**Linking Colorado’s Landscapes**

Julia Kintsch (Phone: 720-946-9653, Email: julia@restoretherockies.org), Program Director, Southern Rockies Ecosystem Project, 1536 Wynkoop St., Suite 309, Denver, Colorado 80202

**Abstract:** In partnership with the Colorado Department of Transportation, the Federal Highway Administration, the Nature Conservancy, and Colorado State University, the Southern Rockies Ecosystem Project (SREP) launched Linking Colorado’s Landscapes in fall 2003. Linking Colorado’s Landscapes is a multifacet collaboration to promote wildlife linkages in the context of long-range planning. Phase I consisted of a statewide analysis of wildlife linkages, the objective of which was to identify broad linkage zones that facilitate movement for Colorado’s diverse array of wildlife species and to prioritize amongst them. Building upon linkage assessment methodologies used elsewhere, we developed a science-based approach integrating local and regional expertise (via a series of workshops) and computer modeling. Recognizing that connectivity is a function of individual species’ perceptions of suitable habitat and barriers in the landscape, a focal species approach was employed as the basis for linkage identification in both the workshops and the modeling. By integrating both qualitative and quantitative processes, we were able to produce a comprehensive biological assessment of the most critical wildlife linkages in the state.

In total, 176 linkages were identified via expert workshops, with additional linkages modeled for Canada lynx, gray wolf, and pronghorn. In prioritizing linkages for further analysis in Phase II, we also considered: the presence of local partners; stretches of roadway with frequent animal-vehicle collisions; planned transportation projects projected by CDOT through 2030; and the distribution of linkages across the state and their complementary contributions to landscape connectivity. Twenty-three linkages were selected and were grouped into 12 high-priority linkage complexes based on similarities in species usage patterns and geography.

Phase II of Linking Colorado’s Landscapes provides an in-depth assessment of each high-priority linkage. Based on this compilation of site-specific information, we will next provide recommendations for possible crossing structures, management alternatives, and other measures to improve permeability in these linkage areas. Phase II analyses include: an assessment of additional species that utilize the linkage; identification of specific crossings; an assessment of land ownership and management within the linkage; and an evaluation of existing natural or man-made features that facilitate or impair movement. The resulting linkage assessment packages and recommendations will be distributed in spring 2006 and will serve as a guide for the Colorado Department of Transportation (CDOT) and other local and regional transportation planners, community leaders, and conservationists working to develop more wildlife-friendly landscapes and transportation networks.

**Introduction**

Habitat fragmentation is now recognized as one of the greatest threats to biodiversity and the decline of species worldwide (Ehrlich 1986; Wilcove et al. 1998), a trend expected only to increase across the Southern Rockies (SREP 2004). Transportation infrastructure in particular is a significant cause of habitat fragmentation, with negative impacts on wildlife (e.g., Harris and Gallagher 1989; Maehr 1984; Reed et al. 1996).

Animals are frequently killed on roads as they move from one part of their range to another (Forman et al. 2003) or they may avoid roads altogether (Gibeau and Heuer 1996; Jalkotzy et al. 1997), limiting their habitat area and ability to fulfill certain needs. The impacts are pervasive—Forman (2000) estimates that 20 percent of the land in the U.S. is directly influenced by public roadways. In Colorado alone there are over 85,000 miles of roads administered by the state Department of Transportation, including 953 miles of designated interstate highways (CDOT 2004). In addition, there are countless miles of county, private, and Forest Service roads that further serve to fragment the landscape.

Mitigation to protect and restore habitat connectivity is both complex and costly. A broad, comprehensive landscape analysis provides the most efficient means for focusing conservation efforts in the most critical linkages. Linking Colorado’s Landscapes was designed to focus conservation efforts on areas of the landscape that provide important connectivity functions for native wildlife. The purpose of this work was to identify and prioritize wildlife linkages across the state of Colorado to promote safe passage for wildlife.

Linking Colorado’s Landscapes is a two-phase project led by the Southern Rockies Ecosystem Project (SREP) in collaboration with the Federal Highway Administration (FHWA), the Colorado Department of Transportation (CDOT), Colorado State University (CSU), and the Colorado Chapter of the Nature Conservancy (TNC), the Colorado Division of Wildlife (CDOW), the U.S. Fish and Wildlife Service, and the U.S. Forest Service.

**Phase I**

The primary objective of Phase I of Linking Colorado’s Landscapes was to identify broad linkage zones that facilitate movement for Colorado’s diverse array of wildlife species and to prioritize amongst them for further study. Building upon the methodology developed by the South Coast Missing Linkages Project (SCML) in California (Penrod et al 2001), we developed a science-based approach integrating local and regional expertise (via a series of workshops) and spatial analysis. Similar to SCML, Linking Colorado’s Landscapes evolved under the direction of a lead group (SREP) supported by an Executive Committee composed of representatives from CDOT, FHWA, CSU, and TNC. This seven-member team provided vision, guidance, and expertise throughout the project, as well as a foundation for additional collaborations in subsequent phases of the project.

The Executive Committee proposed a two-track methodology as a comprehensive approach to identifying and prioritizing critical wildlife linkages. This approach was designed to compile information from a variety of sources including
existing research on wildlife movement, local knowledge from agencies and other informed individuals, and spatial
modeling of predicted movement paths for several different wildlife species. By integrating both qualitative and quan-
titative processes, we intended to produce a more accurate and complete picture of the most critical wildlife linkages in
the state, highlighting clear priorities for further in-depth analysis in Phase II.

Recognizing that connectivity is a function of individual species’ perceptions of barriers in the landscape, we employed
focal species as the basis for linkage identification. We reviewed dispersal, home range, and habitat requirements of
numerous native species to select a comprehensive set of 28 focal species that captured the range of connectivity
needs. Maintaining our focus on a suite of focal species allowed us to concentrate our efforts while ensuring that the
linkages are appropriate for the species for which they are intended. These focal species guided linkage identification
in both the workshop and modeling tracks.

The goal of the workshop track in the two-pronged approach was to compile existing information and knowledge about
habitat and linkages for the selected focal species via a series of regional workshops. This track is analogous to the
first three steps outlined by Beier et al. (2005) for the SCML project (building a coalition; selecting core habitat patches
and prioritizing linkages; and selecting focal species), although we pursued a somewhat modified approach.

Rather than one statewide expert workshop, we elected to hold five daylong workshops at locations across the state
(Alamosa, Fort Collins, Meeker, Montrose and Pueblo). The intent was to encourage greater local participation and
allow more people the opportunity to contribute to the process. In addition, we used these occasions to host additional
information sessions to which local officials, planners and interested community members were invited. Each of the
workshops followed the same format, focusing on the primary goal of identifying linkage areas for the focal species
based on the expertise of the workshop participants, and compiling information about the functionality of each linkage
and its role in the landscape to prioritize the linkages. The information from these workshops was compiled and scored,
based on a prioritization scheme that evaluated conservation significance, opportunity and threat.

The second track (or ‘modeling track’) was incorporated as a parallel process designed to complement the expert
workshop track outlined in the scope of work. These analyses integrated layers of spatial data about the physical
characteristics of the landscape (e.g., topography, vegetation, roads, development etc.) with information about wild-
life-habitat preferences and movement patterns to model areas of the landscape that are key to wildlife movement.
Through this modeling, habitat patches and the multiple linkages between them were identified for gray wolf, Canada
lynx, and pronghorn.

Finally, we overlaid the highest-priority linkages identified by each track for large carnivores and ungulates. This
comparison provided the foundation for determining the location of the most critical wildlife linkages that are the
focus of the Phase II linkage assessments. In selecting high-priority linkages, the Executive Committee considered the
priority ranks from the two biological prioritization processes as well as several other factors: the presence of local
partners that are prepared to engage in these efforts and other feasibility considerations; stretches of roadway with
frequent animal-vehicle collisions; the location of planned transportation projects projected by CDOT through 2030;
the complementary contributions that each linkage offers to network connectivity across the greater landscape; and
the distribution of linkages across the state. All of these factors guided the selection of the final suite of 12 high-priority
linkages.

**Phase II**

The primary objective of Phase II is to provide in-depth analyses of each high-priority linkage, analogous to steps 4-7 as
described by Beier et al (2001), i.e. developing linkage design, providing management recommendations, and creating
implementation and monitoring plans. Linkage assessments identify additional species that utilize the linkage; identify
specific crossing locations; assess land ownership and management within the linkage; and evaluate existing features
that facilitate or impair movement. Based on this compilation of site-specific information, we can develop recommenda-
tions for possible crossing structures, management alternatives, and other measures to improve permeability in these
linkage areas. The resulting linkage-assessment packages and recommendations will serve as a guide for CDOT and
other local and regional transportation planners, community leaders, and conservationists working to develop more
wildlife-friendly landscapes and transportation networks.

Within each site, we characterize the roadway on its permeability (or lack thereof) relative to the suite of focal wildlife
species identified for each linkage in Phase I. These linkage assessments are not designed to provide long-term
analyses of wildlife movements through the linkage area. Instead, they are detailed snapshots that can act to define
future mitigation and monitoring priorities.

Site visits were conducted between June and August 2005. These roadway assessments were conducted along nearly
200 miles of highway in the identified high-priority linkage areas. Highway interference zones were identified where
each linkage intersected with a highway or interstate. For each linkage, the highway interference zone was defined by
easily-identifiable physical locations such that landscape-level wildlife movements across the roadways were
captured. We then characterized potential roadway barriers through the following variables: number of lanes, shoulder
barriers, median barriers, and other features. We also identified unique situations that could potentially serve as a
wildlife crossing locale. These situations were categorized into three types: 1) structures, 2) fill slopes, and 3) at-grade
crossing areas. Finally, we took note of all road-stream crossings and recorded the condition of the inlet and outlet, the substrate type, and vegetation cover.

Detailed information was collected for each situation type that was encountered. Structures were defined as any bridge or culvert that could provide a safe passage for wildlife species underneath the roadway. We also recorded locations of structures along each roadway designed to allow animals to escape the highway right-of-way such as one-way deer gates and ramps. Fill slopes were defined as any location where the roadway was elevated above the surrounding land. These locations typically occurred where the roadway bisected drainages, but were also common along topographic depressions lacking a hydrological component. While it was not uncommon to have some sort of drainage structure under the roadway to allow for water flow, these structures (typically corrugated pipes) are almost always under 1 m in diameter, thus forcing wildlife up the fill slope to attempt a surface crossing of the roadway. All other potential wildlife-crossing locations were designated as at-grade crossings. Unlike structure and fill slope locations, at-grade locations are not specific points along the roadway. Rather, they incorporate longer stretches of the roadway (typically 0.5-2 miles in length). These locations typically include stretches of roads that run parallel to drainages, places where a particular vegetation type comes up to the shoulder of the roadway, or choke points. These areas are also typically stretches of the road where there have been a high level of animal-vehicle collisions. For each situation, we measured a suite of variables unique to the situation type. We also recorded any incidental sign of species activity at each situation location. This included species use of structures, tracks and scat, game trails, and roadkill.

The information collected during these site visits provides the basis for understanding the current level of permeability through these linkages. Additional information about the landscape context is also essential to developing a comprehensive understanding of the linkage situation and opportunities for mitigation at specific crossing points within the linkage. For each linkage, the following information was compiled in the linkage assessment reports: vegetation, topography and landscape context; habitat and dispersal needs for each of the focal species; animal-vehicle collisions per half-mile (from Colorado State Patrol records); land ownership and management, zoning and lot sizes adjacent to the roadway; current and projected traffic volumes; speed limits; and general demographics of the nearby communities.

Following the site evaluation and information compilation, we developed preliminary recommendations to maintain and/or enhance wildlife movement across the roadway. Recommendations were based on the functionality and feasibility of implementation and were grouped into zones, highlighting stretches of highway within that larger linkage that provide clear opportunities and offer the greatest benefit to improved permeability. Recommendations were categorized into several categories: structural, fill slope, vegetation, barriers, aquatic, traffic awareness, and monitoring.

The next step in this process involves review of the linkage assessments by agency biologists and the development of specific recommendations for the key highway segments highlighted within each linkage. To facilitate these discussions, we will host a one-day workshop with a select group of CDOW biologists and engineers for the state and federal transportation agencies. The workshop has two goals: 1) review the key findings of the linkage assessments to further define the focal highway segments, and 2) for commonly found situations, facilitate collaboration between the biologists and engineers to discuss potential solutions that are both feasible from a design standpoint and ecological functional so as to adequately provide for species-movement needs.

The workshop will then be followed up with a series of site visits with regional engineers and biologists from CDOT, FHWA, and CDOW to evaluate the site-specific considerations at each crossing location. These recommendations will complete the final linkage reports (Spring 2006).

Implementation

Linking Colorado’s Landscapes does not end with the completion of Phase II. This is an on-going project, in which our focus narrows at every step until permeability is restored at the most critical crossing points. The Phase II linkage assessments provide important guidelines for achieving this goal. Based on the preliminary recommendations and other information compiled in the linkage assessments thus far, it is clear that there are numerous mitigation opportunities at existing structure locations. Such situations range from minor restoration and management to large-scale reconstruction of structure and include actions such as, the removal of sediment in a culvert; revegetation at the entrances to a structure; fence maintenance; excavation to enlarge clearance area through a structure; or enlarging existing structures to facilitate movement for a greater variety of wildlife species.

However, some situations will require the construction of new structures to overcome the fragmentation presented by highways. One such project is the proposed vegetated wildlife overpass at west Vail Pass in Eagle County, Colorado (Fig. 1). This pilot project would provide a safe passage for wildlife and help to reconnect populations for a variety of native wildlife including elk, moose, deer, mountain lion, black bear, and the recently reintroduced Canada lynx. In addition, the overpass would connect via eight-foot high fencing to existing span bridges, creating multiple crossing opportunities at more frequent intervals. This pilot wildlife overpass will have tremendous visibility on this heavily traveled route, giving the public an opportunity to experience its safety, visual appeal, and utility.
Figure 1: Photosimulation of proposed wildlife overpass on the west side of Vail Pass. Courtesy of Digital Animation Services.

An overpass is proposed as the structure of choice in this area because of the type of animals that will be using the structure, as well as the cost effectiveness in engineering an overpass. Constructing an underpass or span bridge would be prohibitively expensive at this location and would cause unacceptable traffic delays. The proposed overpass, on the other hand, would complement the already existing wildlife underpasses in this area, ensuring that wildlife have multiple options for crossing I-70.

Four independent studies have identified this location as a high priority for restoring connectivity through the spine of the Rockies. Additional site-specific monitoring will determine the exact location of the structure.

**Education and Outreach**

Animal vehicle collisions present a major safety hazard for both people and wildlife. Improving driver awareness is an essential component of any comprehensive efforts to reduce these types of collisions and improve landscape permeability. Because crossing structures are not feasible in many locations and wildlife will continue to be at risk of being hit by a vehicle, driver education and awareness is a major tool in preventing collisions with animals on all types of roads and in all locations.

To address these safety issues, SREP spearheaded Colorado Wildlife on the Move, an on-going driver education and outreach campaign which urges drivers to watch for wildlife on Colorado highways, particularly during migration seasons. A broad array of partners (including state and federal transportation agencies, as well as rental car companies, insurance companies and a non-profit insurance information organization) have come together in support of this campaign, highlighting the diverse community that is struck by the issue of animal-vehicle collisions. By capitalizing on the widespread concern about these issues, we can catalyze support for other restoration and protection measures that will help not only to create safer roadways, but also to improve the permeability of the landscape for our native wildlife.

In an effort to educate motorists about how to avoid dangerous and costly collisions, the campaign prepared a safety-awareness poster and driver-safety tip sheet that includes suggestions for how to avoid hitting animals. These posters and tip sheets have been distributed to rental-car offices, tourist-information centers, highway rest stops, motor-vehicle offices, Forest Service visitor centers and State Patrol offices.

**Biographical Sketch:** Julia Kintsch is the Program Director for the Southern Rockies Ecosystem Project and has been leading the Linking Colorado’s Landscapes project for two years. Julia holds bachelor’s degrees in environmental science and German from the University of Colorado at Boulder and a master’s degree in landscape ecology from Duke University. Prior to joining SREP, Julia worked as a conservation planner for the Michigan Chapter of The Nature Conservancy and was a Peace Corps volunteer in Senegal, West Africa. The Southern Rockies Ecosystem Project is a nonprofit conservation-science organization working to protect, restore, and connect ecosystems in the Southern Rockies of Colorado, Wyoming, and New Mexico.

**References**


THE MISSING LINKAGES PROJECT: RESTORING WILDLAND CONNECTIVITY TO SOUTHERN CALIFORNIA

Wayne Spencer (Phone: 619-296-0164, Email: wdspencer@consbio.org), Wildlife Ecologist
Conservation Biology Institute, San Diego, CA 92116

Abstract

In Fall 2001, the ground-breaking Missing Linkages report identified 232 wildlife linkages in California. South Coast Wildlands immediately spearheaded an effort to prioritize, protect, and restore linkages in the South Coast Ecoregion. We first forged a partnership with 15 federal and state agencies, conservation NGOs, universities, county planners, and transportation agencies. By partnering from the start (rather than developing a plan on our own and asking others to “unite under us”), we garnered spectacular support and are making rapid progress. With our partners, we:

1. Selected 15 priority linkages (out of 69 linkages in the ecoregion) on the basis of biological importance (size and quality of core areas served) and vulnerability
2. Held workshops to identify 12 to 20 focal species per linkage
3. Researched the needs of focal species, obtained high-resolution spatial data, and collected field data to develop a linkage design based on GIS analysis of movement of focal species
4. Made detailed recommendations for protecting key habitat parcels, creating highway-crossing structures in specific locations and land-use guidelines in and adjacent to the proposed linkages
5. Presented the design to partners who are now procuring easements and land, changing zoning, restoring habitat, and mitigating transportation projects

Arizona began a similar effort in 2004. One key difference is that the southern California effort is led by a small conservation NGO, while the Arizona effort is led by state and federal agencies, including the transportation agencies. The ultimate key to success is to streamline the Linkage Designs into transportation projects, land-use plans, and conservation plans (such as the state Comprehensive Wildlife Strategy). This collaborative, science-based, core-to-core approach promises not merely to slow the rate at which things get worse, but to actually improve connectivity over today’s conditions.

Biographical Sketch: Dr. Spencer is a wildlife ecologist with the nonprofit Conservation Biology Institute, which provides scientific expertise for efforts to conserve biological diversity. He specializes in the pragmatic application of science to improve ecosystem health, design and manage nature reserves, and recover endangered species. Dr. Spencer has helped create several multi-species conservation plans in California and serves as a science advisor to various governmental agencies and conservation organizations involved in conservation planning. He’s also performed or directed research on a variety of rare mammal species, including the critically endangered Pacific pocket mouse and Stephens’ kangaroo rat. Dr. Spencer has been a science advisor to the South Coast Missing Linkages project since its inception and serves as President of the Board of South Coast Wildlands.
The Swiss Defragmentation Program—Reconnecting Wildlife Corridors Between the Alps and Jura: An Overview

Marguerite Trocmé (Phone: 41-31-322-80-03, Email: marguerite.trocme@buwal.admin.ch), Senior Scientist, Swiss Agency for the Environment, Forest and Landscape, Nature and Landscape Division, CH 3003 Bern, Switzerland

Abstract: Switzerland has one of the densest infrastructure networks of Europe (3-4 km/km² on the Central Plateau). Fragmentation of natural habitats has become a major conservation concern as vulnerable species become rarer and the red list of endangered species becomes longer. The mortality of animals on roads remains high, with more than 8,000 roe deer killed yearly by traffic. Many amphibian spawn sites along lakeshore have been cut off from their wintering grounds by roads, with populations then disappearing. Highways have proven to be an impassable barrier for the lynx, impeding colonization of eastern Switzerland.

Switzerland participated actively in the COST 341 European research program “Habitat fragmentation due to transportation infrastructure.” A census of bottlenecks where infrastructure intercepts important wildlife corridors was carried out during this program. Fifty-one points needing restoration measures were identified. Many of these are along first-generation highways built along an east-west axis and cutting off any possible exchange between wildlife populations in the Alps and the Jura.

A ministerial guideline sealed a partnership between the Swiss Agency for Environment, Forests, and Landscape (SAEFL) and the Swiss Federal Roads Authority. The defragmentation program has been included in the highway-maintenance program and is to take place over the next 20 years. Five conflict points have been recently retrofitted in the context of highway-widening schemes.

A program methodology is being developed. Conflict points will be addressed as the involved highway section comes up for maintenance. In order to facilitate long-term planning, different instruments have been developed. Standards have been defined by the Swiss Association of Road and Transportation Experts (VSS 2004) to guide engineers and biologists in the analysis of existing structures and potential permeability for fauna. Criteria were developed to facilitate the choice of the optimal type of passage for each given situation.

Further research and standards are being launched to homogenize monitoring programs and develop best practice for retrofitting culverts, as well as to anticipate and eliminate wildlife traps created by certain structures.

Habitat Fragmentation in Switzerland

With 71,000 km of main roads and a total road length of more than 111,000 km, Switzerland has one of the densest infrastructure networks of Europe (3-4 km/km² on the Central Plateau) (Oggier et al. 2001). Figure 1 shows the high density of roads in the Swiss lowlands.

Figure 1. Road map of Switzerland showing main roads and county roads. (Reprinted with permission from: Bundesamt für Landestopographie BA4827)
Traffic Casualties Influence Wildlife Populations

More than 20,000 large mammal road casualties are counted every year (BUWAL, 2003). This affects a number of wildlife populations. For example, road casualties are responsible for 23 percent of the European lynx mortality in Switzerland (Oggier et al. 2001). The species was reintroduced in the 1970's and has yet to recover on a national basis. Highways have proven to be an impassable barrier for the lynx, impeding colonization of eastern Switzerland. To address overpopulation in the west, Lynx had to be captured and transferred to the east at high cost (Breitenmoser 1995).

As the red lists of endangered species in Switzerland lengthen, fragmentation has become a major conservation concern. Due to pressure on habitat, certain vulnerable species (such as the Capercaillie) have dwindled to small isolated populations. Infrastructure barriers complicate restoration efforts. Forests roads attract leisure activities, creating disturbances in once-tranquil habitats.

Along lakeshores, many amphibian spawn sites have been cut off from their wintering grounds by roads, with populations then disappearing (Ryser 1988). More than 1000 conflicts points where roads cross migration paths are known (Oggier et al. 2001).

Birds of prey also cause a high toll to traffic mortality. Almost 30 percent of known mortality of the Barn owl is along roads (Marti 1998).

Inventory of Environmental Bottlenecks

Switzerland participated actively in the COST 341 European research program “Habitat fragmentation due to transportation infrastructure” (Trocmé 2003). The goal of this European program was to describe in each participating country the extent of fragmentation, give an overview of measures used to address the problem and elaborate (on the basis of shared experience) a manual of best practices (Iuell 2004).

A survey of bottlenecks where infrastructure intercepts important wildlife corridors was carried out (Holzgang et al. 2001) during the COST program in Switzerland. The basis of this survey was a study of the main wildlife corridors. Hunting statistics and questionnaires to gamekeepers and huntsmen were used to map dispersal patterns of game, such as roe deer, red deer, wild boar, chamois, and ibex. A simple landscape-permeability model using a geographical-information system (GIS) was also used to define movement axes based on topography and habitat continuums. Figure 2 shows the extensive connectedness within Switzerland for terrestrial forest-dwelling wildlife.

The axes of movement are shown as broad green strips. The corridors are sections of the axes where wildlife movement is bounded permanently by natural or anthropogenic structures or intensive agriculture areas.

An overall assessment reveals that 47 (16 percent) of a total of a 303 supraregional wildlife corridors are now largely disrupted and impassable to wildlife. The functionality of more than a half is moderately to severely impaired (171 corridors; 56 percent). Approximately a third (85; 28 percent) can be classified as intact. A total of 78 supraregional corridors have been identified that need restoration in order to guarantee sufficient permeability between the Central Plateau, the Jura, and the Alps and provide an exchange between populations.

Figure 2. Overview of the wildlife corridors and axes of movement of supraregional importance showing Switzerland’s extensive network for terrestrial wildlife. Green is intact, orange is impacted, and red is interrupted corridors (source: Schweizerische Vogelwarte Sempach 1999).
Defragmentation Program

The wildlife corridor study has been embedded in a much larger strategy, namely a national ecological network (REN). The REN (Berthoud 2004) is based on available data of potential habitat (including existing nature reserves) and combined with the data from the wildlife corridors. The purpose of the REN is to optimize habitat connectivity by focusing habitat-upgrading efforts and ecological compensation in agricultural areas in the sites with most potential.

Inventory

The survey of the wildlife corridors showed 51 spots interrupted by infrastructure needing constructive measures to restore permeability. Many spots are along first-generation highways built along an east-west axis and cutting off any possible exchange for wildlife populations between the Alps and the Jura. The measures advocated go from simply planting natural structures leading up to existing mixed use passages to the full retrofitting of highway sections with fauna overpasses for large ungulates. The measures taken along transport infrastructure are to be coordinated with further incentives from the REN.

Figure 3 shows an extract of the Ecogis website (Ecogis 2003) where the inventory can be consulted by the public. The red striped area is a corridor interrupted by a highway. A viaduct allows animals through, but urbanization is encroaching on the passage.

Application of the inventory: sealing a partnership between nature conservation and road building

The inventory was published (Holzgang et al. 2001) and sent to all the regional authorities. A working group was set up on the federal level between the SAEFL and the Swiss Federal Roads Authority in order to achieve a consensus on what restoration measures were needed and how to initiate them. A ministerial guideline (UVEK 2001) followed. That guideline defined the width of fauna overpasses and the locations where retrofitting would be necessary. A standard width of 40 to 50 m was assigned for overpasses along corridors of supraregional importance with a possibility of narrowing the width to 20-30 m under special circumstances (topography, choice of species). These standards are based on a comparative study of 12 overpasses of different width and their efficiency for wildlife (Pfister et al. 1999). The study showed that between 20 and 50 m width, the frequency of use increases and then flattens off. Small passages were not as readily used.

It was decided to integrate retrofitting in the normal highway upkeep planning, with the result that the defragmentation program will be spread over a time period of 20 years.
A new transport master plan is being developed on the federal level. The inventory of the wildlife corridors is part of the baseline information which will be taken into account by future projects.

On the regional level, the corridor inventory is to be incorporated in the spatial-planning schemes in an effort to keep these corridors free from urbanization. To date, the inventory has been incorporated in 17 of the 26 cantonal spatial-planning schemes. Legally it is weighted only as a recommendation. Because the inventory remains non-binding for local communities, conflicts continue to arise.

However, a federal court injunction stopping a project interrupting a corridor has given new force to the inventory (BGE 2001).

**First results of the defragmentation program**
To date, five locations have been retrofitted: Grauholz (BE), Neu-Ischalg (BE), Birchiwald (BE), Baregg (AG), and Hirschsprung (SG).

Like the passage shown in figure 4, most of these locations have benefited from transport infrastructure-widening schemes. In such cases the new over- or underpass is part of the environmental-impact study and financed through the infrastructure-building project.

![Figure 4. Neu-Ischlag in Canton Bern. The 50-m-wide overpass spans both the existing highway and a new high-speed train line. Photo courtesy of Tiefbauamt canton Bern.](image-url)
Figure 5 shows the mitigation measures chosen for the T10 road-widening project in the three-lake district (see figure 3). The alignment was modified so as to permit the crossing of a watercourse with a high bridge. The old road was ground level and let the stream through a narrow culvert. The road stretch had been often fatal for European beaver, a species reintroduced in Switzerland and still vulnerable.

The highway shown in figure 3 by Cressier will soon undergo major maintenance work. The so called UPlaNS (maintenance plan) underwent an impact assessment (Aquarius 2004). Figure 6 shows the networking measures planned so as to guide wildlife to the viaduct through agricultural land. The project has not yet passed authorization because opposition from farmers has to be addressed.

Figure 5. The T10 between Morat and Neuchâtel cuts through important wildlife corridors. Appropriate mitigation measures such as this bridge replacing a culvert were taken. Photo courtesy of Marguerite Trocmé.

Figure 6. Maintenance program of the A5 includes mitigation measures for wildlife. Improving the efficiency of a viaduct by planting guiding structures. Reprinted with permission of Aquarius/BZA/30.6.2004 Document No AQ 80 308 80 8114.
Standards
To facilitate long-term planning, different instruments have been developed. Standards have been defined by the Swiss Association of Road and Transportation Experts (VSS 2004) to guide engineers and biologists in the analysis of existing structures and potential permeability for fauna. The standards were written by a mixed group of engineers and biologists and are based on the results of the COST 341 action.

A base standard SN 640 690a explains ecological networks and the impact of fragmentation by transport infrastructure in simple terms. For each project phase, standard SN 640 691a develops a standardized procedure that explains in which phase which studies need to be made so that specialists are integrated early enough in the project team.

Standard SN 640 692 focuses on permeability models, giving recommendations for the choice of priorities. The idea is to use (as much as possible) topography and related structures. Wildlife-mitigation measures need to be embedded as a clear concept in future ecological networks.

The last standard (SN 640 694) lists the possible mitigation measures with quality requirements. A selection grid should facilitate the choice of the optimal type of passage for each given situation.

Research
A standard procedure for wildlife-passage-monitoring programs is being developed by the SAEFL. Standard questionnaires will be asked for and results are to be stored in a central data base.

A three-phase approach will be tested. Phase A, just after construction, answers simply the qualitative questions of which species are using the passage. Phase B, two years later, looks at the frequency of use, if animals are actually crossing the structure and the influence on wildlife road casualties. Phase C, five to 10 years later, looks at the impact of the passage on wildlife populations. For each phase, best methods will be suggested (Fornat, Righetti, personal communication).

Further research and standards are being launched to develop least-cost practice for retrofitting culverts as well as to anticipate and eliminate wildlife traps created by certain annex structures of roads and rail.

Biographical Sketch: Born in Paris in 1961, Marguerite Trocmé grew up in Ottawa before moving to the U.S. and received her bachelor of science degree in biology from Brown University in Providence, Rhode Island in 1983. In 1985, a master’s degree in environmental engineering from the Ecole Polytechnique Fédérale (EPFL) of Lausanne, Switzerland followed. She then worked both for the Swiss World Wildlife Fund and the Swiss Ornithological Institute before joining the Swiss Agency for the Environment, Forests, and Landscape in 1989. She is responsible for the impact appraisal of federal infrastructure projects on nature and landscape. She was vice-chairman of the European COST 341 Project. She has led and edited studies and publications in the areas of the impact of high tension lines, roads, and aviation on natural ecosystems.

References


