview of various systems of performance metrics.

AASHTO. 2008. Guidelines For Environmental Performance Measures. NCHRP 25-25, Task 23.

Performance metrics for CSS.

TransTech Mgmt., et al. 2004. Performance Measures for Context Sensitive Solutions - A Guidebook for State DOT's.

Info & data on sustainable material.

Calkins, Meg. 2009. Materials for Sustainable Sites.

Overview of climate change impacts on transportation infrastructure.

Transportation Research Board. 2008. Potential Impacts of Climate Change on US Transportation.

Sustainability metrics.

University of Washington and CH2MHill. 2009. Greenroads Rating System, v1.0. http://www.greenroads.us/.

Example of triple bottom line assessment of infrastructure.

Stratus Consulting. 2009. A Triple Bottom Line Assessment of Traditional and Green Infrastructure ... in Philadelphia's Watersheds.

Road construction at Flint Hills NWR.

USFWS

Triple Bottom Line in Transportation Management

The triple bottom line concept originates in business and accounting practices. It stipulates three key areas or 'resources' that should be addressed in measuring sustainability:

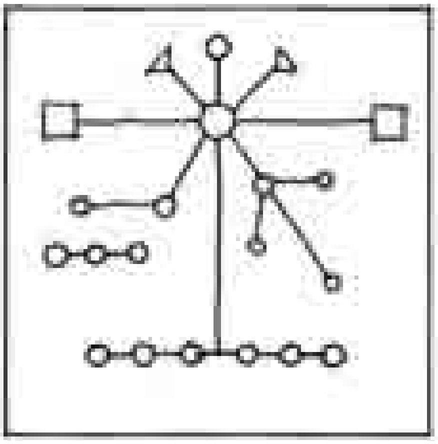
- Society (human capital)
- Environment (natural capital)
- Economy (financial capital)

This concept, also known as "people, planet, profit," offers an expanded spectrum of values and criteria for measuring a project or organization's success. Using this perspective in transportation management means that you would not only consider the long-term economic costs and benefits of a project, but also account for potential environmental and social costs and benefits over time.

PC-5 Communicate With Team and Stakeholders

Intent

Craft and document your approach for communications among your project team and with stakeholders. Ensure that roles and responsibilities are clearly defined in a project management plan. Carefully coordinate communications to help ensure consideration of a broad range of solutions in support of the best possible design outcome. Interdisciplinary project teams are the modern standard to ensure that work products are comprehensive and meet multiple objectives. Ensure that various elements of design are not overlooked and that there is organizational and public buy-in. Provide appropriate opportunities for involvement and review among your project team and stakeholders.



Develop a communications strategy and network.

Principles

- Address both internal and external communication needs in your project management plan
- Define clear roles and responsibilities for members of the project team
- Designate key agency contact(s) for all agencies/organizations involved
- Create a cross-functional (multi-disciplinary) team
- Develop design visualization and communication tools, such as graphics, plans, models, newsletters, web pages
- Identify the audience and develop solutions for communicating with people who don't read plans or technical documents
- Coordinate with transportation planning partners
- Contact Transportation Biologists in Ecological Services (ES) State Field Office to ensure project delivery is consistent with the mission of the Service
- Schedule project team meetings at regular intervals

Metrics

- Character and amount of public feedback on project
- Level of support and understanding of project within the organization
- Achievement of project goals

Resources

Guidelines for community and interdisciplinary planning process.

Lennertz, Bill, and Aarin Lutzenhiser. 2006. The Charrette Handbook. American Planning Association.

Case studies in collaborative management of wetlands and wildlife areas.

Porter, Douglas, and David Salvesen, eds. 1995. Collaborative Planning for Wetlands and Wildlife: Issues and Examples.

Public involvement for CSS.

Myerson, Deborah L., AICP, 1999. Getting It Right in the Right-of-Way: Citizen Participation in Context-Sensitive Highway Design. Scenic America. Available at: http://www.scenic.org/.

Public involvement for transportation projects.

Florida Department of Transportation. 2003. Public Involvement Handbook. Available at: http://www.dot.state.fl.us/EMO/pubs/public_involvement/pubinvolve.htm.

Members of Your Team

There are many professionals and stakeholder groups that you may want to include as part of your project team. Some possibilities include:

- Professional Engineers (PE)
- Landscape Architects (RLA)
- Transportation and Natural Resource Planners
- Field Biologists
- Project Leaders and Refuge Managers
- Refuge Roads Coordinators
- ES Transportation Biologists
- Representatives of other jurisdictions and agencies with local involvement

Project staff and stakeholders meet in the field at Pelican Island NWR (right).

USFWS

Design and Engineering

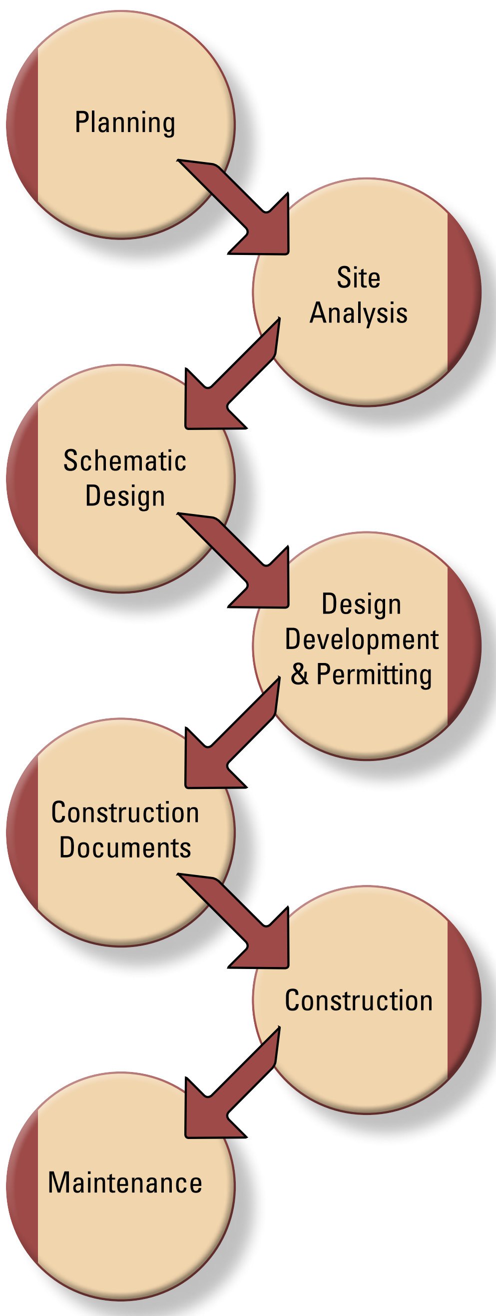
Design and Engineering
Overview

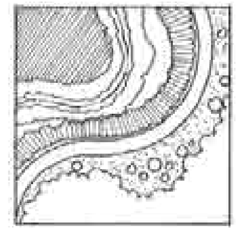
From Concept to Construction

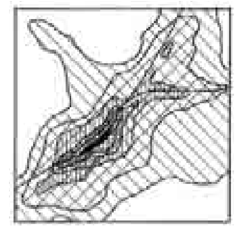
This section recognizes that embedded in the technical aspects of a roadway project is the ability to directly support the mission of the Service. This section will guide you though a suite of considerations regarding the nuts and bolts of a roadway project, such as earthwork, alignment, safety, materials selections, vegetation preservation and management, construction practices and maintenance considerations.

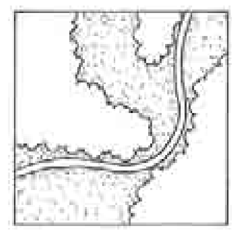
Designing a complete roadway project includes using methods and materials that minimize the environmental impacts of the roadway and associated construction work. It also involves developing a design that leads the roadway to function more often as a restorative system, helping to heal previously impacted or damaged natural environments. Working with an interdisciplinary team can greatly facilitate a holistic design and engineering process. Early coordination through the FWCA, and the ESA can provide valuable insight and expedite permit processes. A roadway design process can be approached methodically, beginning with a broad vision and narrowing down to the technical details and ultimately construction activities to make it happen. In the end, the project should be implemented in a manner consistent with FWS goals, applicable laws, and ideally, such that there is a benefit to the conservation of listed species and other FWS trust resources.

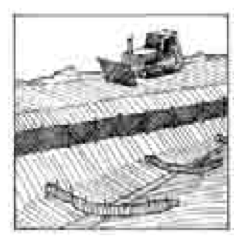
Process - Design to Construction

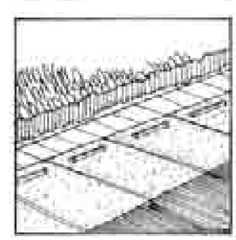








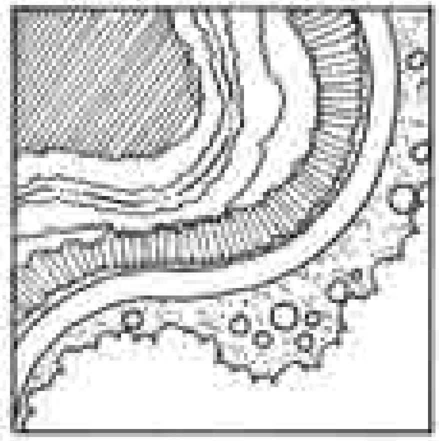




DE-1 Preserve and Restore Native Vegetation and Other Natural Resources

Intent

Roadway projects present opportunities to protect and restore native vegetation. Roadways commonly represent a barrier to wildlife and fragment habitat. However, roadway projects can represent an opportunity to heal historic wounds to a landscape and to ensure no further damage is done. Select roadway sites and alignments that avoid impacts to significant stands of existing vegetation. Look for restoration opportunities and consider what types of vegetation along roadway corridors are compatible with management goals.



Restored vegetation along road corridor can help support management goals.

Principles

- Explore ways to integrate restoration opportunities into project
- Consider how road surface conditions will affect nearby vegetation (e.g. dust, heat, other pollutants generated)
- Consider what types of vegetation and habitat along roadways will be compatible with management goals
- Use site prep and construction methods that protect and conserve existing native vegetation and natural resources
- Protect or stockpile and re-use healthy existing/native soils on site
- Protect heritage and other significant trees during and after construction (e.g. provide fencing, do not dig in or store material on top of root zones)
- Consider irrigation needs for establishing roadway vegetation
- Consider how invasive species will be managed during native vegetation establishment periods

Metrics

- Amount of post-construction restoration planned
- Vegetation surveys
- Reduced invasive species control needs

Resources

Regional guidelines for roadside development.

ODOT. 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Comprehensive guidebook on roadside revegetation.

FHWA. 2007. Roadside Revegetation: An Integrated Approach to Establishing Native Plants.

New technology to minimize pile-driving construction impacts to aquatic organisms.

Reyff, James. 2009. Reducing Underwater Sounds with Air Bubble Curtains.

Road alignment at Nestucca Bay NWR preserves upland vegetation and forest.

Alex Schwartz/USFWS

This roadway project at Steigerwald NWR required integration of native vegetation restoration (right). The planting plan was prepared by a registered landscape architect. The plants were installed by a licensed landscape contractor. Work included a temporary irrigation system and a 1-year maintenance and warranty period.

Brian Bainnson

DE-2 Consider and Plan for Invasive Species Management

Intent
Invasive species are a major issue for habitat restoration and wildlife management efforts. Roadways often serve as a significant vector for the spread of invasive species. Thus, particular attention must be paid to this issue in the planning, design and maintenance of road corridors and road networks.

Principles
- Inventory invasive species in the region that are already present and what steps have been taken to combat their spread
- Ensure that planting plans feature plant species and densities, as well as establishment techniques to limit future invasive establishment
- Consider latest tools and techniques available to combat spread of invasive species
- Examine relevant state and regional lists of invasive species threats
- Search for and consider lessons from other relevant projects, based on similar ecosystems and/or similar project types
- Develop pre-project baselines to measure success of future management goals
- Address and plan for invasive species management during construction and general use
- Create an invasive species management plan following local Best Management Practices (BMPs), addressing both roadside and adjoining habitats
- Minimize disturbance and project footprint, including mobilization and staging areas

Metrics
- Invasive species survey data
- Staff time dedicated to invasive species management (and how that changes over time)

Resources
Invasive species along roadways from the perspective of road and landscape ecology (see Chapter 4, pp. 75-111).

Forman, Richard, et al. 2003. Road Ecology: Science and Solutions.

Establishment and maintenance of native plants along roadways.

Harper-Lore, Bonnie and Maggie Wilson, editors. 2000. Roadside Use of Native Plants. Available online at: http://www.fhwa.dot.gov/environment/rdsduse/index.htm.

FHWA. 2007. Roadside Revegetation: An Integrated Approach to Establishing Native Plants.

Guidance on roadside weed management.

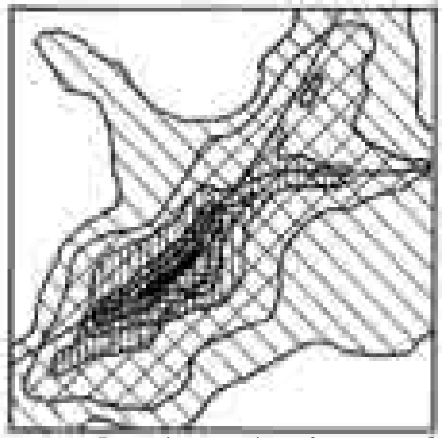
Ferguson, Leslie, C. L. Duncan and K. Snodgrass. 2003. Backcountry Road Maintenance and Weed Management.

Comprehensive list of roadside vegetation management resources.

Center for Environmental Excellence by AASHTO - Invasive Species/Vegetation Management, Reseach, Documents & Reports web page. See: http://environment.transportation.org/environmental_issues/invasive_species/docs_reports.aspx.

List of many resources on controlling invasive species, from construction best practices to ongoing maintenance.

Wisconsin Department of Transportation (WisDOT). 2003. Best Practices for Control of Invasive Plant Species.



Invasive species often spread outward from roadways.

Selected Steps for Invasive Species Management

- Post-construction maintenance plan
- Minimize disturbance
- Retain shade to the extent possible
- Know the quality of topsoil and mulch; avoid importing contaminated topsoils
- Know the quality of seed sources
- Clean equipment that has had contact with weed sources
- Over-sow disturbed areas with native seeds
- Avoid nitrogen fertilizers in the first year

List adapted from FHWA Roadside Revegetation Manual. See section 5.8 in manual.

Ryan Hagerty/USFWS

Controlling invasive species after their spread can be labor-intensive; spraying melaluka in FL (right).

DE-3 Minimize Cut and Fill to Fit With Existing Landscape

Intent

Roadways can be designed to fit with natural topography and seamlessly integrate with the landscape character. By studying the natural topography, designers can attempt to select a road alignment that will take advantage of views, while also minimizing the visual impact of the road itself. Conforming to the natural topography can minimize interruptions to the natural hydrology, and may help to preserve other important natural features, vegetation and habitat.

Elevated structures are often preferable for wildlife and habitat connectivity, and should be considered where possible. If that results in a cut/fill imbalance then seek innovative ways to use fill material. Examples include using excess fill material to construct pullouts, scenic viewpoints, and trailheads. Earthwork considerations discussed in this guideline are appropriate for both new construction projects and alterations or improvements to existing roadways.

Principles

- Consider roadway alignments that will minimize and balance cut and fill volumes
- Consider alternative structures to reduce fill volumes (e.g. bridge vs. culvert, etc.)
- Use roadways to highlight Refuge habitats as they follow existing terrain
- Look for continued opportunities to minimize and improve "aesthetic wounds"

Metrics

- Earthwork volumes per mile (compare to similar projects)
- Balanced cut and fill volumes
- Visual resources assessment

Resources

See cut and fill guideline on page 83.

USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

Case study on context sensitive solutions (CSS) for scenic highway.

Kentucky Transportation Center. Undated. Context-Sensitive Design Case Study No. 1: Paris Pike - Kentucky. College of Engineering, University of Kentucky. Lexington, KY.

Guidelines on appropriate lower-impact road alignment.

Jones, Grant R., et al. 2007. Applying Visual Resource Assessment for Highway Planning (pp.130-139) and Road Alignment (pp.330-341). In Landscape Architecture Graphic Standards. Hoboken, New Jersey: John Wiley & Sons. Available at: http://www.jonesandjones.com/news/publications.html.

Road design guidelines.

FHWA. Undated. Flexibility in Highway Design. FHWA Pub. No. FHWA-PD-97-062. Found at: http://www.fhwa.dot.gov/environment/flex/index.htm.

Common standard on roadway design.

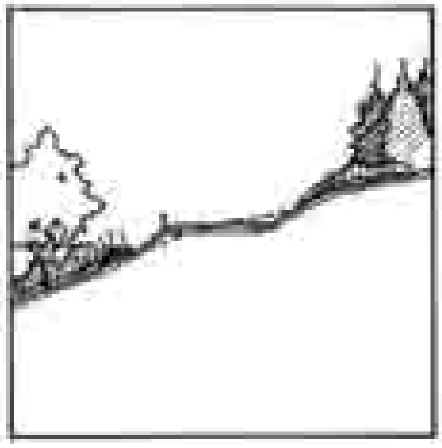
AASHTO. 2004. AASHTO A Policy on Geometric Design of Highways and Streets, 5th Edition (aka 'Green Book). Washington, D.C.

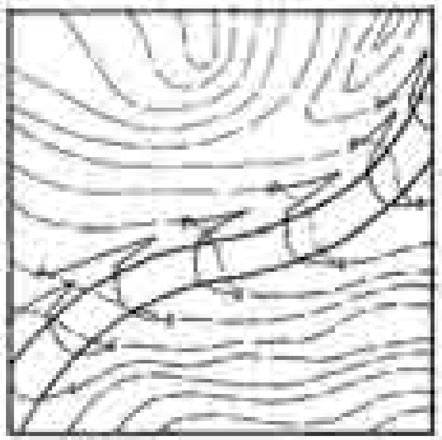
Guidelines for design of very low volume roadways.

AASHTO. 2001. Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400), 1st Edition. Washington, D.C.

Gravel roads maintenance and design.

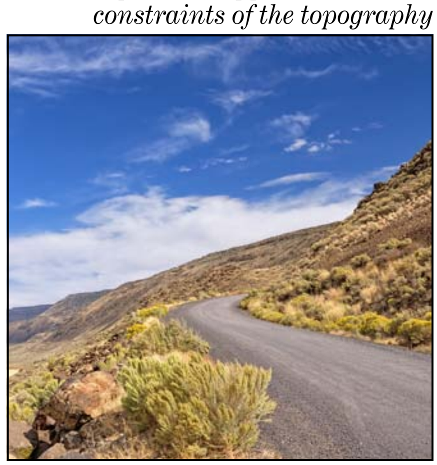
Skorseth and Selim. 2000. Gravel Roads Maintenance and Design Manual. South Dakota Local Transportation Assistance Program (USDOT - FHWA).





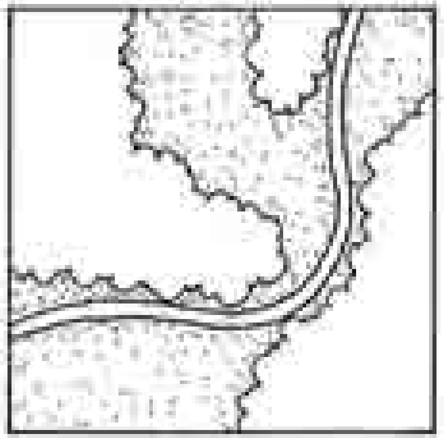
Fitting in with existing topography is key to minimizing impacts.

Roadway terraced along hillside at Hart Mountain NWR responds to opportunities and constraints of the topography



Fort Photo/Flickr.com

DE-4 Consider Road Geometries for Lower Speeds, Safety and Alertness



Curving roads with varying views can promote alertness and lower speeds.

Intent

Low speeds can help protect wildlife, increase the value of roadside habitat and provide a greater degree of safety for all roadway users. In addition to improved safety for wildlife and roadway users, low travel speeds are compatible with the Big Six public uses. Low road speeds help to encourage alternative modes of transportation, including walking and bicycling. Lower actual speeds are achieved through deliberate roadway geometry and design, not simply signage.

Principles

- Road alignments may include continuous curves, spiral curves, curving alignment, etc. in order to support safety and alertness
- Consider how curvilinear road geometries achieve multiple objectives and can specifically support habitat and wildlife management goals
- Consider the effect of road surface on travel speeds
- Determine and design around a roadway 'design speed' so that people will *want* to drive slower
- Consider safety and engineering standards that are applicable to the roadway's context

Metrics

- Road speed and volume study
- Accident reports
- Visual resources assessment
- Balanced cut and fill volumes
- Protection of vegetation and habitat
- FHWA Road Safety Audit

Resources

Design guidance based on human behavior patterns.

Transportation Research Board of The National Academies. 2008. Human Factors Guidelines for Road Systems.

Guidelines on appropriate lower-impact road alignment.

Jones, Grant R., et al. 2007. Applying Visual Resource Assessment for Highway Planning (pp.130-139) and Road Alignment (pp.330-341). In Landscape Architecture Graphic Standards. Hoboken, New Jersey: John Wiley & Sons. Available at: http://www.jonesandjones.com/news/publications.html.

Road design guidelines.

FHWA. Undated. Flexibility in Highway Design. Access at: http://www.fhwa.dot.gov/environment/flex/index.htm.

Standards for roadway design.

AASHTO. 2004. AASHTO A Policy on Geometric Design of Highways and Streets, 5th Edition (aka 'Green Book).

Handbook with design guidance on appropriate construction techniques for low traffic volume roads.

Weaver, William and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

Curving roadway at Nestucca Bay NWR highlights scenery and discourages high speeds (top); emergency personnel respond to an accident at Ridgefield NWR (bottom).

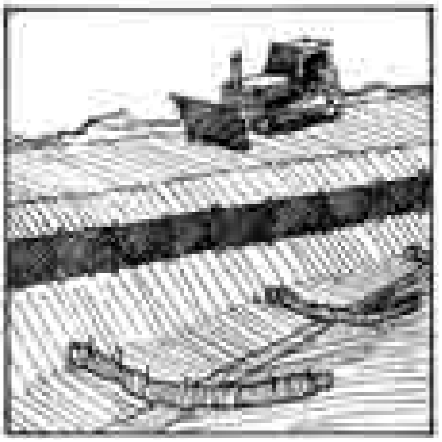
Alex Schwartz/USFWS

USFWS

DE-5 Consider Construction Impacts and Best Practices

Intent

Roadway construction can have major impacts to terrestrial and aquatic organisms, as well as to environmental quality. Appropriate project planning, project management and construction management should be applied to ensure that impacts from construction activities are minimized and acceptable. The overall project footprint should be minimized as much as possible, especially with regard to construction activities such as staging materials and equipment.



Standard practices such as using silt fencing help reduce construction impacts to adjacent habitat.

Principles

- Consider appropriate season for construction
- Minimize construction impacts to terrestrial and aquatic organisms
- Implement construction best practices, such as dust and erosion control
- Look for staging opportunities that use existing developed sites and minimize impact to adjacent habitat areas
- Consider impacts of construction needs, such as water, on the surrounding environment
- Consider how construction elements, such as water wells, could be used for staff and visitor services in the future

Metrics

- Changes in population counts or behavior (e.g. breeding) of local organisms
- Visible signs of disturbance beyond limits of work
- Compliance with erosion control plan elements

Resources

Handbook with design guidance on appropriate construction techniques for low traffic volume roads.

Weaver, William and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

Good checklist for items to address or consider.

ODOT. 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Guidelines with resources on environmentally-friendly construction practices.

University of Washington and CH2MHill. 2009. Greenroads Rating System, v1.0. http://www.greenroads.us/.

New technology to minimize pile-driving construction impacts to aquatic organisms.

Reyff, James. 2009. Reducing Underwater Sounds with Air Bubble Curtains.

BMPs: Best Management Practices

Best management practices are methods that have been determined to be the most effective and practical means of preventing or reducing a project's short- and long-term environmental impacts. BMPs focus on prescriptive measures, typically in the construction and maintenance phases of a project. Design Guidelines are more general and require interpretation and adaptation.

BMPs available for roadway construction projects include:

- Erosion control
- Equipment and operation
- Noise and emissions
- Spill and Pollution Prevention
- Safety

Construction on an entry road, parking lot, and trailhead project at Steigerwald NWR, in partnership with FHWA's Federal Lands Highways program. Project required extensive multidisciplinary planning, design, and construction expertise to ensure implementation of best construction practices and minimization of habitat and scenic area disturbance.

FHWA

DE-6 Consider Range and Sources of Materials for Sustainable Construction

Intent

There are numerous options available for materials that have sustainable characteristics. Consider selecting materials with lower embodied energy and carbon footprints, recycled content, high durability, and which have a high level of environmental performance. Using sustainable materials can achieve compliance with the Service's environmental and performance goals, as well as save money in the long term. Even existing roadway materials can be effectively recycled into a new project, including asphalt, aggregates and fill material.

Principles

- Identify range of materials that would be suitable or possible to use in a given project
- Consider various qualities of material options, including environmental performance, longevity, maintenance needs and aesthetic fit
- Study past performance and success of materials in other sites (case studies)
- Consider using materials that are certified for sustainability
- Consider paying more for a more durable material that may save money (through performance and maintenance) in the long run
- Source materials locally where possible

Metrics

- Embodied energy calculations
- Runoff discharge rates

Resources

See materials listed in Greenroads Guidelines.

University of Washington and CH2MHill. 2009. Greenroads Rating System, v1.0. http://www.greenroads.us/.

Check on embodied energy of proposed materials at University of Bath's Inventory of Carbon & Energy (ICE) Wiki.

See: http://wiki.bath.ac.uk/display/ICE/Home+Page.

The Sustainable Sites Initiative (SSI) provides resources and guidelines for materials and site development.

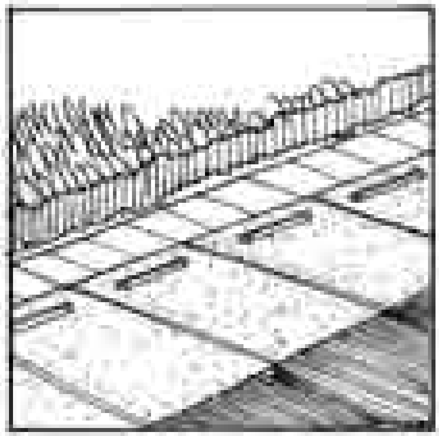
See: http://www.sustainablesites.org/.

For sites that include buildings, calculate the project's carbon footprint at BuildCarbonNeutral.

See: http://buildcarbonneutral.org.

Information and data on sustainable materials.

Calkins, Meg. 2009. Materials for Sustainable Sites.



Materials may vary for travel lanes, parking stalls and pedestrian pathways.

A parking lot at Tualatin River NWR used warm mix asphalt for main travel ways, pervious pavers in parking stalls and features a bioswale with amended soils and native plants to cleanse stormwater in order to protect habitat (top); local and sustainable materials were used to construct an Auto Tour pullout / wildlife viewing area at Modoc NWR (bottom).

Brain Bainnson

Steve Clay/USFWS

Embodied Energy and Carbon Footprints

Embodied energy is generally defined as the energy (commercial and industrial) that was used to make a product. It generally includes the energy used to deliver the product to its point of use or consumption, and may also include any energy needed for the deconstruction and disposal of the product. It is commonly measured in megajoules of energy per kilogram of product (MJ/kg).

A carbon footprint is a similar metric, which measures the total amount of greenhouse gas emissions caused by a product. It is often expressed in terms of tons of CO_2 produced per kilogram of product (tCO_2/kg).

DE-7 Consider Maintenance

Consider trade-offs between longevity and maintenance needs.

Intent

When planning a new roadway or retrofits to existing facilities, it is important to anticipate both short- and long-term maintenance needs. During the design phase, consider whether anticipated maintenance of potential designs is realistic, given existing or likely future budgets, staff training and skills, and other related factors. To be successful in their purpose, new types of materials (e.g. pervious paving) or facilities (e.g. wildlife underpasses or signals) may have new maintenance needs requiring staff training. Consider also that regular maintenance practices can extend the life of a facility. Weigh the pros and cons of potentially higher first costs with the benefit of lower life cycle maintenance costs for durable projects.

Principles

- Examine current maintenance budgets, responsibilities and staff availability in concert with partners
- Estimate increase or reduction of maintenance needs for new facilities
- Consider current skills of maintenance staff and what types of training may be needed
- Consider whether contractors would be required to complete maintenance activities
- Be aware of concerns about adopting new practices, and be prepared to understand and address the concerns of operations and maintenance staff
- Provide achievable and responsive BMPs
- Discuss early in project who is responsible for repairs and maintenance to wildlife-specific facilities such as fencing
- Consider maintenance partnerships with State and County Transportation Dept's to leverage their transportation resources and expertise
- Consider the impacts of chemicals or other products that are used in roadway maintenance

Metrics

- Historic vs. current maintenance costs
- Road closure data
- BMPs correctly applied in field

Resources

Handbook with design guidance on construction and maintenance techniques for low traffic volume roads.

Weaver, William and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

Good checklist for items to address or consider.

ODOT. 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Gravel roads maintenance & design.

Skorseth and Selim. 2000. Gravel Roads Maintenance and Design Manual. South Dakota Local Transportation Assistance Program (USDOT - FHWA).

BMPs for rural road maintenance.

Smith, Stacy (Idaho Technology Transfer Center, Univ. of Idaho). 2005. BMP Handbook: Best Management Practices for Idaho Rural Road Maintenance.

Roadside vegetation management.

WSDOT. 1997. Integrated Vegetation Management for Roadsides.

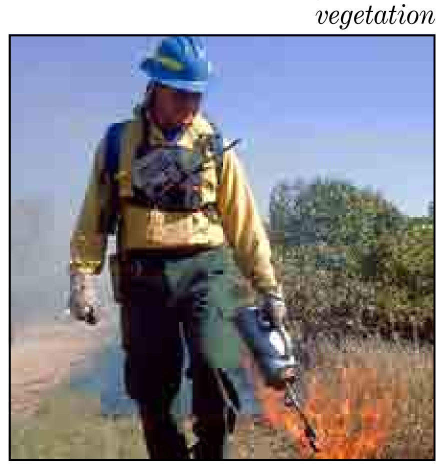
Maintenance guidelines for sensitive areas.

Crane, Bill. 2006. Road Maintenance with Threatened, Endangered, or Sensitive Plants: Finding Solutions.

Maintenance guidelines.

Ruiz, Leo. 2005. Guidelines for Road Maintenance Levels.

Fire being used for maintenance of roadside vegetation



USFWS

Organism Passage

Organism Passage
Overview

Terrestrial and Aquatic Passage

The conservation of fish, wildlife, plants and their habitats is the primary FWS mission. Roadways have major impacts on terrestrial and aquatic organisms. Roadways create barriers to wildlife movement and fragment habitat. Ensuring that organisms are able to safely move across (either over or under) roadways to meet basic life requisites is imperative to meeting the Service's mission.

This section is intended to help direct you to guidance and resources for improving terrestrial and aquatic organism passage. The guidelines in this section reflect the growing body of science that documents the need for wildlife-sensitive planning, design, engineering, and construction of roadways. Recognizing the highly site- and species-specific nature of aquatic and terrestrial passage issues, you are particularly encouraged to seek out resources on regionally-appropriate techniques to facilitate passage of terrestrial and aquatic organisms. In areas where ESA listed species or critical habitat may benefit from a passage improvement, additional conservation measures may be warranted during both the design and construction phases.

Addressing organism passage issues on FWS managed lands is an emerging priority for the Service which these guidelines are intended to support. At present, addressing organism passage issues on FWS lands is most realistic in conjunction with high priority infrastructure projects such as bridge replacements. A future possibility is that projects intended to specifically address organism passage will be eligible for Refuge Roads funding.

OP-1 Develop Your Corridor Plan for Crossing

Intent

It is important to develop a comprehensive plan to address aquatic and terrestrial connectivity along a roadway. Corridor level plans are necessary to document habitat fragmentation, lack of stream continuity, population level roadway avoidance effects and wildlife-vehicle collisions (WVC). In addition to identifying the ecological impacts a roadway is having on organisms, plans should identify funding opportunities and partnerships in support of recommended mitigation measures. Successful plans identify target species and crossing "hot spots". Prioritize your specific individual crossing projects and include conceptual design documentation for crossing structures and supporting mitigation measures.

Examine the roadway corridor for locations where organisms would prefer to cross in the absence of a roadway. Study topography, vegetation patterns and hydrology along the corridor.

Principles

- Develop organizational partnerships
- Solicit expert review and input; wildlife crossing structures require expert design and review
- Monitor to locate roadkill hotspots but consider how roads change animal movements (avoidance)
- Identify target species based on management objectives
- Consider how crossing needs align with other transportation priorities and budgets
- Consider species' home range size and seasonal movements to determine extent of passage needed
- Consider how current or future roadway design speed and traffic volumes may impact wildlife

Metrics

- Safety (animal/vehicle collision reductions)
- Species population health
- Dispersal capability
- Daily/seasonal movement necessary to meet life requisites

Resources

Latest information on road ecology as it relates to mitigating interactions between roads and wildlife.

Beckmann, J. P., A. P. Clevenger, M. P. Huijser, and J. A. Hilty. 2010. Safe Passages.

Coordinating aquatic and terrestrial passage opportunities.

Jacobson et al. 2007. Combining Aquatic and Terrestrial Passage Design into a Continuous Discipline.

Effectiveness of various wildlife crossing facilities.

Transportation Research Board of The National Academies. 2008. Evaluation and the Use and Effectiveness of Wildlife Crossings (NCHRP Report 615).

Best practices for reduction of WVC.

FHWA. 2008. Wildlife-Vehicle Collision Reduction Study, Best Practices Manual. Access at http://www.fhwa.dot.gov/environment/hconnect/wvc/index.htm.

Guidance on reduction of WVC.

FHWA. 2008. Wildlife-Vehicle Collision Reduction Study, Report to Congress. Access at http://www.fhwa.dot.gov/publications/research/safety/08034/index.cfm.

Effects of roadways on wildlife (see entire Conservation Biology issue).

Trombulak, Stephen and C. Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities.

Background research on roadway impacts to wildlife.

Mader, Sharon. 2006. Comparing the Ecological Effects of Linear Developments on Terrestrial Mammals.

See list of crossing issues by state, by FWS national Refuge Roads Coordinator (unpublished).

Wildlife Crossing and Aquatic Organism Passage Issues by State.

A corridor management and wildlife crossing plan is a critical tool to plan and fund projects; map showing monitoring locations for crossing plan study (below).

Robert Henke et al.

OP-2 Provide and Enhance Aquatic Organism Crossings

Intent

Roads, streams and rivers are similar systems in that they all transport material and organisms across the landscape in a linear fashion. Stream and river functions, such as the movement of woody debris, sediment transport and fish and wildlife passage have historically been impeded by engineering solutions intended to minimize disruptions to roadway infrastructure. Recognizing the importance of aquatic resources on FWS managed lands, an ecosystem-based approach to aquatic organism passage focuses on maintaining the continuity of a stream or river's characteristics where that system intersects a roadway.

Principles

- Consider and design for long-range traffic volume projections for road
- Consider seasonality of wildlife movement and stream flows
- Develop list of target species for aquatic organism passage and focus planning and design efforts on supporting overall ecosystem health
- Consider range of stream crossing solutions and techniques
- Culverts or bridges that mimic the slope, structure and dimensions of the natural stream bed can allow aquatic species to freely move under roadways
- Plan for appropriate post-construction riparian and streambed restoration work
- Consider maintenance needs for various stream crossing designs
- Plan for appropriate in-water work windows
- Consider how to best complete road maintenance activities at or near stream crossings in order to avoid impacts to water quality

Metrics

- Surveys to show healthy passage of aquatic organisms
- Water quality measurements (upstream vs. downstream)
- Re-colonization of upstream habitat by aquatic organisms (in cases of improving/upgrading existing crossings)

Resources

Analysis & costs of culvert design and aquatic organism passage.

MN Dept. of Transportation. 2009. Cost Analysis of Alternative Culvert Installation Practices in Minnesota.

Design guidelines and best practices for aquatic organism passage.

USDA Forest Service. 2008. Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings.

Bridge construction guidance.

AZ Game and Fish Dept., Habitat Branch. 2008. Guidelines for Bridge Construction or Maintenance to Accommodate Fish & Wildlife Movement and Passage.

Riparian restoration guidance.

USDA Forest Service. 2002. Management Techniques for Riparian Restorations (Roads Field Guide, Volume II).

Design guidelines for stream crossings and proper road drainage.

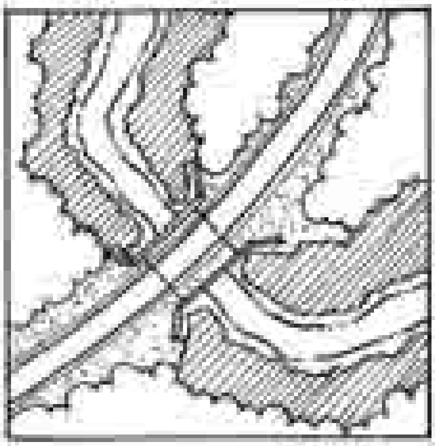
William Weaver and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

See list of crossing issues by state, by FWS national Refuge Roads Coordinator (unpublished).

Wildlife Crossing and Aquatic Organism Passage Issues by State.

See aquatic organism passage in:

Proceedings of International Conference on Ecology and Transportation (ICOET). Access online at: http://www.icoet.net/.



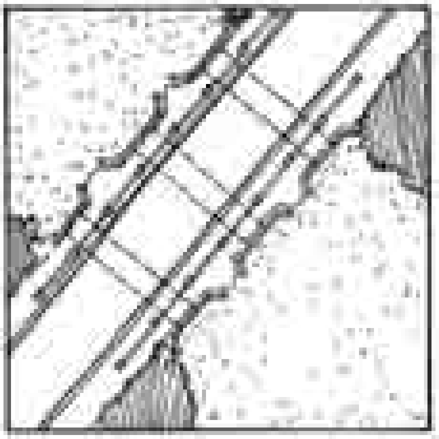
Locate aquatic crossings to minimize interruption to normal stream flow and channel migration.

Site visit to a new aquatic crossing structure during a Refuge Roads coordination meeting at Kenai NWR (top); viability for many aquatic species, such as salmon, depend on their ability to move through river and stream ecosystems (bottom).

John Sauer/USFWS

Florian Schulz

OP-3 Provide and Enhance Terrestrial Wildlife Crossings



Terrestrial wildlife crossings provide safer crossings for wildlife and connect fragmented habitat patches.

Intent

Roadways are a significant barrier and danger for terrestrial organisms. When terrestrial organisms attempt to cross roadways in order to meet life requisites, fatalities and injuries can result for both wildlife and humans. If wildlife-vehicle collisions (WVC) regularly take place along a roadway, this is a good indicator of the need for mitigation. Another less visible effect of habitat fragmentation caused by roadways is avoidance behaviors that can have significant effects on populations.

The most effective mitigation measure to reduce WVC and to enhance terrestrial organism passage across roadways is to design and construct suitable crossing structures, in combination with barrier and diversion fencing, where appropriate. It is important to remember that every species is impacted by roadways in different ways. Terrestrial crossing projects can seek to meet multiple ecosystem connectivity objectives simultaneously.

Principles

- Identify design species and their crossing structure needs; design crossings that work for as many species as possible
- Consider and design for long-range traffic volume projections for roadway
- Consider visual quality and aesthetic impact of structures
- Improve nearby habitat for wildlife, especially areas leading to or connecting with crossings
- Maximize opportunity for restoration project links to crossing/connectivity sites
- Consider “right crossing, right place” when locating crossings
- Review the corridor management or crossing plan
- Bridge replacements are the best opportunity in a 50-70 year time frame to create movement opportunities and should be taken advantage of even if no other projects are in the area

Metrics

- Evidence of unmet need to cross
- Improved wildlife counts in adjacent areas after crossing implementation
- Improved wildlife dispersal rates
- Reduction in WVC

Resources

Bridge construction guidance.

AZ Game and Fish Dept., Habitat Branch. 2008. Guidelines for Bridge Construction or Maintenance to Accommodate Fish & Wildlife Movement and Passage.

Wildlife crossing structures and fencing effectiveness evaluation.

Hardy et al, Western Transportation Institute. 2007. Evaluation of Wildlife Crossing Structures and Fencing US Hwy 93 Evaro to Polson.

Effectiveness of various wildlife crossing types.

Transportation Research Board of The National Academies. 2008. Evaluation and the Use and Effectiveness of Wildlife Crossings.

Best practices for WVC reduction.

FHWA. 2008. Wildlife-Vehicle Collision Reduction Study, Best Practices Manual.

Guidance on reduction of WVC.

FHWA. 2008. Wildlife-Vehicle Collision Reduction Study, Report to Congress.

See FWS Refuge Roads Coordinator list of crossing issues by state (unpublished).

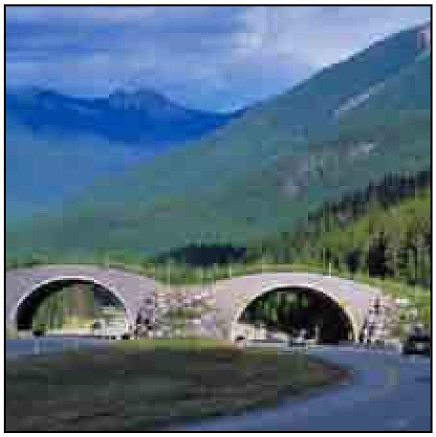
Wildlife Crossing and Aquatic Organism Passage Issues by State.

See crossing structure design in:

Proceedings of International Conference on Ecology and Transportation (ICOET). Access online at: http://www.icoet.net/.

Bridge replacements are excellent opportunities to enhance terrestrial crossing opportunities (top); a wildlife overcrossing in Banff NP, Canada has successfully improved both safety and wildlife movement (bottom).

Brian Bainnson



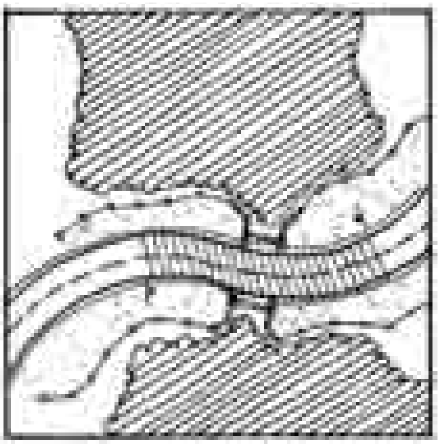
Florian Schulz

OP-4 Evaluate Need for Wildlife Fencing and Other Guiding Features

Intent

Wildlife-vehicle collisions (WVC) can be reduced through the use of barrier and diversion fencing or other features that help guide wildlife to crossing structures, including overpasses or underpasses. Effective wildlife barrier and diversion fencing forces animals off the road and into a crossing structure. In order for a crossing structure to be effective, it needs to be designed in conjunction with fencing. Project teams should consider aesthetics, where to end fencing and how fencing relates to topographical features in the landscape. Fencing design is highly species-specific and should be designed in consultation with an expert.

Barrier and diversion fencing requires maintenance. Successful projects account for maintenance concerns and budgets during the design phase. Fencing discussions might include a consideration of how to handle fence ends. Where to end a fence has major safety implications. It is a difficult decision, and is best done in consultation with an expert.



Fencing can help guide wildlife to safer crossing areas.

Principles

- Study WVC or other interactions along the corridor
- Recognize that fencing is a last resort option, and that the outcomes can be deadly for wildlife inadvertently trapped on a roadway
- Design fencing treatments based on species and environmental conditions
- Include escape structures in the design; jumpouts are more effective than the commonly used one-way gates
- To avoid "end run" WVC, end fencing beyond prime habitat areas *or* at locations with good visibility
- Boulder piles can act as a maintenance-free fence for ungulates
- Consider how best to accommodate multiple species
- Consider the aesthetic impacts of wildlife fencing
- Consider how to handle fencing at access roads

Metrics

- WVC counts
- Reduction in wildlife mortality due to WVC

Resources

BMPs for reduction of WVC.

FHWA. 2008. Best Practices Manual, Wildlife Vehicle Collision Reduction Study (Report to Congress). Found at http://www.fhwa.dot.gov/environment/hconnect/wvc/index.htm.

Wildlife crossing structures and fencing effectiveness evaluation.

Hardy et al, Western Transportation Institute. 2007. Evaluation of Wildlife Crossing Structures and Fencing on US Hwy 93 Evaro to Polson.

Effectiveness of various wildlife crossing types.

Transportation Research Board of The National Academies. 2008. Evaluation and the Use and Effectiveness of Wildlife Crossings (NCHRP Report 615).

Website with additional guidelines and case studies of construction and maintenance practices to benefit wildlife along roadways.

FHWA - Keeping It Simple: Easy Ways to Help Wildlife Along Roads. See: http://www.fhwa.dot.gov/environment/wildlifeprotection/index.cfm.

Continuous page wire fencing is commonly used to keep wildlife off roads and to direct them to crossing structures (top); jumpouts are essential features to allow trapped animals to leave the road whenever continuous fencing is used (bottom).

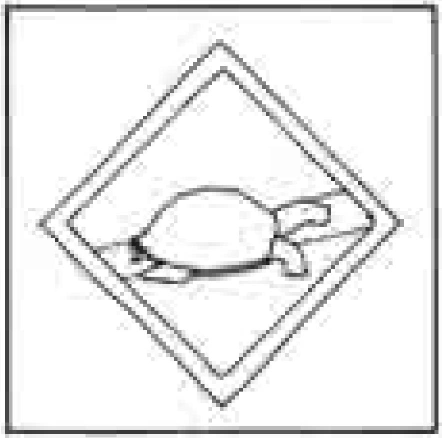
lisahends/Flickr.com

USFWS

OP-5 Consider Warning and Safety Systems for Drivers

Intent

An important component of facilitating terrestrial organism passage is promoting adequate awareness and caution on the part of drivers. Various systems exist to warn drivers of the presence of wildlife on a roadway. These systems include static signs to alert drivers to zones where wildlife typically cross roadways as well as flashing lights or other signals that respond to the presence of wildlife near the roadway. The most effective signage systems are active warning systems. Static warning signs, if strategically placed and well designed, can improve public awareness and may be a good fit for low volume roads.



Warning signs can help remind drivers to look out for wildlife on the road.

Principles

- Select the appropriate type of signage for the species, roadway LOS and site conditions
- Provide public information on the crossing design and intent
- Consider active warning systems for "end runs" of fencing, crossing hot spots and as temporary mitigation measures in the absence of crossing structures
- Consider the related benefits of communicating crossing and habitat areas, such as public education and communicating stewardship

Metrics

- Wildlife-vehicle collision (WVC) statistics (note that these are a better measure of safety than ecological conditions; even then, they are suspect unless expertly interpreted)

Resources

BMPs for reduction of WVC.

FHWA. 2008. Best Practices Manual, Wildlife Vehicle Collision Reduction Study (Report to Congress). Found at http://www.fhwa.dot.gov/environment/hconnect/wvc/index.htm.

Wildlife crossing structures and fencing effectiveness evaluation.

Hardy et al, Western Transportation Institute. 2007. Evaluation of Wildlife Crossing Structures and Fencing on US Hwy 93 Evaro to Polson.

Research on effectiveness of methods for collision reduction.

Huijser et al, and Salsman and Wilson. 2006. Animal Vehicle Crash Mitigation Using Advanced Technology, Phase I: Review, Design And Implementation, SPR-3(076).

In areas where wildlife is known to cross roadways, active warning systems can be effective to alert drivers to the presence of wildlife on or near a roadway.

Florian Schulz

Stormwater Management

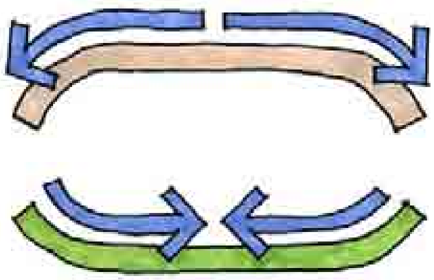
Stormwater Management
Overview

Cleaning Water, Improving Habitat
It is important to consider what happens to stormwater runoff along the entire roadway. Runoff from roadways on FWS managed lands may deliver chemical pollutants and sediment to surface and ground water. Roadways have a profound effect on the hydrology of a given site and watershed. Impervious surfaces increase runoff rates, volumes, temperature and duration. Roadway surfaces can concentrate flows, creating unnatural flow regimes that impact adjacent lands and lead to cumulative impacts downstream at the watershed scale, such as erosion and flooding.

This section discusses sustainable stormwater management techniques and points you to educational resources and guidelines on their design, construction and maintenance. Such techniques can help to clean stormwater runoff from roadways, filtering out particulates and other pollutants. They can also slow flows and detain water during peak storm events, restoring more natural flows to adjacent water bodies. A common term used to describe this approach to stormwater management is low impact development (LID). LID emphasizes conservation and the use of existing natural site features, integrated with distributed, small-scale stormwater controls to more closely mimic natural hydrologic patterns.

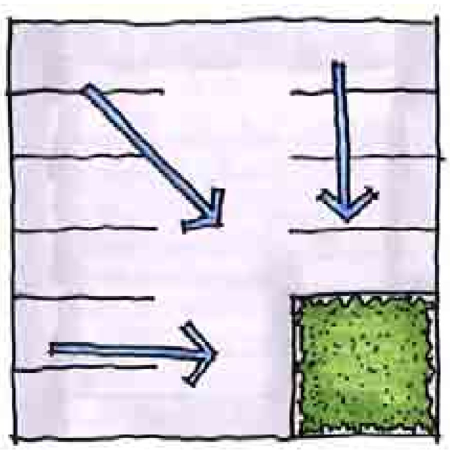
LID techniques include various features known collectively as natural drainage systems (NDS). These rely mainly on plantings, amended soils and other natural materials to treat, detain and retain stormwater runoff; these are often referred to as bioretention. Bioretention features include bioswales and rain gardens. Areas dedicated to NDS serve to buffer high value habitat from ecological disturbances caused by roadway infrastructure. Natural drainage features may also provide screening or visual buffering—functions that are often desirable when separating uses on a site or landscape.

NDS should be designed and implemented with care, so as to be compatible with habitat management goals. Concerns about their use include drawing wildlife closer to roadways through habitat creation (potentially causing increased negative animal-vehicle interactions), and the possibility of concentrating roadway pollutants into specific areas at levels that may be harmful to wildlife. These are important concerns to address, and care should be taken that each facility is designed to meet site-specific concerns.

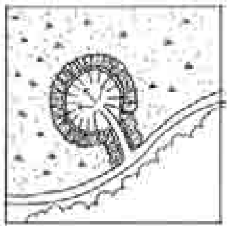


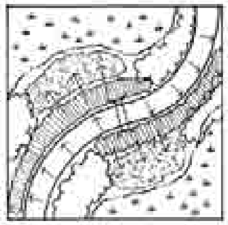
Typical facilities disperse runoff without treatment (top), while an LID approach detains and cleans water on site (bottom)

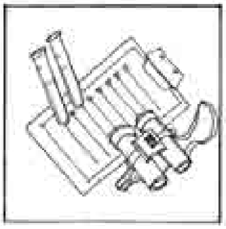
LID Philosophy
LID asks us to nurture stormwater rather than dispose of it. NDS features van help to achieve this.

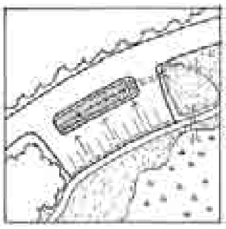


Typical NDS Sizing
An NDS feature such as a bioretention area typically requires an area of only 10% of the impervious area it is designed to treat.





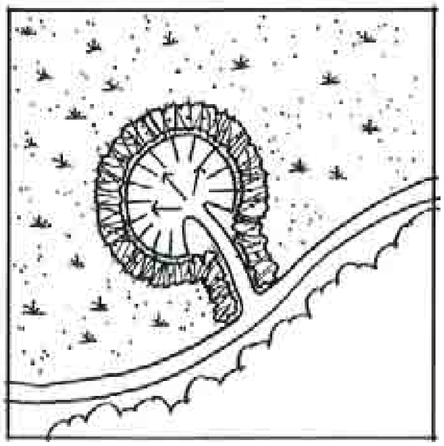




SM-1 Buffer Habitat from Polluted Runoff

Intent

Runoff from roadways can carry unwanted pollutants into adjacent streams and water bodies. It can also adversely affect (increase) the temperature of receiving water bodies. Methods for reducing pollution (chemical, particulate and temperature) should be considered and used to minimize or eliminate water quality issues roadway runoff. Treatment facilities in the right-of-way can also serve to intercept and improve the quality of runoff water from other nearby sources.



NDS features receive, clean and detain or retain runoff from roadways and other impervious surfaces; they can buffer habitat areas from negative ecological impacts.

Principles

- Adhere to a low impact development (LID) strategy in planning and designing repairs and improvements
- Consider natural drainage system (NDS) treatment facilities, including filter strips and bioswales
- Stormwater treatment facilities and approach need to be site-specific
- Consider appropriate NDS features for the type of roadway—parking, auto tour route, entry/access road, highway, etc.
- Look at hydrology planning in the area and be aware of roadway impacts on it

Metrics

- Water quality testing
- Temperature monitoring

Resources

Design guidelines for LID features.

US Dept. of Defense. 2004. Unified Facilities Criteria (UFC) - Design: Low Impact Development.

LID guidelines for Pacific NW.

Hinman, Curtis. 2005. Low Impact Development: Technical Guidance Manual for Puget Sound. Puget Sound Action Team. Access at: http://www.psparchives.com/publications/our_work/stormwater/lid/lid_tech_manual05/LID_manual2005.pdf.

Buffer design guidelines for that include stormwater treatment.

Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Access at: http://www.unl.edu/nac/bufferguidelines/.

Roadway design guidance for lower impact to hydrology.

Dashiell and Lancaster. Undated. Road Design Guidelines for Low Impact to Hydrology. Five Counties Salmonid Conservation Program.

White paper on integrated LID and ecological analysis.

Mensing and Chapman. Undated. Conservation Development and Ecological Stormwater Management: An Ecological Systems Approach.

Parking lot runoff at McNary NWR drains to a central bioswale that treats polluted runoff and buffers habitat from roadway impacts.

Brian Bainsson

Water Quality 101 **Issue: Stormwater runoff from roads and parking lots is laden with pollutants**

Alex Schwartz/USFWS

- Conventional facilities collect and drain polluted runoff using a variety of methods, such as sheet draining, "grassy swales," curbs and drainage inlets. These can quickly convey pollutants directly to sensitive habitats before the pollutants can be filtered out (*left*).
- Improved facilities are designed to intercept and filter polluted runoff before discharge to sensitive habitats (*right*).

SvR Design

SM-2 Protect Habitat from Erosive Flows and Flooding

Intent

The rate of flow of runoff from roadways is major issue of concern. Flow rates are typically much higher and shorter in duration than those which would come from the same areas in unpaved conditions. Such spikes in flow rates create erosion and flooding issues and prevent groundwater recharge. These effects can have major detrimental impacts on fish, wildlife and their habitats. Natural drainage system (NDS) facilities should be designed to not only clean water, but to detain peak flows and, where appropriate retain, runoff locally. Target flow control should be based on undeveloped conditions for local ecosystems, as well as current soil conditions and downstream concerns.

Principles

- Minimize quantity of stormwater runoff
- Minimize use of impervious materials
- Technologies to address water quantity issues include wet ponds, porous pavements, bioswales and rain gardens
- Improvements (stormwater facilities) must be sized appropriately to handle flow

Metrics

- Measurements of stormwater runoff rates and volumes
- Hydrographs for receiving water bodies

Resources

Design guidelines for low-use roads, focusing largely on hydrology.

Weaver, William and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

Low impact development (LID) guidelines for Pacific Northwest.

Hinman, Curtis. 2005. Low Impact Development: Technical Guidance Manual for Puget Sound. Puget Sound Action Team. Olympia, WA.

Design guidelines for LID features.

US Dept. of Defense. 2004. Unified Facilities Criteria (UFC) - Design: Low Impact Development.

Info on vegetative filter strips (page 44) and other practices.

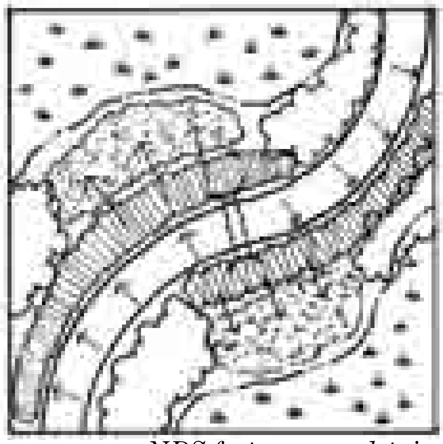
Smith, Stacy (Idaho Technology Transfer Center, Univ. of Idaho). 2005. BMP Handbook: Best Management Practices for Idaho Rural Road Maintenance.

Roadway design guidance for lower impact to hydrology.

Dashiell and Lancaster. Undated. Road Design Guidelines for Low Impact to Hydrology. Five Counties Salmonid Conservation Program.

BMPs for ESA compliance.

WSDOT. Best Management Practices Field Guide for ESA Sec 4(d) Habitat Protection.



NDS features can detain runoff, slowing its flow to adjacent water bodies.

A gravel parking lot with central vegetative swale at Ash Meadows NWR minimizes impervious materials and allows for large storm events to be infiltrated on site, away from more sensitive habitats.

Jeff Holm/USFWS

Water Quantity 101 **Issue: Impervious surfaces increase runoff rates, temperature, and volume**

SvR Design

- Runoff from impervious areas often concentrates flows, which impacts adjacent lands and also leads to cumulative downstream and watershed-scale impacts
- Where space is limited or linear alignment is tight, choose materials such as pervious paving (*left*) to reduce runoff rates
- Use NDS features to detain runoff before discharge (*right*)

SvR Design

SM-3 Monitor and Maintain Stormwater Facilities

Intent

Monitoring and maintaining stormwater facilities after project construction is key to learning from your work and improving the effectiveness of future projects. Particular attention should be given to monitoring the effects of the project on the landscape's environmental quality. Budgeting for and following standard monitoring and maintenance protocols are a critical component for stormwater management on FWS managed lands.

Principles

- Employ stormwater facility monitoring protocols (per ASCE or other standards)
- Maintain facilities in a manner that optimizes facility performance
- Collect relevant baseline data before project construction
- Check for and use appropriate control measures on any invasive species
- Check for levels of contaminants coming from roadway, and track their fate in areas adjacent to roadway
- Monitor level of compatibility with local wildlife and surrounding habitats
- Document maintenance needs and costs
- Document effectiveness of soil mixes and plants used
- Share or publish monitoring results to help improve design and results in other projects
- Use monitoring results in adaptive management

Metrics

- Measurements of stormwater runoff rates, volumes, temperature and contaminants
- Hydrographs for receiving water bodies
- Analysis documenting water quality improvements due to NDS features

Resources

Technical guidelines for monitoring of stormwater in various conditions.

US EPA. 2002. Urban Stormwater BMP Performance Monitoring. Access at: http://water.epa.gov/scitech/wastetech/guide/stormwater/monitor.cfm.

NDS maintenance guidelines that include guidance on monitoring.

City of Bellevue, WA. 2009. Natural Drainage Practices Maintenance Guidelines. Access at: http://www.bellevuewa.gov/pdf/Utilities/Natural_Drainage_Practices.pdf.

Study from UC Davis & USFS finding that bioswale significantly reduced runoff and removed pollutants; includes monitoring protocols used.

Xiao, Qingfu and E. G. McPherson. 2009. Testing a Bioswale to Treat and Reduce Parking Lot Runoff. Access at: http://www.fs.fed.us/psw/programs/cufr/products/psw_cufr761_P47ReportLRes_AC.pdf.

Standard operating procedures for stormwater monitoring.

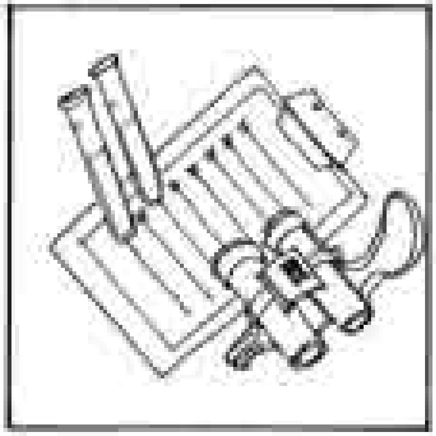
Washington Department of Ecology. 2010. Stormwater monitoring resources. Access at: http://www.ecy.wa.gov/programs/wq/stormwater/municipal/strmH2Omonitoring.html.

Guidance on stormwater monitoring for construction sites.

Washington Department of Ecology. 2006. How to do Stormwater Monitoring: A guide for construction sites. Access at: http://www.ecy.wa.gov/biblio/0610020.html.

Monitoring for larger debris.

ASCE. 2010. Guideline for Monitoring Stormwater Gross Solids. Order at: http://www.asce.org/Product.aspx?id=2147485997.



Monitoring projects will help advance the development of a focused approach to stormwater management on FWS managed lands that is responsive to the Service's mission.

Similar to managed wetlands, stormwater facilities should be periodically monitored for performance and to inform adaptive management and maintenance regimes.

USFWS

SM-4 Promote Stewardship of Aquatic Resources

Intent
Low impact development (LID) facilities for stormwater management serve the functional purposes of cleaning and slowing or retaining stormwater runoff and protecting our aquatic resources. Additionally they can help to raise public awareness and understanding of the relationship of roadways to aquatic resources, wildlife and habitat conservation. Stormwater facilities can be designed to reveal to and educate visitors about the impacts of development on aquatic resources. Facilities can communicate how they protect aquatic resources, and can influence behavior and management practices beyond FWS managed lands in support of the Service's mission.

Principles
- Prioritize aesthetic and educational components of highly visible stormwater management facilities
- Use stormwater facilities to communicate stewardship commitment of FWS
- Design stormwater facilities with native plants in arrangements that respond to multiple objectives, including management, educational/interpretive, aesthetic and maintenance goals
- Make stormwater part of the site's interpretive story and reveal the process of stormwater quantity and quality controls to the extent possible
- Consider educational and volunteer opportunities presented by stormwater management facilities
- Consider potential benefits or drawbacks of additional wetland habitat areas created by natural drainage facilities

Metrics
- "Friends" groups involvement & awareness
- Production/use of interpretive materials or content
- Use of stormwater facilities as positive examples or success stories (e.g. in public media, professional circles, within FWS)

Resources
Social benefits of road and highway systems.

AASHTO. 2008. Above and Beyond: The Environmental and Social Contributions of America's Highway Programs.

Promotional information for visitors to FWS sites.

USFWS. 2005. Byways to America's Wildest Places: Discover Your National Wildlife Refuges.

Scenic byways guidelines with details on benefits of good road design.

USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

Green Values calculator can help to quantify benefits from LID (aka green infrastructure) facilities.

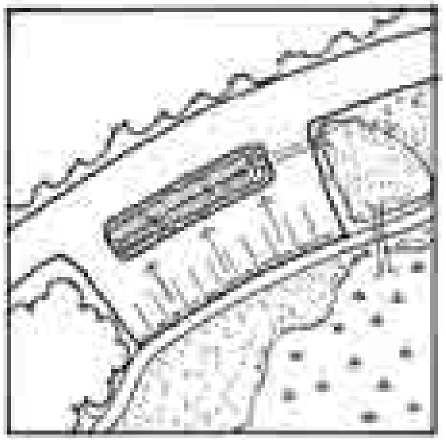
Center for Neighborhood Technology. 2010. Green Values Stormwater Management Calculator. Access at: http://greenvalues.cnt.org/

Additional resources on green infrastructure (another term that includes natural stormwater management facilities).

US EPA. 2010. Green Infrastructure: Managing Wet Weather With Green Infrastructure (website). Access at: http://cfpub.epa.gov/npdes/home.cfm?program_id=298.

Report examining social, economic, and environmental benefits of green infrastructure.

Stratus Consulting. 2009. A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds.



Stormwater treatment facilities integrated into roadways provide places where FWS stewardship of aquatic resources can be demonstrated.

Stormwater facilities can be an important part of visitor experience, providing interpretive opportunities (top) and allowing visitors hands-on experience planting or maintaining native vegetation (bottom).

Justin Martin

USFWS

Visitor Experience

Visitor Experience
Overview

Engaging the Public
Conservation of fish, wildlife, plants and their habitats is at the core of the Service's mission. Providing public access compatible with conservation goals is paramount to achieving this mandate. Roadways are the primary infrastructure elements that facilitate public access to FWS managed lands. Conversely, landscapes without roads or limited or restricted public access on roads can support protection of sensitive habitats when necessary. This section is intended to help you consider how best to provide access to FWS managed lands. Well-designed roadways on FWS lands can help demonstrate to visitors how the Service's mission is carried out at the landscape scale.

Scenic roadways offer visitors a glimpse into the habitat areas that the Service manages, helping to inspire an ethic of stewardship and conservation among the public. Roadways should be designed to afford such experiences and to convey a sense of place that is unique to each site and destination. They should take into account both the natural and cultural histories of the land they traverse, revealing but not destroying special places and artifacts along the way. This section of the guidelines will point you to resources to help with design solutions focused on the visitor's experience. Design of roadway elements such as safety and guiding features, interpretive signs and visitor facilities should be relevant and specific to the region, if not to the individual site or refuge.

National Wildlife Refuges, Fish Hatcheries and other FWS managed lands are national treasures. Facilities there should help visitors connect with the natural heritage that the Service works to conserve.

VE-1 Preserve and Highlight Scenic Value

Intent

The scenic value of wildlife refuges plays an important role in the visitor experience. Road alignments should be chosen or revised carefully so as to preserve the scenic value of the journey. Roadway alignments and locations on FWS managed lands should afford views and simultaneously prevent roadways from becoming dominant features of the visual landscape.

Principles

- Consider designs that respond to the character of the landscape and management practices. For example, an entrance road may offer a change in design speed, scale and geometry in order to help visitors decompress from previous highway travel
- Provide appropriate orientation and directional signage in a style that fits with the local character and landscape
- Consider and plan the viewsheds and impacts of roadways on the visual and auditory landscape
- Consider and plan coherent and consistent design elements with the facility (color, texture, form)
- Consider the entry experience (does it welcome and orient visitors?) and sequence of visitor experiences when arriving at FWS managed lands or high use areas such as visitor centers
- Consider opportunities for interpreting culture and the landscape along the corridor
- Provide safe places, such as overlooks and viewpoints, to enjoy scenery

Metrics

- Visual resource analysis/ management - USFS or BLM methodologies (see Resources below)

Resources

Scenic byways guidelines with details on benefits of good road design.

USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

Study on context sensitive roadway design from New Mexico.

New Mexico Department of Transportation. 2006. Architectural and Visual Quality Design Guidelines for Context Sensitive Design and Context Sensitive Solutions.

Roadside treatment design guidelines.

FHWA. 2008. Safe and Aesthetic Design of Urban Roadside Treatments.

Regional guidelines for roadside development.

ODOT. 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Design guidance based on human behavior patterns.

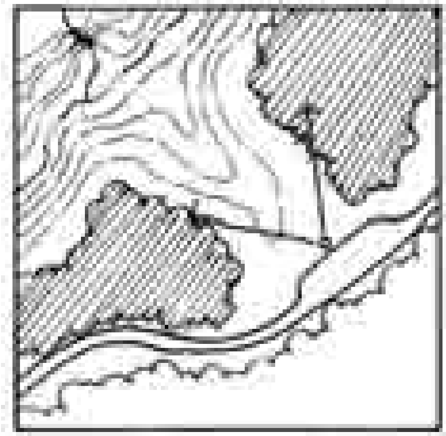
Transportation Research Board of The National Academies. 2008. Human Factors Guidelines for Road Systems (NCHRP Report 600B).

USFS visual assessment technique.

USDA Forest Service. 1995 (rev. 2000). Landscape Aesthetics: A Handbook for Scenery Management. AH-701.

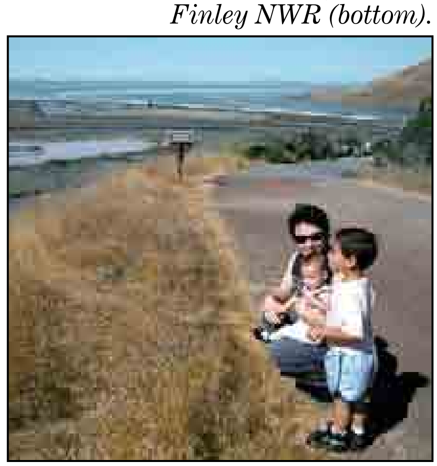
BLM visual assessment technique.

BLM. 2007. Visual Resource Management (website). Access at http://www.blm.gov/nstc/VRM/.



Plan roadways to afford views to areas of high scenic value.

Roadways provide or give access to scenic vistas (top) and visitor facilities such as a viewing blind at Finley NWR (bottom).



USFWS

Brian Bainnson

VE-2 Promote and Facilitate Multiple Modes of Transportation

Intent

Access to FWS managed lands, where compatible with Station purpose, should be available to visitors via multiple forms of transportation, including public transit, bicycle, and walking. Alternative forms of transportation can help reduce visitors' carbon footprints, which in turn may have long term positive affects for the natural resources we manage. Planning and building to accommodate sustainable transportation options can help to achieve the FWS mission.

Principles

- Design alternative transportation facilities that are compatible with wildlife and habitat conservation
- Provide parking for bicycles and other alternative types of transportation
- Consider adding charging stations for electric vehicles
- Coordinate with other agencies or organizations that could provide public transportation to FWS managed lands
- Promote and partner to develop bicycle routes to FWS managed lands
- Consider bicycle routes through FWS managed lands where compatible with wildlife, safety, and user experience
- Consider signage or pavement markings to alert drivers to other types of road users
- Use outreach to encourage use of alternative transportation modes to and within the FWS managed lands

Metrics

- Counts of users arriving by public transportation, using bicycles, etc.
- Use rates of stationary facilities, such as special parking or bike racks

Resources

Potential funding source for transit and other alternative transportation options.

Paul S. Sarbanes Transit in Parks Program (5320). Access at: http://www.fta.dot.gov/funding/grants/grants_financing_6106.html.

Case studies for alternative transportation projects in National Parks.

See: http://www.volpe.dot.gov/nps/projects.html.

Design guidelines (see pp. 70-76).

USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

Potential funding for developing alternative transportation systems for visitors through the Transit in Parks Program (5230)

See: http://www.fta.dot.gov/funding/grants/grants_financing_6106.html.

Bicycling on federal lands - case studies include two National Wildlife Refuges.

FHWA. 2008. Guide to Promoting Bicycling on Federal Lands. FHWA Pub. No. FHWA-CFL/TD-08-007.

Case studies that include alternative transportation programs in parks, such as shuttle bus systems.

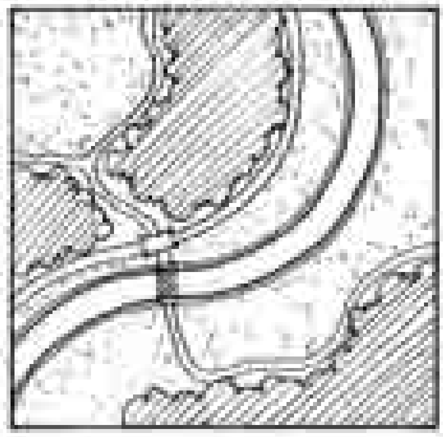
NPS Partnerships Case Studies (Transportation). See: http://www.nps.gov/partnerships/cs_type.htm#anchor19.

Lessons from Europe on traffic calming, enhancing mobility options.

Brewer, Jim, et al. 2001. Geometric Design Practices for European Roads. FHWA, Office of International Programs.

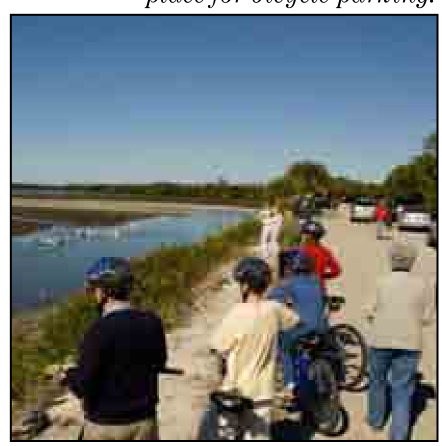
Case Study.

Tualatin River NWR. Two parking spaces designated for hybrid vehicles; bicycle racks provided at parking area; bus stop for a public transit line adjacent to the Refuge.



Providing separate facilities can encourage users who don't want to bike or walk along a roadway.

Roadway projects should facilitate multiple modes of transportation; a roadway at Ding Darling NWR (top) accommodates both autos and bikers for wildlife observation; parking lot at Great Swamp NWR visitor center (bottom) provides a safe, convenient place for bicycle parking.



USFWS

Brian Bainnson

VE-3 Comply With Accessibility Standards and Guidelines

Intent
FWS managed lands should be accessible to all. FWS is subject to accessibility standards as dictated by the Architectural Barriers Act (ABA). Project teams should use the relevant suite of resources and guidance to ensure all FWS facilities are designed and constructed to comply with or exceed the mandates of the ABA.

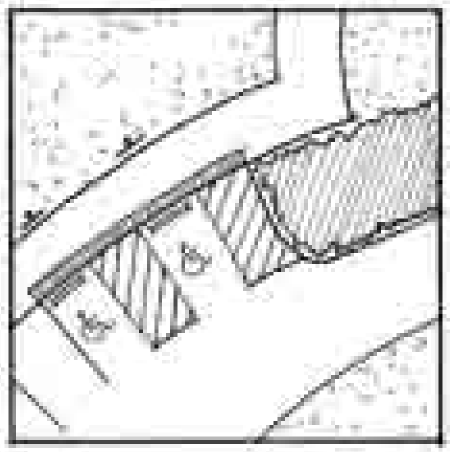
Principles
- Define and consider visitor expectations for accessibility
- Balance safety and accessibility concerns
- Apply all relevant design criteria in order to meet or exceed the requirements of ABA
- Consider the relationship of accessible improvements to related infrastructure. Is there a completely accessible visitor experience?

Metrics
- Compliance with requirements, guidelines and standards
- Visitor use counts
- Outcomes of DCR facility audits

Resources
See ABA accessibility standards.
http://www.access-board.gov/gs.htm.

Draft Final Guidelines for accessibility in Outdoor Developed Areas on Federal lands:
http://www.access-board.gov/outdoor/.

Accessibility guidance for Federal outdoor areas (specific to USDA Forest Service lands/facilities).
USDA Forest Service. 2006. Accessibility Guidebook for Outdoor Recreation and Trails.



Brian Bainnson

Provide accessible parking spaces with appropriate access aisles and access to pathways (top); accessible parking at Great Swamp NWR (right).

What Federal Accessibility criteria should FWS projects follow?

The Architectural Barriers Act (ABA) of 1968
FWS is subject to the ABA. The ABA requires access to facilities designed, built, altered or leased with Federal funds. Passed by Congress in 1968, it marks one of the first efforts to ensure access to the built environment. The Access Board develops and maintains accessibility guidelines under this law. These guidelines serve as the basis for the standards used to enforce the law, the Architectural Barriers Act Accessibility Standard (ABASS).

Americans with Disabilities Act and the Architectural Barriers Act Accessibility Guidelines for Buildings and Facilities (ADAABAAG) as published in the Federal Register on July 23, 2004.
FWS should follow the scoping and technical requirements under the ABA sections. This direction covers accessibility to sites, facilities, buildings and elements by individuals with disabilities. The requirements are to be applied during design, construction, additions to and alterations of facilities.

Draft Final Accessibility Guidelines for Outdoor Developed Areas
Many FWS facilities can be characterized as Outdoor Developed Areas. The Access Board is proposing to issue accessibility guidelines for outdoor developed areas designed, constructed or altered by Federal agencies subject to the ABA of 1968. The guidelines cover trails, outdoor recreation access routes, beach access routes and picnic and camping facilities. Once these guidelines are finalized they will become the technical requirements for accessibility in outdoor developed areas. At this time, FWS may use these guidelines.

Accessibility Guidebook for Outdoor Recreation and Trails, USDA Forest Service, April 2006.
These guidelines only apply within National Forest System boundaries. However, they are a very useful tool for FWS projects recognizing that the Draft Final Accessibility Guidelines for Outdoor Developed Areas are still a work in progress.

And In General…
- Use principles of universal design—programs and facilities should be usable by all people, to the greatest extent possible, without separate or segregated access for people with disabilities.
- Accessibility does not supersede requirements for safety.
- Consider the level of development at a site to help balance safety and accessibility.

VE-4 Facilitate Compatible Wildlife Dependent Recreation and Education

Intent

The FWS mission is working with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. The mission of the Service should be integrated and transparent in the design of roadways on FWS managed lands. Roadways are key in fulfilling the Service's priority of connecting people with nature, and can provide opportunities to do so in ways that are compatible with the conservation mission of the Service.

Principles

- Consider whether current or anticipated visitor impacts are compatible with wildlife and their habitats
- Consider safety for visitors, staff and wildlife
- Provide orientation and interpretive information to support visitor experiences
- Consider the enabling legislation of the refuge - what is the purpose of the unit?
- Consider relationships with other recreational or educational sites within the region
- Consider demand, site carrying capacity and quality of visitor experience
- Determine what kind of access to recreation sites is available, appropriate and necessary
- Consider impacts to recreational activities from roads
- Promote appropriate facilities for safely viewing wildlife from roads where necessary
- Plan for appropriate signage, including entrance, orientation, directional and interpretive
- Consider access for and needs of school groups

Metrics

- Visitor counts
- Diversity and quality of activities available for visitors
- Ease of use (proximity, clarity, etc.) of recreational and educational elements

Resources

California State Parks Children in Nature Campaign.

http://www.parks.ca.gov/?page_id=24914.

Information on local, regional and national programs to connect kids with nature.

Children and Nature Network. See: http://www.childrenandnature.org/movement/info.

National Wildlife Federation's kids outside program.

See: http://www.nwf.org/beoutthere/.

Washington State Parks "No Child Left Inside" campaign.

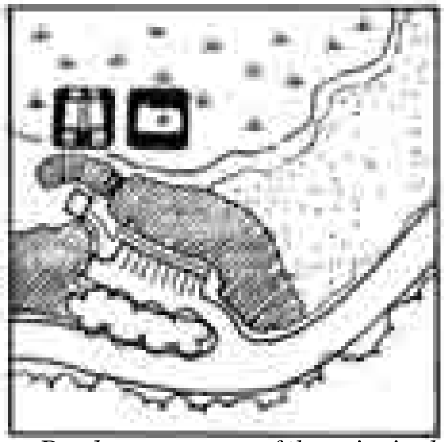
See: http://www.parks.wa.gov/NoChildLeftInside/.

USDA Forest Service Discover the Forest campaign.

http://www.discovertheforest.org/index.php.

Bicycling on federal lands - case studies include two National Wildlife Refuges.

FHWA. 2008. Guide to Promoting Bicycling on Federal Lands. FHWA Pub. No. FHWA-CFL/TD-08-007.



Roadways are one of the principal infrastructure elements that facilitate access to the Big 6 on FWS managed lands.

The Big Six

The 1997 Refuge System Improvement Act outlines "The Big Six" priority public uses for Refuge system improvements:

- Hunting
- Fishing
- Wildlife Photography
- Wildlife Observation
- Environmental Interpretation
- Environmental Education

Auto tour route at Ridgefield NWR provides visitors access to Big 6 activities, such as wildlife observation and photography.

USFWS

Appendices

Appendix A: Bibliography

LE - Landscape Ecology

Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station. 110 p. Access at http://www.unl.edu/nac/bufferguidelines/.

Climate Impacts Group. 2009. The Washington Climate Change Impacts Assessment. University of Washington. Seattle, WA.

Dashiell and Lancaster. Undated. Road Design Guidelines for Low Impact to Hydrology. Five Counties Salmonid Conservation Program. Weaverville, CA.

Dramstad, Wenche, James Olson and Richard Forman. 1996. Landscape Ecology Principles in Landscape Architecture and Land-Use Planning. Harvard GSD and Island Press. Washington, DC.

FHWA. 2008. Wildlife-Vehicle Collision Reduction Study, Best Practices Manual. Access at http://www.fhwa.dot.gov/environment/hconnect/wvc/index.htm.

Forman, Richard. “Roadsides and Vegetation.” 2002. In Proceedings of the International Conference on Ecology and Transportation, Keystone, CO, September 24-28, 2001. Raleigh, NC: Center for Transportation and the Environment, North Carolina State University (March 2002): 85-91.

Forman, Richard, et al. 2003. Road Ecology: Science and Solutions. Island Press. Washington, D.C.

Green Highways Partnership. http://www.greenhighwayspartnership.org.

Jones, Grant R., David F. Sorey and Charles C. Scott. 2007. Applying Visual Resource Assessment for Highway Planning. In Landscape Architecture Graphic Standards (pp.130-139). Hoboken, New Jersey: John Wiley & Sons.

Jones, Grant R. and Charles C. Scott. 2007. Road Alignment. In Landscape Architecture Graphic Standards (pp.330-341). Hoboken, New Jersey: John Wiley & Sons.

Kentucky Transportation Center. Undated. Context-Sensitive Design Case Study No. 1: Paris Pike - Kentucky. College of Engineering, University of Kentucky. Lexington, KY.

Nevada Department of Transportation. 2002. Pattern and Palette of Place: A Landscape and Aesthetic Master Plan for the Nevada State Highway System.

New Mexico Department of Transportation. 2006. Architectural and Visual Quality Design Guidelines for Context Sensitive Design and Context Sensitive Solutions.

ODOT (Oregon Department of Transportation). 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Smith, Stacy (Idaho Technology Transfer Center, Univ. of Idaho). 2005. BMP Handbook: Best Management Practices for Idaho Rural Road Maintenance.

Sperling, Daniel and Deborah Gordon. 2008. Two Billion Cars: Transforming a Culture. In: TR News, No. 259 (Nov-Dec).

Transportation Research Board of The National Academies. 1997. Toward A Sustainable Future: Addressing the Long-Term Effects of Motor Vehicle Transportation on Climate and Ecology (SR 251).

Transportation Research Board of The National Academies. 2002. A Guide to Best Practices for Achieving Context Sensitive Solutions (NCHRP Report 480).

Transportation Research Board of The National Academies. 2008. Potential Impacts of Climate Change on US Transportation (TRB Report 290).

TransTech Mgmt., Oldham Historic Properties Inc. and Parsons Brinckerhoff Quade & Douglas for National Cooperative Highway Research Program. 2004. Performance Measures for Context Sensitive Solutions - A Guidebook for State DOT’s.

Trombulak, Stephen and Christopher Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology 14(1), February 2000, pp. 18-30.

USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

USDA Forest Service, Stream-Simulation Working Group. 2008. Stream Simulation: An Ecological Approach To Providing Passage for Aquatic Organisms at Road-Stream Crossings.

Weaver, William and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

Western Governors’ Wildlife Council. http://www.westgov.org/. Resources include the Wildlife Corridors Initiative Report (2008) and Wildlife Sensitivity Maps.

PC - Planning Context

AASHTO. 2008. Guidelines For Environmental Performance Measures. NCHRP 25-25, Task 23. Prepared by Cambridge Systematics, Inc. Cambridge, MA.

Florida Department of Transportation. 2003. Public Involvement Handbook. Available at: http://www.dot.state.fl.us/EMO/pubs/public_involvement/pubinvolve.htm.

Jones, Grant R., David F. Sorey and Charles C. Scott. 2007. Applying Visual Resource Assessment for Highway Planning. In Landscape Architecture Graphic Standards (pp.130-139). Hoboken, New Jersey: John Wiley & Sons.

Lennertz, Bill and Aarin Lutzenhiser. 2006. The Charrette Handbook. American Planning Association.

Myerson, Deborah L., AICP, 1999. Getting It Right in the Right-of-Way: Citizen Participation in Context-Sensitive Highway Design. Scenic America. http://www.scenic.org/.

NEPA information for EPA Region 10 (Pacific NW). http://yosemite.epa.gov/R10/ECOCOMM.NSF/webpage/national+environmental+policy+act.

ODOT (Oregon Department of Transportation). 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Peaks, Harold E. and Sandra Hayes. 1999. "Building Roads in Sync With Community Values." In Public Roads (Mar./Apr. 1999).

Porter, Douglas and David Salvesen, eds. 1995. Collaborative Planning for Wetlands and Wildlife: Issues and Examples. Island Press. Washington, D.C.

Transportation Research Board of The National Academies. 1997. Toward A Sustainable Future: Addressing the Long-Term Effects of Motor Vehicle Transportation on Climate and Ecology (SR 251).

Transportation Research Board of The National Academies. 2008. Potential Impacts of Climate Change on US Transportation (TRB Report 290).

TransTech Mgmt., Oldham Historic Properties Inc. and Parsons Brinckerhoff Quade & Douglas for National Cooperative Highway Research Program. 2004. Performance Measures for Context Sensitive Solutions - A Guidebook for State DOT's.

Stratus Consulting. 2009. A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds. Prepared for City of Philadelphia Water Department.

University of Washington and CH2MHill. 2009. Greenroads Rating System, v1.0. http://www.greenroads.us/.

USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

WSDOT. 2003. Building Projects that Build Communities: Recommended Best Practices.

DE - Design and Engineering

AASHTO. 2001. Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400), 1st Edition. Washington, D.C.

AASHTO. 2004. A Policy on Geometric Design of Highways and Streets, 5th Edition (aka 'Green Book). Washington, D.C.

BuildCarbonNeutral. 2010. http://buildcarbonneutral.org.

Calkins, Meg. 2009. Materials for Sustainable Sites. John Wiley & Sons. Hoboken, NJ.

Center for Environmental Excellence by AASHTO - Invasive Species/Vegetation Management, Reseach, Documents & Reports web page. Access at: http://environment.transportation.org/environmental_issues/invasive_species/docs_reports.aspx.

Crane, Bill. 2006. Road Maintenance with Threatened, Endangered, or Sensitive Plants: Finding Solutions. 0677 1807P. San Dimas, CA: U.S. Department of Agriculture, Forest Service, San Dimas Technology and Development Center. 60 p.

Ferguson, Leslie, Celestine L. Duncan and Kathleen Snodgrass. 2003. Backcountry Road Maintenance and Weed Management. 0371 2811. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 22 p.

FHWA. 2007. Roadside Revegetation: An Integrated Approach to Establishing Native Plants. FHWA-WFL/TD-07-005. Vancouver, WA.

FHWA. Undated. Flexibility in Highway Design. FHWA Pub. No. FHWA-PD-97-062. http://www.fhwa.dot.gov/environment/flex/index.htm.

Forman, Richard, et al. 2003. Road Ecology: Science and Solutions. Island Press. Washington, D.C.

Harper-Lore, Bonnie and Maggie Wilson, editors. 2000. Roadside Use of Native Plants. Island Press. Washington, D.C.

Jones, Grant R., David F. Sorey and Charles C. Scott. 2007. Applying Visual Resource Assessment for Highway Planning. In Landscape Architecture Graphic Standards (pp.130-139). Hoboken, New Jersey: John Wiley & Sons.

Kentucky Transportation Center. Undated. Context-Sensitive Design Case Study No. 1: Paris Pike - Kentucky. College of Engineering, University of Kentucky. Lexington, KY.

ODOT (Oregon Department of Transportation). 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Reyff, James. 2009. Reducing Underwater Sounds with Air Bubble Curtains. TR News, No. 262 (May-June).

Ruiz, Leo. 2005. Guidelines for Road Maintenance Levels. 0577 1205P. San Dimas, CA: U.S. Department of Agriculture, Forest Service, San Dimas Technology and Development Center. 71 p.

Skorseth and Selim. 2000. Gravel Roads Maintenance and Design Manual. South Dakota Local Transportation Assistance Program (USDOT - FHWA).

Smith, Stacy (Idaho Technology Transfer Center, Univ. of Idaho). 2005. BMP Handbook: Best Management Practices for Idaho Rural Road Maintenance.

Sustainable Sites Initiative (SSI). http://www.sustainablesites.org/.

Transportation Research Board of The National Academies. 2008. Human Factors Guidelines for Road Systems. NCHRP Report 600B.

University of Bath. Inventory of Carbon & Energy (ICE) Wiki. http://wiki.bath.ac.uk/display/ICE/Home+Page.

University of Washington and CH2MHill. 2009. Greenroads Rating System, v1.0. http://www.greenroads.us/.

USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

Washington Department of Ecology. 2006. How to do Stormwater Monitoring: A guide for construction sites. Access at: http://www.ecy.wa.gov/biblio/0610020.html.

Washington Department of Ecology. 2010. Stormwater monitoring resources. Access at: http://www.ecy.wa.gov/programs/wq/stormwater/municipal/strmH2Omonitoring.html.

Weaver, William and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

Wisconsin Department of Transportation (WisDOT). 2003. Best Practices for Control of Invasive Plant Species.

WSDOT. 1997. Integrated Vegetation Management for Roadsides.

OP - Organism Passage

Arizona Game and Fish Department, Habitat Branch. 2008. Guidelines for Bridge Construction or Maintenance to Accommodate Fish & Wildlife Movement and Passage.

Beckmann, J. P., A. P. Clevenger, M. P. Huijser, and J. A. Hilty. 2010. Safe Passages. Island Press. Washington, D.C.

FHWA. 2008. Wildlife-Vehicle Collision Reduction Study, Best Practices Manual. http://www.fhwa.dot.gov/environment/hconnect/wvc/index.htm.

FHWA. 2008. Wildlife-Vehicle Collision Reduction Study, Report to Congress. Access at http://www.fhwa.dot.gov/publications/research/safety/08034/index.cfm.

FHWA. 2010. Keeping It Simple: Easy Ways to Help Wildlife Along Roads. http://www.fhwa.dot.gov/environment/wildlifeprotection/index.cfm.

Hardy et al, Western Transportation Institute (Montana State Univ.). 2007. Evaluation of Wildlife Crossing Structures and Fencing on US Highway 93 Evaro to Polson. Phase I: Preconstruction Data Collection and Finalization of Evaluation Plan.

Henke, R.J., P. Cawood-Hellmund and T. Sprunk. 2001. Habitat connectivity study of the I-25 and US 85 corridors, Colorado. Pages 499-508. Proceedings of the International Conference on Ecology and Transportation. Keystone, Colorado, September 24-28, 2001. Center for Transportation and the Environment, North Carolina State University, USA.

Huijser et al (Western Transportation Institute - Montana State University) and Salsman and Wilson (Sensor Technologies and Systems, Inc.). 2006. Animal Vehicle Crash Mitigation Using Advanced Technology, Phase I: Review, Design And Implementation, SPR-3(076). Oregon Dept. of Transportation Research Unit. Report No. FHWA-OR-TPF-07-01.

Jacobson, Sandra, Robert Gubernick and Michael Furniss. "Combining Aquatic and Terrestrial Passage Design into a Continuous Discipline". In Proceedings of the 2007 International Conference on Ecology and Transportation, edited by C. Leroy Irwin, Debra Nelson, and K.P. McDermott. Raleigh, NC: Center for Transportation and the Environment, North Carolina State University, 2007. pp. 136-142. http://escholarship.org/uc/item/6w6573r8.

Mader, Sharon. 2006. Comparing the Ecological Effects of Linear Developments on Terrestrial Mammals. Wildlands CPR. Missoula, MT. http://www.wildlandscpr.org/biblio-notes/comparing-ecological-effects-linear-developments-terrestrial-mammals.

Minnesota Department of Transportation. 2009. Cost Analysis of Alternative Culvert Installation Practices in Minnesota.

Proceedings of the International Conference on Ecology and Transportation. Access biennial conference proceedings (2003, 2005, 2007, 2009) online at: http://www.icoet.net/.

Transportation Research Board of The National Academies. 2008. Evaluation and the Use and Effectiveness of Wildlife Crossings (NCHRP Report 615).

Trombulak, Stephen and Christopher Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology 14(1), February 2000, pp. 18-30.

USDA Forest Service. 2002. Management Techniques for Riparian Restorations (Roads Field Guide, Volume II).

USDA Forest Service, Stream-Simulation Working Group. 2008. Stream Simulation: An Ecological Approach To Providing Passage for Aquatic Organisms at Road-Stream Crossings.

USFWS. Unpublished. Wildlife Crossing and Aquatic Organism Passage Issues by State. Contact FWS national Refuge Roads Coordinator.

Weaver, William and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

SM - Stormwater Management

AASHTO. 2008. Above and Beyond: The Environmental and Social Contributions of America's Highway Programs.

Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station. 110 p. Access at http://www.unl.edu/nac/bufferguidelines/.

City of Bellevue, WA. 2009. Natural Drainage Practices Maintenance Guidelines. Access at: http://www.bellevuewa.gov/pdf/Utilities/Natural_Drainage_Practices.pdf.

Dashiell and Lancaster. Undated. Road Design Guidelines for Low Impact to Hydrology. Five Counties Salmonid Conservation Program. Weaverville, CA.

Hinman, Curtis. 2005. Low Impact Development: Technical Guidance Manual for Puget Sound. Puget Sound Action Team. Olympia, WA. http://www.psparchives.com/publications/our_work/stormwater/lid/lid_tech_manual05/LID_manual2005.pdf.

Mensing and Chapman. Undated. Conservation Development and Ecological Stormwater Management: An Ecological Systems Approach. Applied Ecological Services. Prior Lake, MN.

Smith, Stacy (Idaho Technology Transfer Center, Univ. of Idaho). 2005. BMP Handbook: Best Management Practices for Idaho Rural Road Maintenance.

Stratus Consulting. 2009. A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds. Prepared for City of Philadelphia Water Department.

US Dept. of Defense. 2004. Unified Facilities Criteria (UFC) - Design: Low Impact Development.

USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

US EPA. 2002. Urban Stormwater BMP Performance Monitoring. Access online at: http://water.epa.gov/scitech/wastetech/guide/stormwater/monitor.cfm.

US EPA. 2010. Green Infrastructure: Managing Wet Weather With Green Infrastructure (website). Access at: http://cfpub.epa.gov/npdes/home.cfm?program_id=298.

USFWS. 2005. Byways to America's Wildest Places: Discover Your National Wildlife Refuges.

Weaver, William and Danny Hagans. 1994. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads.

WSDOT. Best Management Practices Field Guide for ESA Sec 4(d) Habitat Protection. http://www.wsdot.wa.gov/NR/rdonlyres/A0C3F307-1548-4BED-8C7B-C4A79A788791/0/BMP_Field_Guide.pdf.

Xiao, Qingfu and E. G. McPherson. 2009. Testing a Bioswale to Treat and Reduce Parking Lot Runoff. Access at: http://www.fs.fed.us/psw/programs/cufr/products/psw_cufr761_P47ReportLRes_AC.pdf.

VE - Visitor Experience

BLM. 2007. Visual Resource Management (website). Access at http://www.blm.gov/nstc/VRM/.

Brewer, Jim, et al. 2001. Geometric Design Practices for European Roads. FHWA, Office of International Programs.

California State Parks. Children in Nature Campaign. http://www.parks.ca.gov/?page_id=24914.

Children & Nature Network. Regional Campaigns and Initiatives. http://www.childrenandnature.org/movement/info.

FHWA. 2008. Guide to Promoting Bicycling on Federal Lands. FHWA Pub. No. FHWA-CFL/TD-08-007.

FHWA. 2008. Safe and Aesthetic Design of Urban Roadside Treatments. NCHRP Report 612. www.TRB.org.

National Park Service. NPS Partnerships Case Studies (Transportation). http://www.nps.gov/partnerships/cs_type.htm#anchor19.

National Wildlife Federation. 2010. Be Out There Campaign. http://www.nwf.org/beoutthere/.

New Mexico Department of Transportation. 2006. Architectural and Visual Quality Design Guidelines for Context Sensitive Design and Context Sensitive Solutions.

ODOT (Oregon Department of Transportation). 2006. Roadside Development Design Manual - Guidelines for Visual Resource Management, Landscaping, and Hardscaping (DRAFT).

Transportation Research Board of The National Academies. 2008. Human Factors Guidelines for Road Systems (NCHRP Report 600B).

US Access Board. Guidelines and Standards (ABA, ADA, etc). http://www.access-board.gov/gs.htm.

USDA Forest Service. 1995 (rev. 2000). Landscape Aesthetics: A Handbook for Scenery Management. AH-701.

USDA Forest Service. 2002. Scenic Byways: A Design Guide for Roadside Improvements.

USDA Forest Service. 2006. Accessibility Guidebook for Outdoor Recreation and Trails. Publication number 0623-2801-MTDC.

USDA Forest Service. 2010. Discover the Forest campaign. http://www.discovertheforest.org/index.php.

USDOT Federal Transit Administration. 2010. Transit in Parks Program (5230). http://www.fta.dot.gov/funding/grants/grants_financing_6106.html.

Washington State Parks. 2008. No Child Left Inside campaign. http://www.parks.wa.gov/NoChildLeftInside/.

Additional Resources

Anderson, Linda. 2005. Highway Crossing Structures for Metropolitan Portland's Wildlife. Portland State University. Portland, OR.

Bates, Ken. 2003. Design of Road Culverts for Fish Passage. Washington Dept. of Fish and Wildlife.

Cosgrove and Orrick. 2004. The Future that Never Was: Lessons from Visions of Transportation.

FHWA. 2008. Consistency In Safety-Related Design Decisions on Federal Lands Highway Jobs. FHWA Pub. No.

FHWA and USFWS. 2005. Guidance on the Federal Lands Highway Refuge Roads Program.

Green Infrastructure Wiki. 2010. Access at: http://www.greeninfrastructurewiki.com/.

Iowa State University Dept. of Civil Engineering and Minnesota Dept. of Transportation. 2005. Economics of Upgrading an Aggregate Road.

Marriott, Paul Daniel. 1998. Saving Historic Roads: Design and Policy Guidelines. Preservation Press and John Wiley & Sons, Inc.

Maryland National Capital Park and Planning Commission and The Montgomery County Department of Parks and Planning. 1996. Rustic Roads Functional Master Plan.

National Park Service. 1984. Park Road Standards.

Otto, Sandra. 2000. "Environmentally Sensitive Design of Transportation Facilities." In Journal of Transportation Engineering, 126(5) Sept/Oct, pp. 363-366.

Regional Road Maintenance Technical Working Group (Washington) Regional Road Maintenance Endangered Species Act Program Guidelines.

Robson, Sara, and James Kingery. 2006. Idaho Native Plants for Roadside Restoration and Revegetation Programs. Idaho Transportation Department.

USFWS. 2008. Project List Meeting Report: Long-Range Transportation Plan for the US Fish and Wildlife Service Lands in Region 1. Report prepared by PBS&J.

Appendix B: Glossary

Abbreviations

ABA Architectural Barriers Act

ABAAS Architectural Barriers Act Accessibility Standards

ADA Americans with Disabilities Act

ASCE American Society of Civil Engineers

BGEPA Bald and Golden Eagle Protection Act

BLM Bureau of Land Management

CCP Comprehensive Conservation Plan

CFR Code of Federal Regulations

DCR Division of Diversity and Civil Rights (FWS Region 1)

EE Environmental Education

ES Ecological Services

ESA Endangered Species Act

FHWA Federal Highway Administration

FWCA Fish and Wildlife Coordination Act

FWS U.S. Fish & Wildlife Service (also Service, USFWS)

GIS Geographic Information System

LID low impact development

LOS level of service

LRTP Long Range Transportation Plan

MBTA Migratory Bird Treaty Act

NDS natural drainage system

NEPA National Environmental Policy Act

NWR National Wildlife Refuge (also Refuge).

NWRS National Wildlife Refuge System

ODOT Oregon Department of Transportation

R1 Region 1 of the FWS (HI, ID, OR, WA, Pacific Islands)

ROW Right-of-way

SAMMS Service Asset Maintenance Management System

USDA United States Department of Agriculture

USFS United States Forest Service

VMT Vehicle miles traveled

WDFW Washington State Department of Fish and Wildlife

WSDOT Washington State Department of Transportation

WSPRC Washington State Parks and Recreation Commission

WVC Wildlife-vehicle collisions

Definitions

Adaptive Management. Refers to a process in which policy decisions are implemented within a framework of scientifically driven experiments to test predictions and assumptions inherent in management plan. Analysis of results help managers determine whether current management should continue as is or whether it should be modified to achieve desired conditions.

Alternative. Alternatives are different means of accomplishing Refuge purposes and goals and contributing to the System mission (draft Service Manual 602 FW 1.5). The no action alternative is the manner in which the refuge is currently managed, while the action alternatives are all other alternatives.

Bald and Golden Eagle Protection Act (Federal). This law makes it illegal for anyone to take (as defined therein) a bald or golden eagle, or their parts, nests, or eggs except as authorized under a permit. Since this law extends protection to eagle nests, it may come into play during the construction and maintenance of transportation infrastructure.

Biological Diversity (also Biodiversity). The variety of life and its processes, including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur (USFWS Manual 052 FW 1. 12B). The System's focus is on indigenous species, biotic communities, and ecological processes.

Biological Integrity. Biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities (NWRS Biological integrity policy).

Compatible Use. A wildlife-dependent recreational use or any other use of a Refuge that, in the sound professional judgment of the Director, will not materially interfere with or detract from the fulfillment of the Mission of the System or the purposes of the refuge (Service Manual 603 FW 3.6). A compatibility determination supports the selection of compatible uses and identifies stipulations or limits necessary to ensure compatibility.

Comprehensive Conservation Plan. A document that describes the desired future conditions of the Refuge, and provides long-range guidance and management direction for the Refuge manager to accomplish the purposes of the refuge, contribute to the mission of the System, and to meet other relevant mandates (Service Manual 602 FW 1.5).

Contaminants (also Environmental Contaminants). Chemicals present at levels greater than those naturally occurring in the environment resulting from anthropogenic or natural processes that potentially result in changes to biota at any ecological level (USGS, assessing EC threats to lands managed by USFWS). Pollutants that degrade other resources upon contact or mixing (Adapted from Webster's II).

Cooperative Agreement. This is a simple habitat protection action, in which no property rights are acquired. An agreement is usually long term but can be modified by either party. They are most effective in establishing multiple use management of land. An example would be a wildlife agreement on a Corps reservoir.

Context Sensitive Solutions (CSS). A theoretical and practical approach to transportation decision-making and design that takes into consideration the communities and lands through which streets, roads, and highways pass ("the context"). CSS seeks to balance the need to move vehicles and other transportation modes efficiently and safely with other desirable outcomes, including historic preservation, environmental goals such as wildlife and habitat conservation and the creation of vital public spaces.

Critical Habitat. Areas that are essential to the conservation of ESA listed species.

Cultural Resources. The physical remains, objects, historic records and traditional lifeways that connect us to our nation's past (USFWS, Considering Cultural Resources).

Disturbance. Significant alteration of habitat structure or composition. May be natural (e.g. fire) or human-caused events (e.g. aircraft overflights).

Ecosystem. A dynamic and interrelating complex of plant and animal communities and their associated non-living environment.

Ecosystem Management. Management of natural resources using system-wide concepts to ensure that all plants and animals in ecosystems are maintained at viable levels in native habitats and that basic ecosystem processes are perpetuated indefinitely.

Environmental Assessment. A concise public document, prepared in compliance with the National Environmental Policy Act (NEPA), that briefly discusses the purpose and need for an action, alternatives to such action, and provides sufficient evidence and analysis of impacts to determine whether an environmental impact statement must be prepared, or a finding of no significant impact can be issued (40 CFR 1508.9).

Endangered Species Act (Federal). The purpose of the ESA is to protect and recover endangered and threatened species and the ecosystems upon which they depend. Under the ESA, species may be listed as either endangered or threatened and critical habitat may be designated.

ESA Listed Species. A plant or animal species listed under the Endangered Species Act that is in danger of extinction throughout all or a significant portion of its range (endangered) or likely to become so within the foreseeable future (threatened).

Environmental Education Facility. A building or site with one or more classrooms or teaching areas and environmental education resources to accommodate groups of students.

Fish and Wildlife Coordination Act (Federal). This law provides the basic authority for the FWS to evaluate impacts to all fish and wildlife from proposed water resource development projects. This law may come into play for transportation projects that involve effects to a water body(ies).

Gap Analysis. Analysis done to identify and map elements of biodiversity that are not adequately represented in the nation's network of reserves. It provides an overview of the distribution and conservation status of several components of biodiversity, with an emphasis on vegetation and terrestrial vertebrates (Cassidy et al.1997).

Goal. Descriptive, open-ended and often broad statement of desired future conditions that conveys a purpose but does not define measurable units (Draft Service Manual 620 FW 1.5).

Green infrastructure. A concept and approach in which natural assets are managed and/or designed to provide multiple ecosystem and human services, including services such as stormwater management, flood prevention, carbon sequestration, and habitat. Green infrastructure includes natural drainage systems (NDS) and may be applied as a tool in achieving low impact development (LID).

Habitat. Suite of existing environmental conditions required by an organism for survival and reproduction. The place where an organism typically lives.

Habitat Connectivity (Also Landscape Connectivity). The arrangement of habitats that allows organisms and ecological processes to move across the landscape; patches of similar habitats are either close together or linked by corridors of appropriate vegetation/habitat. The opposite of fragmentation (Turnbull NWR Habitat Management Plan).

Habitat Management Plan. A plan that guides Refuge activities related to the maintenance, restoration, and enhancement of habitats for the benefit of wildlife, fish, and plant populations.

Habitat Restoration. Management emphasis designed to move ecosystems to desired conditions and processes and/or to healthy ecosystems.

Historic Conditions. Composition, structure and functioning of ecosystems resulting from natural processes that we believe, based on sound professional judgment, were present prior to substantial human related changes to the landscape (NWRS Biological integrity policy).

Hydrologic influence. Having an effect on water quality and quantity.

Hydrology. A science dealing with the properties, distribution and circulation of water on and below the earth's surface and in the atmosphere (yourdictionary.com).

Indicator. Something that serves as a sign or symptom (Webster's II).

Interpretation. A teaching technique that combines factual information with stimulating explanation (yourdictionary.com). Frequently used to help people understand natural and cultural resources.

Interpretive Trail. A trail with informative signs, numbered posts that refer to information in a brochure, or where guided talks are conducted for the purpose of providing factual information and stimulating explanations of what visitors see, hear, feel, or otherwise experience while on the trail.

Landform. A natural feature of a land surface (yourdictionary.com).

Landscape Linkages. Landscape features linking areas of similar habitat. Plants and smaller animals are able to use landscape linkages to move between larger landscape blocks over a period of generations.

Landscape Ecology. The science and study of the relationship between spatial pattern and ecological processes on a wide variety of landscape scales and organizational levels.

Low Impact Development (LID). A stormwater management strategy that emphasizes conservation and use of existing natural site features integrated with distributed, small-scale stormwater controls to more closely mimic natural hydrologic patterns. (LID Guidance Manual for Puget Sound).

Maintenance. The upkeep of constructed facilities, structures and capitalized equipment necessary to realize the originally anticipated useful life of a fixed asset. Maintenance includes preventative maintenance; cyclic maintenance; repairs; replacement of parts, components, or items of equipment, periodic condition assessment; periodic inspections, adjustment, lubrication and cleaning (non-janitorial) of equipment; painting, resurfacing, rehabilitation; special safety inspections; and other actions to assure continuing service and to prevent breakdown.

Mesh Size. The average area or diameter of the polygons enclosed by a road network, as in a fishnet; it is proportional to road density but focuses on the enclosed parcels rather than the roads (Forman 2003).

Migratory Bird Treaty Act (Federal). This law makes it illegal for anyone to take any migratory bird, or the parts, nests, or eggs of migratory birds, except under the terms of a valid permit issued pursuant to federal regulations. This law can come into play during the maintenance and removal of transportation infrastructure as well as during the construction of new structures.

Mission Statement. Succinct statement of a unit's purpose and reason for being.

Monitoring. The process of collecting information to track changes of selected parameters over time.

National Environmental Policy Act of 1969 (NEPA). Requires all Federal agencies, including the Service, to examine the environmental impacts of their actions, incorporate environmental information, and use public participation in the planning and implementation of all actions. Federal agencies must integrate NEPA with other planning requirements, and prepare appropriate NEPA documents to facilitate better environmental decision making (from 40 CFR 1500).

National Register of Historic Places. The Nation's master inventory of known historic properties administered by the National Park Service. Includes buildings, structures, sites, objects and districts that possess historic, architectural, engineering, archeological, or cultural significance at the national, state and local levels.

National Wildlife Refuge (also Refuge). A designated area of land, water, or an interest in land or water within the System.

National Wildlife Refuge System (NWRS; also System). Various categories of areas administered by the Secretary of the Interior for the conservation of fish and wildlife, including species threatened with extinction; all lands, waters and interests therein administered by the Secretary as wildlife refuges; areas for the protection and conservation of fish and wildlife that are threatened with extinction; wildlife ranges; games ranges; wildlife management areas; or waterfowl production areas.

Native. With respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem (NWRS Biological integrity policy).

Natural Drainage System (NDS). A set of stormwater management features using plants and specialized soils that slow and infiltrate stormwater and can help remove pollutants through filtration and bioremediation. These features—such as open, vegetated swales, stormwater cascades and small rain gardens or wet ponds—mimic or restore natural functions impeded by development. In contrast to pipes and vaults, these systems increase in functional value over time.

Non-Consumptive Recreation. Recreational activities that do not involve harvest, removal or consumption of fish, wildlife or other natural resources.

Noxious Weed. A plant species designated by Federal or State law as generally possessing one or more of the following characteristics: aggressive or difficult to manage; parasitic; a carrier or host of serious insect or disease; or non-native, new, or not common to the United States, according to the Federal Noxious Weed Act (PL 93-639), a noxious weed is one that causes disease or has adverse effects on man or his environment and therefore is detrimental to the agriculture and commerce of the United States and to the public health.

Nutrient Loading. The presence of nutrients, such as nitrogen and phosphorus, in waterways insufficient amounts to cause effects such as algal blooms and oxygen depletion, with potentially lethal effects on fish and wildlife species.

Operations. Activities related to the normal performance of the functions for which a facility or item of equipment is intended to be used. Costs such as utilities (electricity, water, sewage) fuel, janitorial services, window cleaning, rodent and pest control, upkeep of grounds, vehicle rentals, waste management and personnel costs for operating staff are generally included within the scope of operations.

Outreach. The process of providing information to the public on a specific issue through the use of the media, printed materials and presentations.

Plant Community. An assemblage of plant species unique in its composition that occurs in particular locations, under particular influences, which reflect or integrate the environmental influences on the site, such as soils, temperature, elevation, solar radiation, slope, aspect and rainfall.

Preferred Alternative. This is the alternative determined (by the decision maker) to best achieve the Refuge purpose, vision and goals; that best contributes to the System mission and addresses the significant issues; and that is consistent with principles of sound fish and wildlife management.

Priority Public Uses. Hunting, fishing, wildlife observation and photography, environmental education and interpretation were identified by the National Wildlife Refuge system Improvement Act of 1997 as the six ("Big Six") priority public uses of the National Wildlife Refuge System.

Public. Individuals, organizations, and groups outside the planning team, including officials of Federal, State, and local government agencies, Indian tribes and foreign nations. It includes those who may or may not have indicated an interest in Service issues and those who may be affected by Service decisions.

Refuge Purpose(s). The purpose(s) specified in or derived from the law, proclamation, executive order, agreement, public land order, donation document, or administrative memorandum establishing, authorizing, or expanding a refuge, a refuge unit, or refuge subunit (Draft Service Manual 602 EW 1.5).

Restoration. The act of bringing back to a former or original condition (Webster's II).

Riparian. An area or habitat that is transitional from terrestrial to aquatic ecosystems, including streams, lakes, wet areas, and adjacent plant communities and their associated soils which have free water at or near the surface; an area whose components are directly or indirectly attributed to the influence of water; and of or relating to a river. Specifically applied to ecology, "riparian" describes the land immediately adjoining and directly influenced by streams. For example, riparian vegetation includes any and all plant life growing on the land adjoining a stream and directly influenced by the stream.

Road Density. The average total road length per unit area of landscape (i.e. kilometers per square km, or miles per square mile) (Forman 2003).

Road-Effect Zone. The zone of influence of a roadway into the surrounding areas. Distance depends upon the type of effect and site conditions (Forman 2003; see graphic, p. 308).

Roadway. The suite of typical improvements associated with a vehicle-focused transportation project. This extends from the centerline of an existing or proposed road outward, to include associated infrastructure components such as paving, utilities, grading and planting. Roadway also refers here to other facilities and infrastructure commonly associated with vehicular transportation, such as parking, visitor contact facilities and pullouts. From an ecological perspective, the roadway conceptually includes impacts such as habitat fragmentation, habitat disturbance, pollution, and aquatic and terrestrial species conflicts.

Strategy. A specific action, tool, or technique or combination of actions, tools, and techniques used to meet unit objectives (Service Manual 602 FW 1.5).

Viewpoint. A designated point that provides an opportunity to see wildlife or habitats of interest. The point may or may not be "supported" with an interpretive sign. Usually the viewpoint is supported by a pullout or a parking area.

Visitor Center. A building with staff that provides visitors with interpretation, education and general information about the natural and cultural resources of the Refuge and the local area.

Visitor Contact Point or Center. A kiosk or other location where visitors may go to learn about Refuge resources, facilities, trails, etc.

Vision Statement. A concise statement of the desired future condition of the planning unit, based primarily upon the System mission, specific Refuge purposes and other relevant mandates (Service Manual 602 FW 1.5).

Watershed. The region or area drained by a river system or other body of water (Webster's II).

Wetlands. Transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water at some time each year (Service Manual 660 FW 2).

- Permanent wetland - a wetland basin or portion of a basin that is covered with water throughout the year in all years except extreme drought. Typically, the basin bottom is vegetated with submerged aquatic plant species, including milfoil, coontail and pondweeds.
- Semi-permanent wetland - a wetland basin or portion of a basin where surface water persists throughout the growing season of most years. Typical vegetation is composed of cattails and bulrushes.
- Seasonal wetland - a wetland basin or portion of a basin where surface water is present in the early part of the growing season but is absent by the end of the season in most years. Typically vegetated with sedges, rushes, spikerushes or burreed.

Wildlife-Dependent Recreation. Hunting, fishing, wildlife observation and photography, environmental education and interpretation. These are also referred to as the priority public uses of the National Wildlife Refuge System or "Big Six".

U.S. Department of the Interior
U.S. Fish & Wildlife Service

http://www.fws.gov

August 2012