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A RAPID ASSESSMENT PROCESS FOR DETERMINING POTENTIAL WILDLIFE, FISH AND PLANT LINKAGES FOR HIGHWAYS

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Abstract: The authors developed and tested a rapid assessment fish and wildlife linkage process on Highway 93 in Western Montana. Highway 93 is a north-south route that traverses remote high mountain ranges and intensively managed and settled valleys from Canada to Idaho. Twenty-nine species were analyzed including large carnivores such as grizzly bear, black bear, mountain lion and wolves, five ungulates, numerous species of small mammals, birds, reptiles, amphibians, plants and fish (including bull trout and cutthroat trout). The rapid assessment process uses readily-available public geographic information system data on vegetation, habitats, wildlife, fish, road kill, rare plant communities, topography, hydrology, land ownership patterns, existing conservation easements and point data on special habitats and species occurrences. An interagency group of local wildlife and fish experts was able to review approximately 200 miles of the 290-mile corridor in less than two days. Forty-eight potential wildlife and fish linkage areas were mapped and reported by milepost. The linkage areas are species and location specific. Some wildlife linkage areas were identified primarily from high vehicle collision rates with large ungulates (highway safety). The process is designed as a mid-scale analysis. It has value for initial determination of wildlife and fish linkage areas, potential wildlife and fish highway crossings, identification of key areas for wildlife and fish mitigation, potential areas for open space, conservations easements or land adjustments to benefit wildlife, fish and plant habitats. Involvement included county, state, federal agencies and non-profit conservation interests. Use of the process could substantially improve wildlife and fish coordination with highway planning throughout the United States and Canada. The process is cost effective, fast and accurate.

Introduction

Since 1996 when the first International Conference on Wildlife Mortality was held in Orlando, Florida, great strides have been made by many transportation agencies towards coordinating highways with wildlife and fish resources. In many states, wildlife crossings and wildlife habitat linkage analysis has become a “standard procedure” when building new highways, or whenever major construction is planned. Two situations often stand in the way of making further progress. First, most major highway projects often have significant resources expended before wildlife and fish habitat linkage information is known. Second, defining wildlife and fish habitat linkages far ahead of project designs was expensive and usually not provided until long after the information was needed. As a result, most highway projects in most states are developed without knowledge of where wildlife and fish crossings, as well as other mitigation, should be focused. Many wildlife and fish crossing opportunities are lost because the basic biological information needed does not exist and has previously been too expensive to obtain. In several situations, highway projects have been delayed or have cost above planned budgets.

The principle author of this study looked at opportunities to use existing mapped physical and biological information, plus available knowledge of biologists, highway planners and others, to provide accurate information on where most of the critical wildlife and fish habitat linkages are located. While not 100 percent accurate, the process developed allows highway agencies, wildlife agencies and land management agencies to integrate their existing information on highway collisions with wildlife, wildlife occurrence, habitat mapping, hydrology and topography into habitat linkage maps for significant lengths of highways that can be produced for a few thousand dollars and a few days of staff time. The authors believe it would be possible to provide rapid assessment wildlife and fish linkage maps for all major highways for an entire state for a relatively small amount of financial and personnel resources. The benefit of doing this would be: (1) much better integration of wildlife and fish resource information early in highway project designs, (2) better understanding of highway project costs, including total mitigation costs, (3) less potential for wildlife and fish resource “surprises” coming up late in the project design, or worse, the project implementation phases, (4) the information also has ancillary benefits such as providing key information for county, state and Federal agencies, as well as private nonprofit groups, concerned with wildlife habitat, wildlife habitat connectivity, highway safety, open space planning and other land management concerns.

Wildlife Habitat Connectivity – Why It Is Critical To Conservation

Identifying areas where fish and wildlife may safely move between habitats separated by highways is important for several reasons. First, mortality from collision with vehicles can limit wildlife populations, especially of rare species (Forman and Alexander 1998, Ruediger 1998). Highways can be significant barriers to the movement of wildlife, either because individuals avoid crossing highways or because those that do attempt to cross are
The Process For Rapid Assessment of Highway Wildlife and Fish Linkages

The process of identifying fish and wildlife linkages is based on the use of spatially explicit, computerized data contained within a geographic information system (GIS). GIS data layers are available from most state GAP databases (US Fish and Wildlife Service), U.S. Forest Service, State Fish and Wildlife Departments, State Natural Heritage Programs, State Departments of Transportations, Rocky Mountain Elk Foundation and several other sources.

In the test example for Highway 93, Montana, we worked with Geodata Services, Inc., to determine the various wildlife and physical data to include in our model, based on the quality and quantity of public GIS data available in Montana. For other states, the specific GIS data used as well as its sources would likely vary. The GIS coverage spanned four miles on either side of Highway 93, a scale sufficient to ensure that the occurrence of wide-ranging species such as elk, moose, and mid- and large-sized carnivores would be identified in the corridor. The physical attributes of the model included data on vegetation type; elevation; presence of streams, lakes, and wetlands; land ownership; and site-specific data (by milepost) on the frequency of road-kill of large animals (Appendix A). The occurrence of 29 species of fish and wildlife was analyzed in the model (Appendix B); species were included because they were either representative of habitats along Highway 93 or were of special interest to the public or government agencies. These species were selected by Bill Ruediger and Ken Wall as being representative of fauna along Highway 93 and for which adequate information was available. To avoid biasing the selection of potential linkage areas, the list included large, wide-ranging animals, small animals with limited mobility, and fish. To highlight potentially important natural areas along Highway 93, data were obtained on bird abundance, points of special concern, and the presence of rare plants or animals not otherwise included in our model (e.g., location of common loon nesting sites). Although these data are not relevant to the location of potential highway crossings, they do serve to highlight areas in which special attempts could be made to mitigate highway effects on rare plants and animals in adjacent habitat.

After selecting species and data to include in the GIS output, two technical teams were selected to review the data and select the most appropriate wildlife and fish linkages along Highway 93 (see Appendix C). The members were selected from agencies with management authority for wildlife, fish or plants; for wildlife or fish habitat; who had local knowledge of species and habitats; or who had special knowledge of wildlife in a particular area. The first group to meet was the South Highway 93 Team, which reviewed and recommended wildlife and fish linkages from Lookout Pass at the Idaho/Montana border to Evaro Hill on the Flathead Indian Reservation (wildlife crossings for the proposed North Highway 93 expansion were not changed, nor were other wildlife crossings already planned for the Highway 93 expansions in the Bitterroot Valley). The second group to meet was the North Highway 93 Team, which made recommendations for wildlife and fish linkages from Polson to the Canadian Border.

Each team started at one end of the assigned Highway 93 corridor and moved segment by segment. Rigid criteria were not established for the selection of potential linkage areas, but instead, selections were based on discussion of the GIS data and input from team members with experience working in the segment under review. Linkage areas were added only after the committee reached consensus. After some initial start-up discussions and questioning, each team was able to rapidly decide if a given segment was suitable as a wildlife or fish linkage, and for which species it would likely be appropriate. Data on public and private land ownership patterns (including plated or existing subdivisions and private lands with existing conservation easements) were used to determine whether existing conditions were suitable to link habitat across Highway 93.

Each team took approximately six hours to thoroughly discuss each major segment (approximately 100 miles in length) and come to consensus as to: (1) whether or not a specific area was suitable for wildlife or fish linkage; (2) what species it was appropriate for; (3) accurately define the boundaries of the linkage area; and (4) provide valuable information on characteristics relevant to the linkage area, such as, public land ownership, existing conservation easements, number of landowners and size of private land blocks, association with major or
minor riparian habitats, etc. Each major segment was approximately 100 miles in length. Subsequent tests of the methodology with other groups suggest that the process productivity was similar to the original test group. Providing that adequate GIS information is available, a group of biologists and planners familiar with the process could accurately provide wildlife and fish linkages for 100-200 miles of highway per day.

**Highway 93, NW Montana: Test Location and Landscape**

Highway 93 starts at Lost Trail Pass on the Idaho-Montana border and winds north for approximately 263 miles to the US/Canada border a few miles north of Eureka, Montana. In doing so, it is the major highway connector for Darby, Hamilton, Victor, Stevensville, Lolo, Missoula, Arlee, Ravalli, Ronan, Polson, Lakeside, Kalispell, Whitefish and Eureka. In addition to Lost Trail Pass, it crosses mountainous country around Evaro Hill, along the shoreline of Flathead Lake, and through the Stillwater-Dickey Lake country of northwestern Montana. The mountainous country around Highway 93 is generally part of either the Flathead Indian Reservation or the National Forest system. Much of the intervening area is low valleys (Bitterroot, Missoula, Flathead and Tobacco Plains) that are generally privately owned or part of the Flathead Indian Reservation. These valleys are heavily populated with people and are among the fastest growing areas in Montana.

**Fish and Wildlife Along Highway 93, Montana**

Wildlife along Highway 93 is diverse and unique in the lower 48 states. Areas along Highway 93 support rare carnivores, such as grizzly bear, gray wolf, lynx and wolverine (scientific names can be found in Appendix B). Carnivores, such as bobcat, coyote, striped skunk, raccoon, American badger, mink, northern river otter, and weasels, are relatively common along Highway 93. Game species are abundant throughout the highway corridor and include elk, moose, mule deer, white-tailed deer, bighorn sheep and black bear. Mallard, blue-winged teal, green-winged teal, northern shoveller, gadwall, common golden-eye, American widgeon, common merganser, ruddy duck, wood duck, and Canada goose all nest in the vicinity of the highway, and Highway 93 is also one of the few highways in the United States where a traveler might encounter nesting common loons on one of the adjacent lakes. The diversity of non-game birds in general is high because Highway 93 passes through a variety of habitats, ranging from high-elevation conifer forests to deciduous riparian forests and even remnants of Palouse prairie. For example, a Breeding Bird Survey route near Highway 93 in the Bitterroot Valley has recorded over 90 species of birds, excluding waterfowl.

Amphibians and reptiles resident in the Bitterroot, Clark Fork and Flathead Valleys include long-toed salamander, Rocky Mountain tailed frog, boreal toad, western toad, bullfrog, Columbia spotted frog, northern leopard frog, boreal chorus frog, Pacific tree frog, northern alligator lizard, western skink, rubber boa, gopher snake, western terrestrial garter snake, and common garter snake.

Native fish species in the Highway 93 corridor include northern pike-minnow, longnose sucker, largescale sucker, mountain whitefish, cutthroat trout, bull trout, slimy sculpin, and shorthead sculpin. Introduced species include rainbow trout, brook trout, brown trout, northern pike, yellow perch, largemouth bass, and smallmouth bass.

**Applying the Process: Identification of Fish and Wildlife Linkages on Highway 93**

Note: The milepost descriptions start at Lost Trail Pass and go north to the Canadian border. Montana Department of Transportation mileposts start at Lost Trail and go to I-90, then start over again at I-90 and got to the Canadian border. To minimize the confusion of having two similar mileposts at different places on Highway 93, this report uses approximate miles from the Lost Trail (Idaho Border) as milepost descriptions.

**Southern Highway 93**

1. **Lost Trail Pass** (Milepost 1) Provides a linkage for a variety of carnivores including lynx, wolverine, American marten, gray wolf, and potentially grizzly bear. Some of the common larger mammals that may...
cross the highway at Lost Trail Pass include elk, mule deer, white-tailed deer, black bear, and mountain lion. Northern bog lemming, a mammal of special interest, is found in bogs near Lost Trail Pass.

Lost Trail Pass is believed to be a pivotal wildlife habitat linkage because the Bitterroot Mountains, Pintlar Mountains, and Big Hole Mountains converge at the pass.

2. Camp Creek (Milepost 7) This area provides habitat connectivity for many species. Montana Department of Fish, Wildlife and Parks and the Bitterroot National Forest consider this area to be critical elk winter range, but elk must cross Highway 93 to fully utilize this habitat. A lowland meadow complex follows Camp Creek, and is important habitat for small mammals and amphibians, as well as for white-tailed deer and other animals.

![Fig. 2. Linkage areas along the first segment of Highway 93 from Lost Trail Pass to Big Creek. For details, see corresponding numbers in text.](image)
3. Sula Canyon (Milepost 13) The area adjacent to Highway 93 in the Sula Canyon is unique in the Bitterroot Valley in that bighorn sheep are often encountered on and adjacent to the highway. In addition to being an occasional traffic hazard, these bighorn sheep are highly prized by motorists and wildlife viewers, and as big game animals.
Many other large mammals are encountered in this section of highway, including mule deer, white-tailed deer, elk, bobcat, American marten, mountain lion, and black bear. The Sula Canyon area is an important link between the East Fork and West Fork of the Bitterroot River. Collisions with various species of wildlife were noted in this section.

4. West Fork of the Bitterroot River
(Milepost 21) Myriad wildlife and fish species can be found in this section of Highway 93, and the area is an important link between National Forest lands to the east and west. Fish passage for bull trout, cutthroat trout, rainbow trout, and mountain whitefish is important. Large animals using this section of Highway 93 include elk, white-tailed deer, mule deer, mountain lion, and black bear. The area is also used by a number of large and mid-sized carnivores.

This area is also important to a wide variety of smaller mammals, reptiles and amphibians because the East Fork and West Fork of the Bitterroot River converge here.

5. Rye Creek (Milepost 25) Still in the upper reaches of the Bitterroot River drainage, the Rye Creek area provides an opportunity to link National Forest land on both sides of the highway for elk, mule deer, white-tailed deer, mountain lion, and black bear. Some of the highest concentrations of mule deer in the valley occur here. The Bitterroot River corridor exists in this area and fish passage is an important consideration.

6. Lost Horse – Rock Creek (Milepost 34) Montana Fish, Wildlife and Parks has designated this area as critical deer and elk winter range. Black bear and mountain lions also inhabit this area, as well as medium and small carnivores. The highway is near the Bitterroot River riparian zone, which is important to most species using the area. An amphibian of special interest in this area is the Pacific treefrog.

Many conservation easements exist on private lands in this area, making connectivity across the valley feasible.

7. Sleeping Child (Milepost 40) Large animal species using this section frequently include mule deer, white-tailed deer, and black bear. A number of small mammals, birds, and amphibians also use the nearby Bitterroot River riparian areas.

A linkage in this area would provide habitat connectivity across the Bitterroot Valley.

8. Mill Creek (Milepost 54) This section of Highway 93 is adjacent to many sites that are important in a conservation context. At Mill Creek, the highway is near the Bitterroot River and the large river riparian habitat it provides. Montana, Fish, Wildlife and Parks has a fishing access area here and the Teller Wildlife Refuge is nearby. The Schwab property is a privately owned area of significant conservation value. Suitable habitat for deer, black bear, small mammals, and amphibians exists in this linkage area.

Fish passage is an important consideration.

9. North and South Fork of Bear Creek (Milepost 58) Fish passage is an important consideration where the north and south forks of Bear Creek flow under Highway 93. White-tailed deer and black bear inhabit the valley bottom, and small mammals and amphibians also use habitat along the creek. An experimental bat house is being constructed in the new highway bridge.

10. Sweathouse Creek (Milepost 59) Fish passage is an important consideration on Sweathouse Creek, and small mammals and amphibians also use riparian habitat on the drainage. Western toads breed in this area. White-tailed and mule deer use habitat adjacent to Sweathouse Creek and frequently cross Highway 93 in this area.
11. **Big Creek** (Milepost 61) Big Creek has a number of wildlife and fish conservation concerns. Fish passage is an important consideration, as bull trout use and spawn in Big Creek. The riparian habitat hosts a diversity of animals. White-tailed deer, mule deer, elk, and black bear occur in this area and cross Highway 93. The present bridge is built on pilings and provides excellent movement for large and small animals and fish going up or down Big Creek.

Many of the private properties immediately adjacent on the east side of the Bitterroot River have existing conservation easements.

12. **McCalla Creek** (Milepost 63) With a well-developed riparian area, McCalla Creek provides habitat for small animals and deer. Montana Department of Transportation has plans for bridges that would facilitate wildlife movement on both the north and south crossings of McCalla Creek.

13. **Kootenai Creek** (Milepost 65) Similar to McCalla Creek, which flows into Kootenai Creek to the east of Highway 93, Kootenai Creek provides a well-developed riparian area. Kootenai Creek drains into the Bitterroot River just south of Highway 269, which is the primary access to Stevensville from Highway 93. Deer, black bear, small and medium mammals, amphibians, and reptiles utilize the riparian corridor. Kootenai Creek is a short distance from Lee Metcalf National Wildlife Refuge. Montana Department of Transportation has plans for a seventy-foot bridge across Kootenai Creek when Highway 93 is reconstructed.

14. **Bass Creek** (Milepost 67) Bass Creek is another major tributary of the Bitterroot River. Common species along Bass Creek include white-tailed deer, elk, and black bear. The area is also thought to be an important wildlife linkage for carnivores. Small mammals and amphibians inhabit the Bass Creek riparian area and adjacent habitat.

Habitat linkage from the Lee Metcalf National Wildlife Refuge to the Bitterroot National Forest to the west could be developed, which would provide a great benefit to species utilizing the Lee Metcalf National Wildlife Refuge, as well as most species inhabiting the Bitterroot River corridor.

Vehicle collisions with deer are common in this area, raising safety concerns for motorists using Highway 93. Wildlife crossings, with fencing, would provide for fewer collisions with deer and other animals.

15. **McClain Creek** (Milepost 79) McClain Creek may provide one of the only places in the lower Bitterroot Valley where large animals could cross between National Forest lands in the Bitterroot Mountains and National Forest lands in the Sapphire Range. White-tailed deer, mule deer, elk, and black bear currently inhabit this area, and McClain Creek could also provide a linkage area for carnivores.

In addition to the main Bitterroot River bottomlands, many high-quality marshes and wetlands occur in this vicinity. Consequently, many small mammals, amphibians, and reptiles, including western painted turtles, use the area around McClain Creek.
16. Lolo Creek (Milepost 82) Lolo Creek crosses Highway 93 near the town site of Lolo. Although this drainage goes through part of south Lolo, many species use the riparian area, which is remarkably intact, as a corridor. Lolo Creek is also an important local fishery and spawning stream, and fish passage is a concern. Small and medium sized mammals (like raccoon) and amphibians also inhabit the riparian habitat along Lolo Creek, even through the heavily developed portions.

Lolo Bridge on Highway 93 was recently rebuilt. Unfortunately for wildlife, large riprap was used for bridge protection and the close confinement of Lolo Creek beneath the bridge prevents many wildlife species from crossing under the highway. As a consequence, trails indicate deer and other species must cross Highway 93 by going over the pavement. The bridge could likely be modified to include a trail on both sides to facilitate wildlife movement under the highway. Some wing fencing may also be warranted. Fish passage is excellent through the bridge.

17. Miller Creek (Milepost 85) The Miller Creek area poses a dilemma in that elk and other animals can often be seen on the steep forested lands west of Highway 93 during winter and spring, yet the high traffic volume, steep cut banks, and cement median barriers in this section prevent wildlife movement across the highway. Consequently, few wildlife species currently attempt to cross this section of Highway 93.

Miller Creek flows east into the Bitterroot River. Some of Miller Creek is already highly developed, and more development is proposed. However, an opportunity may exist to provide a wildlife crossing on Highway 93 and, with the retention of open space on the Bitterroot River and Miller Creek, elk, deer, black bear, and other species would likely use this crossing. This opportunity should be reviewed as part of the overall land-use pattern for the west side of Highway 93 and the Lower Miller Creek developments.

18. Bitterroot River (Milepost 89) Highway 93 crosses the Bitterroot River just south of Missoula in the area known as Bunkhouse Bridge. Much of the area is currently open space, although development is proceeding quickly. Extensive riparian habitat, containing cottonwood and other large trees, exists in the floodplain of the Bitterroot River. Small mammals, white-tailed deer, and mid-sized carnivores (coyotes, raccoon, striped skunks, otter, mink, and weasels) use this portion of the Bitterroot River. Wildlife crossing space under the bridge is recommended for these species. The slow, meandering river also provides habitat for birds of prey such as bald eagles and osprey, as well as waterfowl.

The Bitterroot River is a world-renowned trout fishery and provides a high population of large trout. Fish passage and water quality are thus concerns.

Since this portion of the Bitterroot River is rapidly becoming part of the urban Missoula area, it is used intensively for floating, fishing, swimming, wildlife watching, and other recreation.

19. Clark Fork River (Milepost 93) Motorists traveling across the bridge on the Clark Fork River often have prolonged vistas of the river and surrounding habitat. This portion of Highway 93, known as the Reserve Street Strip, often has high traffic volumes and traffic jams. Despite dikes and canalization, the Clark Fork River still has extensive riparian habitat, and many species of wildlife can still be found here. This portion of the river is one of the best locations to see bald eagles and osprey. Other birds of prey are
also common, as are many species of songbird. A number of old gravel pits provide habitat for waterfowl and shorebirds. Small mammals and mid-sized carnivores exist here. Occasionally, white-tailed deer and black bear wander up the Clark Fork River, and adequate space under the bridge should be provided for passage of these species.

The Clark Fork River has very good trout fishing for rainbow, cutthroat, and brown trout, as well as occasional brook trout and bull trout. Whitefish, sculpins, suckers, and northern pike also inhabit the river. A considerable effort has been made by the city of Missoula to maintain the river corridor as open space. Fish passage and water quality are both concerns.

**20. Butler Creek** (Milepost 99) A small drainage that crosses Highway 93 in the vicinity of the Missoula Airport, Butler Creek is dry much of the time where it crosses Highway 93. The adjacent area is highly developed and becoming more so. Allowing passage for small mammals and amphibians is recommended; however, the cement pipe crossing Highway 93 is partially blocked by road fill due to pipe separation. If this pipe is removed or repaired, a small box culvert may provide better passage. A culvert on the old highway grade just north of Highway 93 should also be assessed.

**21. Evaro Canyon** (Milepost 105) Heading north from Interstate 90, Evaro Canyon is the first mountainous country outside of the Clark Fork Valley. The lower canyon was the site of a deer reflector test area, and collisions with deer, elk, mountain lion, and black bear are common from here to the developed area of the Jocko Valley on the other side of the pass. Wolves and grizzly bears are also known to use this area. Animals coming from the Mission Mountains and Rattlesnake Range (and probably animals dispersing from the Swan Valley and Bob Marshall area) find movement to the south nearly impossible due to the city of Missoula and Interstate 90. This location has been identified as an important crossing area for many species, and allowing for their passage is recommended. Conservation easements in key wildlife linkage areas in Evaro Canyon should be considered as well. Contiguous areas of mountain habitat occur westward toward the Ninemile Valley.

Small mammals and amphibians also inhabit riparian habitat along the stream in Evaro Canyon.

**22. Frog Creek** (Milepost 108) Frog Creek is the first small drainage crossing Highway 93 north of Evaro Canyon. Fish passage is a concern, as is passage for small mammals and amphibians. This drainage has been identified in the Highway 93 reconstruction project being planned on the Flathead Indian Reservation.

**23. North Evaro (South of Joe's Smoke Ring)** (Milepost 109) White-tailed deer, mule deer, and black bear commonly cross Highway 93 in this area. A wildlife crossing is proposed for this area as part of the Highway 93 reconstruction.

**24. Evaro Railroad Crossing** (Milepost 110) Montana Rail Link tracks cross Highway 93 in this segment. Animals trying to avoid Joe’s Smoke Ring and adjacent developments are often funneled into this crossing area. The railroad bridge is narrow in this location and most animals cross Highway 93 by going around the railroad bridge to the south and walking across the highway pavement. Traffic volume is very heavy in this section of Highway 93, making this a dangerous wildlife crossing for both wildlife and motorists.

Species using this crossing are white-tailed deer, mule deer, elk, and black bear. The railroad bridge is planned for widening, which would allow better access for wildlife. When this occurs, the crossing will be used by the above species, as well as by small and mid-sized carnivores and small mammals.
25. **Evaro Wildland Corridor** (Milepost 111) This area has been identified as an important crossing area and wildlife linkage area for many species. The linkage area connects the Rattlesnake Mountains to the east with the Ninemile Divide to the west. This linkage zone is a critical connection for animals dispersing or moving from the Mission Mountains, Rattlesnake Mountains, Swan Range (including areas north in the Bob Marshall Wilderness), Cabinet Mountains, Ninemile Divide, and the Bitterroot Range.

Species known or suspected to use the Evaro Wildland Corridor include grizzly bear, wolf, lynx, black bear, wolverine, fisher, and other mid-sized and small carnivores (Servheen et.al. 2000). Ungulates using the linkage area include white-tailed deer, mule deer, elk, and moose. A variety of small mammals and amphibians likely use this area as well.

A great effort is being made to establish a major wildlife crossing in the Evaro Wildlands Corridor. Some human residences are being moved and plans are underway to build a wildlife overcrossing and several smaller underpasses, such as at Finley Creek. The Salish and Kootenai Tribe has worked for many years with the Montana Department of Transportation and the Federal Highway Administration to incorporate these crossings into the Highway 93 reconstruction project.

**Northern Highway 93**

26. **South of Jette** (Milepost 164) Two or three small streams cross Highway 93 at this location. Providing stream crossings adequate in size to allow small mammal and amphibian passage is recommended. More field review is needed.

27. **Jette Hill** (Milepost 168) Going north from Polson, Jette Hill is at the top of the long grade. White-tailed deer, elk, black bear, and mid-sized carnivores use the surrounding forest and frequently attempt to cross Highway 93. Smaller animals also cross this portion of highway. Traffic volume is heavy in this section of highway, particularly in summer months. Provisions for wildlife passage are recommended. In addition to reducing collisions between wildlife and vehicles, a linkage at this site would connect tribal lands separated by the highway.

28. **Elmo** (Milepost 178) Two small creeks cross Highway 93 at Elmo and empty into Flathead Lake. Passage for small mammals and amphibians is recommended when the drainage structures are replaced or the road reconstructed.

29. **Dayton Creek** (Milepost 183) Dayton Creek is a fishery. Fish passage is an important consideration, as is passage for small mammals and amphibians. In addition, the highway bridge over Dayton Creek supports a nesting colony of cliff swallows.

30. **Painted Rocks** (Milepost 190) Highway 93 traverses an important deer wintering area at this location and deer commonly cross the highway here. This is a potential site for a deer crossing structure.
31. Somers North (Milepost 204) The portion of Highway 93 is bordered by a number of marshes and wetlands that are attractive to painted turtles, wetland birds, small and medium mammals, and amphibians. Vehicle collisions with wildlife are common here, and road-killed turtles, songbirds, and mammals are often evident along the roadside. Consideration should be given to these resources when the highway is reconstructed. Currently, a culvert crossing exists at this site that allows for the passage of cattle underneath the highway. The culvert is not well designed for use by wildlife, but with some modification might be effective in linking the wetlands currently bisected by the highway.

32. Ashley Creek (Milepost 209) Highway 93 crosses Ashley Creek via a relatively new bridge. However, this area poses several obstacles for the passage of fish and wildlife. First, fencing for a bike path, fencing for erosion control, and the erosion of the south bank generally preclude most wildlife movement under the bridge. Second, a culvert passing underneath a railroad bridge immediately upstream likely blocks fish passage during part of the year; local residents report high flows out of the culvert and significant ponding of water above the railroad bridge during the spring. Finally, the railroad bridge itself, which is a nearly vertical earthen dam several meters high, may completely block passage of smaller animals. Thus, passage for small mammals, amphibians, fish, and mid-sized carnivores is a concern, and mitigation measures are recommended.

33. Stillwater Crossing (Milepost 216) Another new bridge crosses the Stillwater River at this site, which has a relatively intact riparian corridor that provides habitat for many nesting birds. Small mammals and amphibians are also present, along with mid-sized and small carnivores. In general, this site is adequate for the passage of large and small mammals, but DOT fencing and erosion control fencing likely hinder crossing for some species. The addition of wing fencing might help funnel animals under the bridge. Fish passage is also a concern on the Stillwater River.

34. Happy Valley (Milepost 221) Vehicle collisions with deer are common at Happy Valley. Motorist safety and reducing collisions with wildlife are concerns. However, Happy Valley is heavily developed on both sides of the highway and few opportunities appear to exist to reduce collisions between wildlife and vehicles.

35. Whitefish River (Milepost 227) This area is heavily developed, but is still of significant value for fish and wildlife. Habitat exists for small mammals and mid-sized carnivores like raccoon, striped skunks, weasels, otter, and mink, as well as for amphibians and turtles. However, the current configuration of the highway likely prevents almost all passage by either fish or wildlife. The highway crosses the river over a large earthen dam perforated with three culverts, which presumably prevent fish passage at all times except during extremely low flows. The large size, and nearly vertical nature, of the earthen dam...
also prevent passage by wildlife. Animals seeking to cross the highway at this point are funneled into residential or commercial areas, at which point they must cross over the pavement to pass the highway. From the standpoint of fish and wildlife passage, this site is likely one of the worst along the length of Highway 93.

36. Spencer Lake Corridor (Milepost 230)
Vehicle collisions with deer are common in this corridor, and thus a potential safety hazard exists for motorists. Large-animal crossings could reduce this hazard. Most collisions are with white-tailed deer, but mule deer, elk, moose, and black bear also cross in this area. Safe passage for small mammals, mid-sized carnivores like coyotes, amphibians, and turtles is also a concern here.

37. Lower Stillwater Lake Corridor
(Milepost 235) Collisions with deer are common here, apparently associated with forested patches near the road sought by deer when trying to cross Highway 93. Most collisions are with white-tailed deer, although black bear and moose habitat exists on both sides of the highway. Of note are Common Loons nesting on Stillwater Lake.

38. Stillwater State Forest
(Milepost 244) Large carnivores like grizzly bear, gray wolf, mountain lion, and black bear exist in the Stillwater State Forest and adjacent National Forest lands. Mid-sized carnivores such as lynx, wolverine, American marten, bobcat, raccoon, striped skunk, and coyote also inhabit the area. Small mammal habitat is present in both forested uplands and wetland habitats. A variety of amphibians use this area, and Western painted turtles occur in surrounding wetlands. Public lands surround Highway 93 in this area and thus this segment has significant potential as a linkage for the species listed above.

39. Upper Stillwater River
(Milepost 258) The Upper Stillwater River provides important habitat for cutthroat trout, bull trout, and other species. Fish passage under this bridge appears to be adequate. Wildlife considerations include large carnivores like grizzly bear, wolf, mountain lion, and black bear. A variety of mid-sized carnivores use this area, including aquatic-associated species such as otter, raccoon, and mink as well as more terrestrial species such as lynx, wolverine, American marten, coyote, and bobcat. The area is also an important crossing for white-tailed deer, mule deer, elk, and moose. The current bridge does not provide adequate space for the passage of medium or large animals, and during high flows even small animals would be precluded from crossing under the bridge.

40. Summit Creek
(Milepost 259) Summit Creek has a number of interesting wildlife attributes. It is an important linkage area for many species, including wolf, grizzly bear, black bear, and mountain lion. Mid-sized carnivores known to cross at Summit Creek include lynx, wolverine, bobcat, American marten, and coyote. Vehicle collisions with deer (white-tailed and mule) are common in the Summit Creek area. Elk and moose are also present and would be expected to cross Highway 93. The U.S. Forest Service manages the land around Summit Creek.

41. Murphy – Dickey Creeks
(Milepost 263) Driving can be hazardous in this area because deer are frequently encountered on the highway. In fact, deer are more frequently killed on Highway 93 in this area than in nearly any other segment of the highway. Most are white-tailed deer, but mule deer also frequently cross this portion of the highway. Other large ungulates include moose and elk. Both large and mid-sized carnivores use habitat on both sides of Highway 93. These include black bears, grizzly bears, mountain lions, wolves, bobcats, lynx, wolverine, coyotes, raccoons, striped skunks, otter, mink, and American marten. Many species of small mammals, amphibians and reptiles (including turtles) are present. This is a linkage area for all the above species. Other concerns include: common loons and bald eagles that use habitat adjacent to Highway 93, the presence of rare plants, and fish passage in Dickey Creek.
Fig. 4. Linkage areas along the third segment of Highway 93 from Jette Hill to Happy Valley. For details, see corresponding numbers in text.
Fig. 5. Linkage areas along the fourth segment of Highway 93 from Whitefish River to Tobacco Plains. For details, see corresponding numbers in text.
42. Deep Creek (Milepost 268) Small mammal and amphibian passage are considerations. Vehicle collisions with deer are common, and this area can be hazardous for motorists.

43. Graves Creek (Milepost 270) Bull trout use Graves Creek, and the existing bridge provides good fish passage. White-tailed deer, mule deer, elk, moose, black bears, grizzly bears, wolves and several common mid-sized carnivores like coyote, bobcat, raccoon, and mink also use this area. However, passage under the bridge is likely difficult or impossible for most of these species as the bank is narrow and heavily rip-rapped. The fencing along the road likely imposes an additional barrier to the movement of animals. Except during periods of high stream flow, small mammals and amphibians using the riverine habitat along Graves Creek can probably cross under the west side of the bridge.

44. Mud Creek – Terrialt Creek (Milepost 273) Fish passage is a concern for bull trout and other trout, as well as mountain whitefish and sculpin. Large mammals that utilize habitat in the Mud Creek and Terrialt drainages include white-tailed deer, mule deer, elk, moose, black bear, grizzly bear, coyote, bobcat, and mink. Providing habitat connectivity for small mammals and amphibians should be considered. Vehicle collisions with deer and other animals in this section of Highway 93 are a concern. Providing deer crossings could reduce this road hazard to motorists and provide safe crossings for many wildlife species.

45. Lick Creek (Milepost 274) Vehicle collisions with deer are common. Measures should be considered to reduce this hazard to animals and motorists. Small mammals and amphibian passage are also concerns. A unique wildlife value in this area is the presence of a large number of wild turkeys. The adjacent area is private land.

46. Sinclair Creek (Milepost 277) Concerns here include fish passage and passage for small mammals and amphibians.

47. Indian Creek (Milepost 281) Passage for fish, small mammals and amphibians is a concern.

48. Tobacco Plains (Milepost 283) Much of the northern portion of Highway 93 is surrounded by relatively dense forests, but this area is unusual in that the surrounding country is open. Elk move between the Whitefish Range to the east and the forested areas along Lake Koocanusa to the west, but additional study is necessary to determine if elk crossings are feasible.

Discussion
The purpose of the project was to develop a relatively fast and cost-effective process to assess wildlife and fish habitat linkages on highways. The authors believe this process accurately provides a mid-scale assessment as to where wildlife and fish crossings are beneficial. It also provides other information critical to state-of-the-art wildlife and fish management, such as where various kinds of mitigation projects could be desirable, wildlife habitat linkages on public and private lands and the feasibility of providing long-term management of wildlife linkage habitat based on private land ownership patterns. It also provided one of the first examples of wildlife linkages along an entire highway length within a large state. This information is already being used by Montana Department of Transportation for planning future highway projects and by Federal Highway Administration and several other agencies in a “programmatic” mitigation prototype. Montana Department of Transportation is...
looking into the feasibility of doing a similar analysis for all western Montana highways. If this is successful, all highways in Montana may be assessed. The authors believe state and federal transportation planning in all areas of the United States and Canada would benefit from similar efforts. Understanding how highways affect wildlife and fish habitat fragmentation, wildlife mortality, highway safety and which species are affected in specific locations are essential information to coordinate highways with ecological factors. Beforehand knowledge of where these areas are is critical to keeping highway costs down. Planning for wildlife and fish crossings at early transportation planning phases is the most cost-effective way to integrate these factors and is the essence of most streamlining approaches. Involvement of appropriate wildlife, land management and transportation agencies at the inception of the highway planning process to determine wildlife and fish linkages is paramount for agency commitment.

Caution needs to be used when applying this process to the project phase – that being the actual placement of wildlife and fish structures on highways. Additional review of the site is necessary to ensure that the GIS models accurately depict the present situation. Past experience indicates wildlife use of structures is optimized by putting the correct type of structures in exactly the right locations. Site-specific wildlife information that may be required includes track surveys, remote cameras, sightings, road-kill data or radio telemetry. For fish and aquatic species, it is important to check for upstream or downstream barriers that could negate appropriate passage on highways.

Another issue is the use or misuse of the assessment information and conclusions. Every effort was made to do a professional assessment based on the best biological and physical data available, as well as knowledgeable biologists. Neither GIS data nor people are infallible. Also, this information is only one piece of many that transportation, wildlife and land management agencies must use in their decisions. Costs feasibility, social acceptance, landowner cooperation and other competing uses must also be considered and factored into the final decision. The product provided Highway 93 is a full range of feasible wildlife and fish habitat linkages for agency consideration. It would be quite remarkable if all of these wildlife and fish habitat linkages came to pass. Some habitat linkages are more important than others. The written descriptions provide direct information relevant to priorities, but no prioritization was attempted.

There is a number of ways wildlife and fish habitat linkages can be assessed. Some rely on computerized models and rigid criteria. Some are based on “professional judgment” or data collected on site for wildlife crossing patterns. This process maximizes the use of available GIS data and models and uses this information with an expert panel. One of the recommended uses of the Rapid Assessment Process for Determining Potential Fish and Wildlife Habitat Linkages is to overlay this information with proposed state and Federal highway projects (these are usually referred to as state STIP’s).

It is quite certain that widespread use of wildlife and fish habitat linkage analysis would substantially improve the ecological coordination of most state and Federal highway programs. Future highway programs could provide both better highways and wildlife and fish habitat restoration. Highway programs could become major conservation partners with communities, counties, conservation groups, state and Federal wildlife and land management agencies. By cooperating and pooling resources these groups and agencies could bring far more resources to the conservation of important ecological areas. These partnerships are just beginning to develop. Let us hope that these alliances grow and mature in future decades.

**Biological Sketches:**

*Bill Ruediger,* ecology program leader for highways, USDA Forest Service (200 East Broadway, Missoula, MT. 59807. Ph. 406-329-3100, E-mail: bruediger@fs.fed.us.) has 33 years experience working the USDA Forest Service in a variety of wildlife and fish positions. Other experience includes working with large and mid-sized carnivores, salmon, spotted owls and other threatened and endangered species issues.


References


Appendices

Appendix A. Data layers used in the GIS model (source in parentheses).

- National Land Cover Data (U.S.G.S.)
- Shaded Relief (U.S.G.S.)
- Highway 93 location (U.S. Bureau of the Census)
- National Hydrography Dataset (U.S.G.S.)
- Land Ownership (Montana Natural Heritage Program)
- Elk Winter and Summer Range and Migration Areas (Rocky Mountain Elk Foundation)
- Mule Deer, Bighorn Sheep, and White-tailed Deer Range (Montana Fish, Wildlife, and Parks)
- Road-kill Data (Montana Department of Transportation, not publicly available)
- National Wetland Inventory (National Resource Information System)
- Rare and Special Resources (Montana Natural Heritage Program, not publicly available)
- Montana GAP Analysis (Wildlife Spatial Analysis Lab, University of Montana)
- Public Land Survey System (Natural Resource Information System)
- IRS Imagery (U.S.F.S.)
Appendix B. Species included in the analysis or mentioned in the text.

Species included in analysis:

<table>
<thead>
<tr>
<th>Species Included in Analysis</th>
<th>Species Mentioned in Text</th>
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<tr>
<td>Bull Trout <em>Salvelinus confluentus</em></td>
<td>Gray Wolf <em>Canis lupus</em></td>
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<td>Westslope Cutthroat Trout <em>Oncorhynchus clarki lewisi</em></td>
<td>Grizzly Bear <em>Ursus arctos</em></td>
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<td>Long-toed Salamander <em>Ambystoma macrodactylum</em></td>
<td>Fisher <em>Martes pennanti</em></td>
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<td>Tiger Salamander <em>Ambystoma tigrinum</em></td>
<td>American Badger <em>Taxidea taxus</em></td>
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<td>Western Toad <em>Bufo boreas</em></td>
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<td>Painted Turtle <em>Chrysemys picta</em></td>
<td>Bighorn Sheep <em>Ovis Canadensis</em></td>
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<td>Western Rattlesnake <em>Crotalus viridis</em></td>
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Other species mentioned in the text:

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<td>Striped Skunk <em>Mephitis mephitis</em></td>
</tr>
</tbody>
</table>
Appendix C. Linkage Area Selection Team Members:

**Southern Highway 93 Wildlife and Fish Technical Team**
Pat Basting – Montana Department of Transportation  
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