Title
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Conserving the Connections: A Nationwide Inventory of State-Based Habitat Connectivity Analysis

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Abstract: Habitat fragmentation is among the most serious threats to species and biological diversity. Highways can divide wildlife habitat into smaller patches, reducing or prohibiting necessary wildlife movement between core habitat areas for foraging, mating, and other life functions. Defenders of Wildlife reviewed all 50 states to identify those that are working to address habitat connectivity in the context of transportation planning. The goal of these plans is to facilitate interagency cooperation in order to enhance wildlife connectivity while continuing to expand and improve transportation infrastructure. We found that eleven states have completed, or are currently completing, a statewide habitat connectivity analysis, which will allow them to incorporate habitat wildlife and linkage needs into highway project planning. An additional eight other states are working on connectivity issues but on a regional scale or without a direct link to transportation planning. This analysis provides a snapshot of the status of connectivity planning across the nation. By comparing lessons learned and successful methods, states considering connectivity planning can draw from the experience of others, while states with existing plans can use this information to improve as plans are updated.

Introduction

As highways and associated development continue to expand, many wildlife species must face the difficult challenge of crossing unnatural and often dangerous environments, particularly highways, as they attempt to move between habitat areas. A new or expanded highway through natural areas will destroy, degrade or fragment ecologically important habitats. Human-caused habitat fragmentation is the isolation of wildlife habitat caused by manmade barriers like highways disrupting the natural landscape (Gore et al. 2001). Fragmentation is among the most major threats to the health and viability of many species, as well as to biodiversity as a whole, and contributes to the loss of habitat connectivity. Habitat connectivity is defined as “the degree to which the landscape facilitates animal movement and other ecological flows” (Forman, et al. 2003).

In recent years, many state departments of transportation (DOTs) and resource agencies, as well as federal agencies, have recognized the severity of the impacts of highways on habitat and wildlife populations. Some states have taken steps beyond required federal regulations by creating state-specific habitat connectivity analyses. These analyses identify the most important habitat areas and wildlife movement corridors across the state as they intersect with existing and proposed highways. By integrating wildlife movement patterns, protected natural areas, and transportation infrastructure into one statewide plan, states can use this data to begin to reverse the trend of fragmented habitats and reduced wildlife populations. As of spring 2007, eleven states have created, or are in the process of creating, a statewide habitat connectivity analysis by identifying the most important natural linkage areas which connect core habitat for vulnerable wildlife, and integrating this data into transportation planning. Eight other states profiled here are taking steps to improve connectivity, but are not considered a full connectivity plans as they either do not encompass the entire state, or the analysis is not integrated with transportation planning. In total, nineteen plans are profiled.

Where the information is available, Defenders of Wildlife has examined and inventoried the features of each of the existing and in-progress plans, such as sponsoring organizations, methodology, data sources, legislative support, funding, action, and implementation. By inventorying each analysis, we can compare plans and successful methods, as well as share data. Those states which have yet to conduct their own analysis can draw from the collective knowledge and experience of the currently participating states in order to create their own successful connectivity plan. States which have already conducted analyses can examine the successes and conclusions of others, which may assist in maximizing the efficacy of existing plans as they are implemented and updated over time.

Some of the plans discussed are currently being organized or analyzed at the time that this inventory was conducted and written. As such, some of these plans, in particular those identified as in progress, will warrant being revisited in coming years.

Habitat Connectivity

Connectivity can be defined as the “...degree to which landscape characteristics facilitate or impede the ability of an organism to move within a landscape and acquire resources” (Fahrig and Merriam 1985). A loss of connectivity due to human-induced separation of natural areas is associated with restricted or severed wildlife movement between habitats. These isolated patches of habitat often cannot support large numbers or many kinds of species if movement corridors connecting these areas are fragmented by a highway or other development. Increasing connectivity between core habitat patches can help alleviate this problem. According to Bennett, 2004, reconnecting these patches of habitat will assist local wildlife population viability in five distinct ways:

1. It allows individual animals access to a larger area of habitat – for example, to forage, to facilitate the dispersal of juveniles or to encourage the recolonization of ‘empty’ habitat patches.
2. It facilitates seasonal migration.
3. It permits genetic exchange with other local populations of the same species.
4. It offers opportunities for individuals to move away from a habitat that is degrading or from an area under threat.
5. It secures the integrity of physical environmental processes such as periodic flooding that are vital to the requirements of certain species. (Bennett 2004)

More broadly, Bennett is referring to the needs of species in order to survive and remain healthy such that biodiversity may be maintained. Biodiversity is the variety of living organisms, species, habitats and ecosystems which comprise life on Earth, as well as all the natural processes which occur between species and within these systems (Meffe, et al. 1997). Allowing for species diversity to be maintained in the face of increased human development is certainly a challenge, but is vital for the long-term sustained ecological integrity of natural areas and processes upon which both humans and wildlife rely. Reconnecting important habitat otherwise fragmented by development such as highways is a key step in preserving biodiversity and essential ecological processes.

Figure 1. Representation of a wildlife corridor fragmented by a highway (Donaldson and Weber 2006).

Reconnecting natural landscapes fragmented by a highway may be accomplished through a combination of preserving core habitat areas and the natural corridors or linkages connecting them. Beier and Noss (1998) conducted an extensive review of literature on habitat corridors, and concluded that corridors indeed provide landscape connectivity when core habitats are fragmented by development such as highways. They define the term corridor as “a linear habitat...that connects two or more larger blocks of habitat and that is proposed for conservation on the grounds that it will enhance or maintain the viability of specific wildlife populations in the habitat blocks” (Beier and Noss, 1998). While a corridor is considered a travel route for wildlife, a linkage may be described as a travel route which can also support low density wildlife (Servheen et al. 2003). However, for the sake of this inventory, both terms may refer to the same basic idea of natural land and structural connections which serve to bridge fragmented core habitats.

If a natural land corridor is disturbed or destroyed, engineering manmade wildlife crossing structures to traverse a highway may also partially alleviate the effects of fragmentation. These structures can include under and overpasses, extending bridges to allow passage beneath them, and installing widened aquatic culverts for both fish and other wildlife passage. Some of these structures have been extensively studied and their successes documented, such as underpasses in Canada’s Banff National Park (Clevenger and Waltho 2000) and suggested practices discussed (Forman et al. 2003, West 2006).

Habitat Connectivity Analyses

More than simply identifying and conserving valuable habitat areas, state-based habitat connectivity analyses, also sometimes referred to as wildlife linkage analyses or other similar phrases, stress the importance of permeability across landscapes and through highway systems. Properly considered and implemented habitat connectivity analyses identify ecologically intact core habitats in need of preservation or restoration, and also pinpoint wildlife movement corridors as they intersect with highways. Connectivity analyses identify and prioritize those areas most important for a variety of wildlife conservation needs and enables DOTs, resource agencies, conservation partners, and others to make better decisions regarding transportation planning, design and mitigation. Ultimately, data can then be used to reduce animal-vehicle collisions, thus improving the safety of the traveling public and the viability of wildlife (Austin et al. 2006). Producing statewide or regional plans for habitat connectivity is an essential component to the development of a comprehensive system of conserved corridors and effective wildlife crossing structures.

The mapping of ecologically significant areas is certainly not a new practice. Many states have implemented various plans and programs to conserve valuable habitat and green areas. However, the creation of statewide habitat connectivity plans which addresses wildlife movement in the context of highways is a fairly recent development, garnering political traction in the 1990s. Florida, one of the first states to address the issue of connectivity as it relates to
highways, initiated a study in 1990 to map the biologically rich areas in the state. The resulting 1994 report was titled “Closing the Gaps in Florida’s Wildlife Habitat Conservation System”. The Florida Game and Fresh Water Fish Commission mapped the state’s land cover and wildlife habitat needs, while the Florida DOT assisted in creating a wildlife occurrence geographic information system (GIS) database (AASHTO NCHRP 25-25 2004). Although “Closing the Gaps” was not specifically created in order to integrate transportation and conservation planning, it was the first iteration in a series of Florida’s statewide efforts to address wildlife linkage needs. This early effort likely was initiated due to a myriad of factors, including Florida’s well-studied biological diversity, rapid land and highway development in recent decades, and political will to have more control over growth patterns and wildlife health.

As the creation of these plans is not mandated by law, each was produced a little differently. Of the nineteen states inventoried here, most have taken different approaches to identifying wildlife connectivity threats, formulating, and then implementing connectivity plans. Many of these states’ efforts are collaboratively negotiated with different partners, while some have made an effort to consult with a combination of state and federal agencies, universities, nonprofit organizations, and the private sector. These plans are produced with different methodologies and partners, with varying budgets and political support, and are in varying stages of adoption and implementation.

Despite the multiple avenues by which a state may go about producing a connectivity analysis, a fully comprehensive habitat connectivity plan will likely contain a combination of some important elements:

- aerial photos
- land ownership maps
- vegetation maps
- topographic maps
- wildlife habitat or range maps
- Monitoring wildlife behavior
- Roadkill information
- Existing and planning highways (Ruediger 2007)

Inclusion of these elements will provide planners with access to a wide range of data with defined ecological priorities paired with fairly spatially precise maps.

Planning connectivity on a statewide basis as it relates to highway infrastructure often can help participating states conserve not only natural resources, but time and money as well. Instead of constructing wildlife crossings and several miles of exclusionary fencing on a project-by-project basis, by using a habitat connectivity plan agencies can be assured they are conserving and mitigating in areas most in need of connectivity. Statewide connectivity mapping allows states to make the most fiscally sound mitigation investments with their limited dollars, and to avoid developing altogether those areas most critical for wildlife habitat. Some states, such as Vermont and Virginia, also boast that their connectivity plans will allow for a more efficient permit review process, as planning will provide a stronger degree of predictability than currently available (Austin et al. 2006, Donaldson and Weber 2006).

![Figure 2. A map from Utah’s statewide connectivity plan with priority highway segments (West 2006).](image-url)
States would also benefit from integrating connectivity analyses into their respective State Wildlife Action Plan (SWAP). Each SWAP is a comprehensive wildlife conservation plan that addresses species in greatest conservation need and their major threats, as well as proposed conservation actions to address these threats. Allowing for wildlife migration and dispersal through the promotion and support of habitat connectivity is a major component in conserving species sited in the SWAPs. If each SWAP, which must be revised every ten years, adopts the findings and priorities of statewide habitat connectivity plans, states would possess a fully integrated plan addressing vulnerable species, threats, connectivity through highways, and actions to be implemented.

This inventory examines eleven statewide habitat connectivity analyses. In a separate section, eight more states are profiled. These eight plans deal with reconnecting natural areas for wildlife; however, they are not considered statewide habitat connectivity plans because they are one or more of the following:

1. Analysis does not cover the entire state or the connectivity analyses is project-specific
2. Analysis is connectivity-oriented but not integrated with transportation plans
3. Connectivity is being integrated into highway projects, but without a statewide plan

Many other states not examined in this inventory have also made significant efforts to reduce or even reverse the trend of habitat fragmentation. However, this inventory examines comprehensive efforts for habitat connectivity and wildlife linkages in relation to highways, or at a minimum, reconnecting fragmented habitats. Proactive and successful state and city efforts such as Washington DC’s Green Infrastructure program, Florida’s Efficient Transportation Decision Making tool, New Jersey’s Landscape Project, or other various open space programs were considered but could not be included in this assessment as interlinked habitat and highway connectivity were not their primary focus.

Below is an inventoried summary of each statewide habitat connectivity plan currently completed or in progress.

**Statewide Habitat Connectivity Analyses**

**Alaska** (Completed)

**Description:** One of the first states to address this issue, FHWA Alaska Division and the Alaska Department of Transportation and Public Facilities received a grant from FHWA Headquarters in 1992 to fund a habitat connectivity study. However the study did not take place until 2003.

**Plan Name:** Alaska Habitat Connectivity Project

**Year:** 2003 (research), 2004 (published)

**Partners:** FHWA Alaska Division, Alaska Department of Transportation and Public Facilities, FHWA, Environment and Natural Resources Institute of the University of Alaska Anchorage

**Process:** Five months of research, and two partnership workshops to share data and identify species of concern.

**Contents:** A “toolbox” of information that may be used by the Alaska Department of Transportation & Public Facilities to assess the effects of existing and proposed roads on habitat quality and connectivity” (DiBari 2004). More specific information is not readily available.

**Application:** No evidence that Alaskan agencies have made a concerted effort to implement.

**Website:** http://www.akhcp.org (website currently offline)

**Contact:** Alaska Department of Transportation and Public Facilities

**Arizona** (Completed)

**Description:** The Arizona Wildlife Linkages Workgroup was built upon the cooperative 2002-2006 partnership between FHWA, Arizona DOT, Arizona Game and Fish Department and the U.S. Forest Service to study elk-movement across State Route 260, which resulted in the construction of a series of wildlife crossing structures. (FHWA Exemplary Ecosystems Initiative 2003). The Workgroup then took the lead in producing the Wildlife Linkages Assessment.

**Plan Name:** Arizona’s Wildlife Linkages Assessment

**Year:** 2003 (Arizona Wildlife Linkages Workgroup formed), December 2006 (Assessment published)

**Partners:** Arizona DOT, Arizona Game and Fish Department, Bureau of Land Management, FHWA, U.S. Forest Service, U.S. Fish and Wildlife Service, Northern Arizona University, Wildlands Project, Sky Island Alliance

**Process:** In April, 2004 the Wildlife Linkages Workgroup organized and facilitated the Missing Linkages Workshop. More than 100 biologists and planners attended the workshop to identify “missing linkages” (critical connectivity areas). Subsequent workshops expanded and refined data and maps.

**Contents:** Identifies, prioritizes, and maps over 150 wildlife linkages.
Application: As the website states: “This non-binding document and map will serve as an informational resource to planners and engineers, providing suggestions for the incorporation of these linkage zones into their management planning to address wildlife connectivity at an early stage of the process”.

Website: http://www.azdot.gov/Highways/OES/AZ_WildLife_Linkages/assessment.asp

Contact: Bruce D. Eilerts, Arizona Department of Transportation  
Siobhan E. Nordhaugen, Arizona Department of Transportation  
Ray Schweinsburg, Arizona Game and Fish Department

**Figure 3. Arizona’s Wildlife Linkages Assessment (Arizona DOT).**

**Colorado (Completed)**

Description: Using a FHWA grant, Colorado produced a statewide habitat connectivity plan. The non-profit Southern Rockies Ecosystem Project was instrumental in bringing partners onboard in order to create the Linking Colorado’s Landscapes connectivity analysis. Linking Colorado’s Landscapes has not been adopted in its entirety by the state, nor has every key state agency joined as a partner in determining priority areas, notably the Colorado Division of Wildlife.

Plan Name: Linking Colorado’s Landscapes

Year: 2003 (partnership began), 2006 (publication of Linking Colorado’s Landscapes)

Partners: Southern Rockies Ecosystem Project, Colorado DOT, FHWA, The Nature Conservancy, Colorado State University

Process: Southern Rockies Ecosystem Project hosted a series of interagency workshops across the state to identify priority wildlife linkages. Colorado State University then created maps overlaying landscape characteristics, wildlife movement patterns, preferred habitats, and Colorado DOT animal-vehicle collision data and transportation planning data (Southern Rockies Ecosystem Project 2006).

Contents: 176 identified wildlife linkages across the state, with 23 linkages designated as high priority for both wildlife and safety.

Application: Colorado DOT is beginning to implement some of linkage analysis’ findings, identifying 13 wildlife crossing areas on I-70.

Website: http://www.restoretherockies.org/linkages.htm

Contact: Julia Kintsch, Southern Rockies Ecosystem Project
Idaho (In Progress)

Description: For several years, Idaho Transportation Department Region 6 has been conducting a linkage analysis and building a roadkill database under a special FHWA grant. Idaho has since received FHWA grant money to conduct a habitat connectivity analysis on a statewide scale (Tim Cramer, personal communication).

Plan Name: Currently unnamed

Year: In Progress 2006-2007


Process: Currently partners are surveying existing databases and meeting with local interested parties as well as state, federal, and local governments. The plan will also include many sources of data, including aerial photos, U.S. Geological Survey maps, climate, local zoning, development changes, Census data, Gap Analysis project data, wetland inventories, games census data, fire records, and more (Kim Just, personal communication).

Contents: Unknown

Application: Plan will be used to draw conclusions for what types of procedures and structures will be most effective for wildlife mobility in particular areas.

Website: N/A

Contact: Kim Just, Idaho Transportation Department

Maine (In Progress)

Description: In early 2006, Maine formed a working group to discuss the creation of a statewide habitat connectivity plan which would stem from the locally-oriented Beginning with Habitat Program.

Plan Name: Beginning with Habitat Connectivity Project

Year: In Progress

Partners: Maine Department of Conservation, Maine Department of Inland Fisheries and Wildlife, Maine Department of Transportation, Maine State Planning Office, Maine Department of Environmental Protection, U.S. Fish and Wildlife Service, The Nature Conservancy, Maine Audubon, and others

Process: A two-tiered approach: mapping core habitats and the natural areas connecting them on a broad landscape level by consulting habitat permeability models; identify and monitor specific species and track their habitat use and movement patterns. Once modeling is complete, Beginning with Habitat will implement these connectivity plans in several pilot towns (Steve Walker, personal communication).

Contents: The project is proposed to include a protocol to analyze connectivity between habitat areas, develop connectivity maps, conduct a demonstrative case study for local planners.
Application: “To ensure wildlife habitat connectivity in Maine by improving the knowledge and tools available to local planners through the Beginning with Habitat program” (Department of Inland Fisheries and Wildlife, and Department of Conservation).

Website: http://www.beginningwithhabitat.org/

Contact: Steve Walker, Maine Department of Inland Fisheries and Wildlife

New Hampshire (In Progress)

Description: New Hampshire DOT is currently engaged in a pilot project with partners to develop a predictive model for determining wildlife movement which can be applied across the state. Currently only a pilot project, the goal is to expand the model into a developed GIS map of habitats frequented by wildlife and the areas where they most often cross highways (AASHTO NCHRP 25-25 2004).

Plan Name: Currently unnamed

Year: In Progress

Partners: New Hampshire DOT, New Hampshire Fish and Game Department, New Hampshire Audubon Society, others

Process: NHDOT has contacted Fish & Game Conservation Officers, local road agents, conservation commission members, and NHDOT maintenance patrol foremen to collect anecdotal evidence of crossings and road kills and record that information in a database. Partners will then compare this field data with the predictive habitat and wildlife crossing modeling that the New Hampshire Audubon Society produced.

Contents: Plans call for the development of a GIS layer of important wildlife habitat areas and locations of frequent wildlife crossings to be used as a planning and design tool for future projects (AASHTO NCHRP 25-25 2004).

Application: The New Hampshire State Wildlife Action Plan calls for a statewide landscape connectivity analysis / mapping wildlife corridors and buffers. The project described here may fulfill this need when completed.

Website: N/A

Contact: New Hampshire DOT

New Mexico (Completed)

Description: In February 2003 the New Mexico legislature passed House Joint Memorial 3, which asked officials to determine mitigation strategies to reduce vehicle-wildlife collisions. The result of this directive was the June 2003 two-day Critical Mass workshop, which brought together about 100 New Mexico DOT employees, private consultants, federal and state biologists, and conservation groups. (MacCarter 2003-2004).

Plan Name: Critical Mass

Year: June 2003 (Critical Mass workshop held)

Partners: New Mexico DOT, New Mexico Department of Game and Fish, federal and state biologists, Wildlands Project, Tijeras Canyon Safe Passage Coalition, private consultants, others

Process: In June 2003 New Mexico Department of Game and Fish and New Mexico DOT hosted a two-day Critical Mass workshop to identify and prioritize wildlife linkages most threatened by highways across the state. Among others, Tijeras Canyon was identified as a high priority linkage. Following this workshop, the conservation organizations The Wildlands Projects and Tijeras Canyon Safe Passage Coalition have partnered with the state to begin implementing priority wildlife crossing structures.

Contents: Identified and prioritized wildlife linkage areas as they cross highways.

Application: Critical Mass’s findings have not been implemented into transportation planning with regularity. New Mexico still mainly deals with wildlife linkage and habitat connectivity issues on a project-by-project basis, such as elk-proof fencing on U.S. 64 (Mark Watson, personal communication).

Website: http://wildlife.state.nm.us/conservation/criticalmass/index.htm http://www.safepassagecoalition.org/

Contact: New Mexico Department of Game and Fish
Oregon (In Progress)

Description: This in progress statewide habitat connectivity plan will identify potential wildlife linkage areas by studying the movement needs of a number of focal species. These areas will then be evaluated and prioritized based upon the availability of conservation opportunities and the needs of the wildlife.

Plan Name: Oregon Wildlife Movement Strategy
Year: In Progress, scheduled for completion likely early 2008
Partners: Oregon Department of Fish and Wildlife, Oregon DOT, U.S. Fish and Wildlife Service, Bureau of Land Management, others
Process: Agency experts will identify and begin to prioritize linkages. During the summer and fall of 2007, Oregon Department of Fish and Wildlife and partners will hold a series of workshops to bring together biologists, engineers, land managers and planners to discuss the prioritized linkages and how the Movement Strategy’s findings will be incorporated into their work. The state is also evaluating wildlife collision incidents in order to map hotspot areas, which will then be included in the linkage assessment (Mindy Trask and Audrey Hatch, personal communication).

Contents: The Oregon Wildlife Movement Strategy will provide prioritized wildlife linkage information, including mapping of hotspots.

Application: Can be used throughout the state to be incorporated into transportation planning.
Website: http://www.dfw.state.or.us/conservationstrategy/StakeholderRequest.pdf
Contact: Audrey Hatch, Oregon Department of Fish and Wildlife
Melinda Trask, Oregon Department of Transportation

Utah (Completed)

Description: A multi-partner collaborative process created a detailed map of connectivity areas, with descriptions and recommendations for each. This statewide plan is now being implemented into highway planning as Utah’s highways are expanded and built.

Plan Name: Wildlife Connectivity Across Utah’s Highways
Year: 2006 (published)
Partners: Utah DOT, Utah Division of Wildlife Resources, U.S. Forest Service, U.S. Fish and Wildlife Service, several private consulting and conservation groups
Process: A two day workshop occurred on May 11-12, 2004 for experts to determine connectivity areas. Participants determined which species were at risk, and to what degree, on the state’s highways. Also
Contents: Contains a detailed description of identified linkage areas, listing the conservation issues for each as well as its priority, species of concern, comments, and recommendations. Each connectivity region is mapped. The plan also contains a discussion of various mitigation methods.

Application: The identified linkages are integrated with the state’s transportation planning and current projects. Utah DOT engineers, project managers, environmental managers, and long-range planners are aware of the information in Wildlife Connectivity Across Utah's Highways and use it often (Paul West, personal communication).

Contact: Paul West, Utah Department of Transportation

Vermont (Completed)

Description: In recent years, Vermont has constructed wildlife crossings as part of its highway projects but has done so without a statewide connectivity plan to help guide priority action areas. Partners set out to identify and prioritize the most important habitat areas for wildlife as they come in contact with highways, and to create tools to make this process easier and more accurate.

Plan Name: Wildlife Linkage Habitat Analysis
Year: May 2006 (published)
Partners: Vermont Agency of Transportation (VTrans), Vermont Fish and Wildlife Department
Process: Researchers incorporated multiple data layers into a GIS map, including ecological value of habitat near roadways, roadkill data, development density, land use data, the amount of core habitat surrounding a potential linkage, and more (Austin et al. 2006).
Contents: Partners created two products. The first product is a centralized database of wildlife road mortality and road crossing locations as well as related habitat data for key selected species throughout the state. The second product is the GIS-based Wildlife Linkage Habitat Analysis.
Application: These planning tools are now available for VTrans and Vermont Fish and Wildlife Department to use. VTrans is currently using this new tool during early project development to assess wildlife hotspots, which will help determine the best practice to reconnect severed wildlife linkages (Glenn Gingras, personal communication).
Website: http://www.aot.state.vt.us/TechServices/EnvPermit/Documents/Wildlife_Linkage_Habitat_Report_5_15_06.pdf
Contact: John Austin, Vermont Fish and Wildlife Department
Kevin Viani, Vermont Agency of Transportation
Forrest Hammond, Vermont Fish and Wildlife Department

Virginia (Completed)

Description: Virginia’s Department of Conservation and Recreation created a GIS mapping analysis of the state’s natural core habitat areas and the corridors which connect them together for Virginia DOT’s use.
Plan Name: Virginia Natural Landscape Assessment (VANLA)
Year: December 2006 (report published)
Partners: Virginia Department of Conservation and Recreation, Virginia Department of Transportation
Process: Except for technical discussions on GIS mapping capabilities, VANLA was created by Virginia’s Department of Conservation and Recreation without the input of Virginia DOT.
Contents: The mapping analysis uses land cover data to determine appropriate designations of landscape core and corridor areas. Cores, habitat fragments, and natural landscape blocks have been mapped.
Application: VANLA has not been officially adopted or implemented by Virginia DOT. However VANLA was designed to be both relevant and applicable to Virginia DOT project planning and environmental analysis, and may prove useful to both agencies if it is adopted in coming years.
Website: http://www.virginiadot.org/vtrc/main/online%5Freports/pdf/07-r14.pdf
http://www.dcr.virginia.gov/natural_heritage/vclnavnla.shtml
Contact: Bridget Donaldson, Virginia Transportation Research Council
Joseph Weber, Virginia Department of Conservation and Recreation
Other Connectivity Work

California (Multiple plans, some In Progress)

Description: Currently no official statewide habitat connectivity analysis exists for California. Many of the state's potential habitat connectivity corridors have been identified and mapped, but without the official input of some key agencies. An important wildlife connectivity identification effort occurred at the November 2, 2000 Missing Linkages workshop at the San Diego Zoo, which brought together one hundred sixty scientists, conservationists, land managers and planners. 232 problem areas and potential linkages were identified (South Coast Wildlands 2006). Negotiations are currently underway to consider the creation of an official statewide habitat connectivity model.

Plan Name: N/A
Year: March 2007 (first meeting of interagency partners and others to create official plan)
Partners: Department of Fish and Game, CalTrans, California Department of Parks and Recreation, South Coast Wildlands, others
Process: California agencies are holding preliminary meetings with partners to determine if the state will create an official plan.
Contents: An official statewide plan would likely include new research as well as previously identified linkages from sources like the South Coast Missing Linkages Project.
Application: Linkages from the Missing Linkages workshop, as well as from other sources, have been incorporated into the design of some particular road projects, such as Freeways 118 and 101 (Lauren 2006).
Website: N/A
Contact: Kristeen Penrod, South Coast Wildlands Project

Florida (Multiple plans, some In Progress)

Description: Florida does not have one official statewide plan, but does have at its disposal many different datasets, biological surveys, and wildlife plans which have been used in different capacities to date, including the Cooperative Conservation Blueprint, Critical Lands/Waters Identification Project, Closing the Gaps, Florida Ecological Greenways Network (GeoPlan), Florida Natural Areas Inventory, and the Century Commission. This abundance of biological data and planning has proven difficult to consistently integrate with transportation planning, as no singular overarching statewide directive combines these numerous plans and data sets into one unit.

Plan Name: N/A
Year: N/A
Partners: Different plans and datasets have included partners such as Florida Game and Fresh Water Fish Commission, Florida DOT, Florida Fish & Game Commission, University of Florida, Florida Fish and Wildlife Conservation Commission, Florida Department of Environmental Protection, U.S. Fish and Wildlife Service
Process: N/A
Contents: Varies for each plan or dataset, but no single statewide habitat connectivity plan exists. Some efforts such as the Cooperative Conservation Blueprint and Conservation Land and Water Identification Project are underway to unify the plans.
Application: N/A
Website: N/A
Contact: N/A

Maryland (Completed)

Description: In 2001 Maryland launched the GreenPrint program to identify important unprotected natural areas, link these areas through a system of natural connections, and acquire or purchase conservation easements for the highest priority areas (GreenPrint Program 2006). Maryland DOT is not a partner so GreenPrint’s direct application to transportation planning may be limited.

Plan Name: GreenPrint
Year: 2001 (GreenPrint program created)
Partners: Maryland Department of Natural Resources
Process: GreenPrint uses a computer tool developed to help identify and prioritize areas in Maryland for conservation and restoration. Elements considered include the variety of natural resource in an area, how a given place fits into a larger system, ecological importance, a regional or landscape-level
view for wildlife conservation. The tool will also designate land as a “hub” (a large core habitat) or a “corridor” (a wildlife travel linkage).

Contents: Identify important unprotected natural lands in the state, link these lands through a system of corridors or connectors, and save those lands through targeted acquisitions and easements (GreenPrint Program 2006).

Application: A number of large parcels have been purchased through this program

Website: http://dnr.maryland.gov/greenways/greenprint/

Contact: Maryland Department of Natural Resources

Massachusetts (Completed)

Description: Both Massachusetts’s BioMap and the Conservation Assessment and Prioritization System (CAPS) are used to identify lands in critical need of conservation protection. They are not integrated with the state’s transportation plans.

Plan Name: BioMap, and Conservation Assessment and Prioritization System

Year: BioMap: On Going

Partners: BioMap: Massachusetts Division of Fisheries and Wildlife, Executive Office of Environmental Affairs
CAPS: University of Massachusetts

Process: BioMap: Biologists select populations to map based on elements such as habitat and resource requirements, threats, and conservation needs. Species habitat and supporting natural landscapes are mapped using GIS software (BioMap 2002).
CAPS: Uses GIS mapping to assess the ecological integrity of developed and undeveloped areas in the state.

Contents: BioMap: A map of areas in need of strategic land protection
CAPS: A comprehensive land cover map with ecological integrity designations, and a list of priority areas for conservation

Application: Both are used by the state when considering land purchases or other methods for conservation.

Website: BioMap: http://www.mass.gov/dfwele/dfw/nhesp/nhbiomap.htm
CAPS: http://masscaps.org/

Contact: BioMap: Natural Heritage & Endangered Species Program - Massachusetts Division of Fisheries & Wildlife
CAPS: University of Massachusetts, Department of Natural Resources Conservation

Montana (Completed)

Description: Montana is not currently working on creating a statewide habitat connectivity plan. However the rapid assessment process which enabled the identification and prioritization of wildlife crossing structures along U.S. Route 93 in western Montana is noteworthy. The process is now being used selectively in other states such as Wyoming.

Plan Name: N/A

Year: 2003 (finalized)


Process: As an alternative to a lengthy and expensive – though likely more thorough - study, an interagency team assessed wildlife movement patterns, animal-vehicle crash data, and landscape characteristics such as topography and vegetation over two days to determine likely wildlife movement-highway intersection hotspots (Ruediger, Lloyd and Wall 2003). Planners then took this data into consideration when designing U.S. Route 93.

Contents: A map of U.S. 93 with 48 potential wildlife linkages identified, and a brief description of the landscape and local wildlife in each linkage area (Ruediger, Lloyd and Wall 2003). One over-crossing and 39 large under-crossing structures are currently in design (American Wildlands 2005).

Application: Montana DOT is installing wildlife crossing structures on U.S. 93 to allow wildlife safe passage.

Website: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1194&context=jmie/roadeco
North Carolina (In Progress)

Description: North Carolina is currently involved with three projects which relate to wildlife linkages. First, the Ecosystem Enhancement Program, in cooperation with the North Carolina GAP project, is analyzing habitat cores and corridors needed for vulnerable species. Second, the Department of Environment and Natural Resources is working on four multi-county projects to identify key conservation sites and corridors, with the intention of sharing this data with North Carolina DOT. Third, the state is beginning a statewide conservation planning effort similar to Maryland’s (Linda Pearsall, personal communication). Fragmentation of habitat from highways and wildlife linkages are not being addressed directly through these programs at this time.

Plan Name: North Carolina Ecosystem Enhancement Program (the first of three programs)
Year: July 2003 (Ecosystem Enhancement Program begins)
Process: Unknown
Contents: Unknown
Application: Unknown
Website: http://www.nceep.net
Contact: Linda Pearsall, Department of Environment and Natural Resources

Washington (Completed)

Description: Washington State does not have a statewide connectivity plan. The state is committed to enhancing wildlife connectivity along the I-90 Snoqualmie Pass, however, as the highway is upgraded. After several years of deliberations, appropriate wildlife crossing structures and their locations were selected, and the state has allocated money to begin installing a series of under and overpasses and extended bridges to allow for habitat connectivity in this ecologically unique area.

Plan Name: I-90 Snoqualmie Pass Wildlife Habitat Linkage Assessment
Year: 1998 (assessment began), May 2000 (assessment published)
Partners: U.S. Forest Service, Washington State Department of Transportation, I-90 Wildlife Bridges Coalition, others

Process: Under a cooperative agreement between the U.S. Forest Service and Washington State DOT, a comprehensive habitat connectivity assessment was produced for the I-90 Snoqualmie Pass area.

Contents: Researchers included a least-cost path model to identify potential linkage areas for sensitive species, GIS analysis of ungulate roadkill, monitoring of existing wildlife crossing structures to assess effectiveness, camera documentation of wildlife found near I-90, and winter snow tracking to determine common crossing locations and species distribution (Singleton Lehmkuhl 2000).

Application: As of December 2006 the Governor’s 2007-2009 calls for $525 million to be used for I-90 construction. This cooperative partnership is designed to enhance both transportation utility and wildlife connectivity. Yet the I-90 project is not part of a broader-scale statewide connectivity plan. Without a statewide habitat connectivity plan in place to prioritize project areas, it is difficult to determine if mitigation dollars are all best spent on this one project or perhaps dispersed amongst a few priority areas.

Website: http://www.wsdot.wa.gov/research/reports/fullreports/489.1.pdf
http://www.i90wildlifebridges.org/

Contact: Patty Garvey-Darda, U.S. Forest Service
Jen Watkins, I-90 Wildlife Bridges Coalition

Wyoming In Progress

Description: Wyoming has no system-wide connectivity plan like many of the states analyzed in this inventory. Despite this, agencies have partnered on several highway projects in order to install wildlife crossing structures in important wildlife habitat areas (Bill Ruediger, personal communication).

Plan Name: N/A
Year: N/A
Partners: Wyoming Game and Fish Department, Wyoming Department of Transportation
Process: Conservation and mitigation determinations are decided on a project-by-project basis between the Wyoming Game and Fish Department and Wyoming DOT.
Contents: N/A
Application: Wyoming has installed wildlife crossing structures on particular highway projects in order to maintain connectivity for wildlife which use and inhabit the surrounding habitat.
Website: N/A
Contact: Wyoming Game and Fish Department
Wyoming Department of Transportation

Conclusion

In order to be successfully implemented, a habitat connectivity plan must be:

- detailed
- spatially explicit
- agreed upon by the parties affected
- incorporated into long-term statewide transportation and conservation plans
- have the political and financial backing of state officials

Of the most comprehensive plans included in this inventory, some of these common threads of success emerged. An important factor to a plan’s success often begins with a partnership between the state department of transportation and the land and wildlife management agencies during the process of identifying and prioritizing critical natural resources and sensitive habitat areas. It is difficult for a connectivity plan to succeed and be implemented on a wide scale without the support of state transportation and fish and game agencies in partnership with land management agencies. States which take meticulous care to identify valuable resources, but did not do so in partnership with all relevant agencies such as the DOT or Forest Service, may have difficulty in sustaining large-scale conservation efforts if the transportation department’s plans are not integrated with these conservation plans. As new projects are proposed, agencies’ plans may conflict if they are unaware of each other’s long term goals. For a statewide habitat connectivity plan to be successful and implementable, an open and continuous relationship between multiple partners appears to be of crucial importance, in particular between state agencies but also between federal partners and knowledgeable non-profits.
It should also be noted that a successful plan does not necessarily have to map out the specific location of every natural resource sited anywhere near a possible highway project in order to be useful. If a plan maps the general locations of important habitats and (more specifically) the common movement corridors of key species, then planners will be able to apply this general research when scoping transportation projects. A finely detailed analysis may not be necessary until the specific project has been decided upon. At that stage, planners may anticipate the ecological factors most likely to be present in the project area, and can plan accordingly to avoid the area, or to take appropriate mitigation measures if the project is deemed to not have an alternative.

As the science supporting the benefits of habitat connectivity in relation to highway systems expands, so too does the practice of states seeking proactive solutions to issues associated with wildlife movement across state highways. States need to continue to make strides in seeking to protect ecologically valuable blocks of habitat across the landscape and the crucial linkages between them while not comprising the needs of human mobility. Embracing interagency cooperation, creating these statewide habitat connectivity plans have allowed participating states to conserve time, money and natural resources, while improving safety for travelers due to reduced wildlife getting onto the road. As the states inventoried here continue to expand upon and approve their planning processes, states which are currently considering beginning a similar project can look to the myriad plans of state peers for inspiration and practical solutions in order to conserve the connections for people and wildlife.

Biographical Sketch: Since June 2006, Jesse Feinberg has been a Conservation Policy Assistant with the Habitat and Highways program at Defenders of Wildlife. A Washington, DC based non-profit, Defenders of Wildlife is a conservation organization dedicated to the protection of all native wild animals and plants in their natural communities. Before joining Defenders Jesse worked at the Wisconsin Department of Natural Resources in the Community Financial Assistance and Communications Departments, and received his Bachelors degree at the University of Wisconsin-Madison in international studies and communication arts.

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