Abstract: The author gives an overview in this paper of the span of mitigation measures now being used in Switzerland. Switzerland has one of the densest infrastructure networks of Europe (3-4 km/km2 on the Central Plateau). Linear transport infrastructure has an important impact on wildlife populations and natural habitats. More than 20,000 large mammal road casualties are counted every year. This affects a number of wildlife populations. For example road casualties are responsible for 23% of the European lynx mortality in Switzerland. As the red lists of endangered species in Switzerland lengthen, fragmentation has become a major conservation concern. First mitigation measures aimed simply at improving traffic safety by fencing in roads. The awareness that specific measures were needed to mitigate the barrier effect goes back to the 1970’s, when the Netherlands began building of badger tunnels under roads to reduce high mortality. In 1978 France published the first technical report on how help large game cross roads. However these first fauna passages were mostly undersized and were later found inefficient. Switzerland built its first overpasses in 1992 in canton Thurgau. These were of a width superior to 100 m. After years of scientific dispute over the size of theses passages, the COST 341 European research program "Habitat fragmentation due to transportation infrastructure" has published a handbook based on latest research results in Europe and giving optimal dimensions. A Swiss ministerial guideline has been published defining the width of fauna overpasses and setting the basis of a national defragmentation program. With better locations and dimensions more adapted to the target species, the new generation passages of about 50 m width are a success. Standards have been defined by the Swiss Association of Road and Transportation Experts to guide engineers and biologists in the analysis of existing structures and potential permeability for fauna. To date 24 fauna overpasses have been built in Switzerland. A survey of bottlenecks where infrastructure intercepts important wildlife corridors has been carried out. 51 points needing restoration measures were identified. The defragmentation program has been included in the highway maintenance program and is to take place over the next 20 years. 5 conflict points have been recently retrofitted in the context of highway widening schemes.
Habitat Fragmentation due to Linear Transportation Infrastructure: An overview of mitigation measures in Switzerland

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Habitat Fragmentation due to Linear Transportation Infrastructure: An overview of mitigation measures in Switzerland

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Abstract

The author gives an overview in this paper of the span of mitigation measures now being used in Switzerland.

Switzerland has one of the densest infrastructure networks of Europe (3-4 km/km² on the Central Plateau). Linear transport infrastructure has an important impact on wildlife populations and natural habitats. 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% of the European lynx mortality in Switzerland (Oggier et al., 2001). As the red lists of endangered species in Switzerland lengthen, fragmentation has become a major conservation concern.

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To date 24 fauna overpasses have been built in Switzerland. A survey of bottlenecks where infrastructure intercepts important wildlife corridors has been carried out (Holzgang et al., 2001). 51 points needing restoration measures were identified. The defragmentation program has been included in the highway maintenance program and is to take place over the next 20 years. 5 conflict points have been recently retrofitted in the context of highway widening schemes.

**Keywords**

fragmentation – fauna passage – wildlife corridors – … infrastructure
1. Impact of habitat fragmentation on wildlife 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). Linear transport infrastructure has an important impact on wildlife populations and natural habitats. More than 20'000 large mammal road casualties are counted every year (BUWAL, 2003).

A survey of bottlenecks where infrastructure intercepts important wildlife corridors was carried out (Holzgang et al., 2001). The survey is based on hunting statistics and questionnaires to gamekeepers and huntsmen permitting the mapping of 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.

An overall assessment reveals that 47 (16 %) 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%). Approximately a third (85; 28 %) can be classified as intact.

Fragmentation affects a number of wildlife populations. For example road casualties are responsible for 23 % of the European lynx mortality in Switzerland (Oggier et al., 2001). Highways have proven to be an impassable barrier for the lynx, impeding colonization of eastern Switzerland. To address over-populations in the west Lynx, had to be transferred at high cost to the east (Breitenmoser, 1995).

Many amphibian spawn sites along lakeshore 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 pay also a high toll to traffic mortality. Almost 30 % of known mortality of the Barn owl is along roads (VSE 1997).

To preserve wildlife populations, specially vulnerable species on the red list it is no longer sufficient to simply preserve prockets of prime habitat. Landscape connectivity is vital in order to permit exchanges between populations. Wildlife corridors need to be rehabilitated.
Figure 1 Overview of the wildlife corridors of supraregional importance showing Switzerland’s extensive network for terrestrial wildlife. Green are intact, orange impacted and red interrupted corridors.

Source: Schweizerische Vogelwarte Sempach 1999
2. A set of standards for mitigation measures

2.1 History of mitigation measures in Europe

The awareness that beyond fauna casualties, roads create also barriers for wildlife goes back to the 1970's. At that time in the Netherlands the Directorate-General for Public Works and Water Management started building tunnels for badgers (Bekker & Canters, 1997) under roads. These were accompanied with fencing and have proven to be very effective at limiting mortality.

In 1978 France published the first technical report on how to help large game cross roads (CTGREF, 1978). However these first fauna passages were mostly undersized (under 15 m in width) and were later found inefficient for big game.

2.2 A turning point: COST action 341

The handbook underlines the best practice principles of avoiding in priority new fragmentation (B). When avoidance is impractical then mitigation measures are to be integrated in the project as to restore at best biological connectivity (C). Compensation measures may be needed to reduce residual impacts (D).

The European Handbook develops a catalog of mitigation measures, explaining in what situations their use is appropriate. Measures permitting to reduce the barrier effect such as overpasses and underpasses are distinguished from measures aiming at the reduction of animal mortality, with fences, warning signs and the adaptation of infrastructure.

It was found that the efficiency of measures was partly species and habitat dependent. What seemed to work in certain conditions did not always apply for other conditions. For example the European hare or wild boar appeared to accept certain types of passages in the Mediterranean region that are not accepted in central or northern Europe.
With the TREN planning more than 23,000 km (comm. 7.12.05) of transportation infrastructure across Europe, fragmentation and its mitigation have moved high in the European agenda. COST Action 341 was launched in 1998 uniting the efforts of 15 countries to bring together state-of-the art knowledge and produce an European handbook on wildlife and traffic – identifying conflicts and designing solutions (Iuell, 2003).

With the knowledge gained from COST 341, the new generation passages are successful. Locations are carefully chosen and dimensions adapted to the target species. The dimensions of wildlife overpasses vary depending on target species and topography with an average at about 50 m in width. More than a 120 wildlife overpasses have been censused through Europe (Trocmé et al.).

### 2.3 New guidelines and standards for Switzerland

COST 341 offered a basis in Switzerland for a standardization of the approach to fragmentation problems in transport infrastructure planning.

A working group was set up on the federal level between the Swiss Agency for the environment and the Swiss Federal Roads Authority. A ministerial guideline (UVEK, 2001) set a standard width of fauna overpasses that could receive federal funding. 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 significantly and then flattens off. Small passages under 20 m width were not readily used. Therefore a optimal width of 40 to 50 m was assigned for overpasses mitigating transport barriers through wildlife corridors of supraregional importance with a possibility of narrowing the width to 20-30 m under special circumstances (topography, species).

Following the ministeral guideline on overpasses it was decided to create general standards for all types of passages to guide engineers and biologists in the analysis of existing structures, potential permeability for fauna and the choice of mitigation measures. The standards were written by a mixed group of engineers and biologists of the Swiss Association of Road and Transportation Experts (VSS 2004) and are based on the results of the COST 341 action. A base norm SN 640 690a explains ecological networks and the impact of fragmentation by transport infrastructure in simple terms. Norm SN 640 691a develops for each project phase a standardized procedure, explaining at what point which studies need to be made, so that specialists are integrated early enough in the project team. Norm SN 640 692 focuses on permeability models, giving recommendations for priorities when choosing a new route. The idea is to use as best possible topography and related structures. Wildlife mitigation measures are to be embedded in a clear concept of future ecological networks. The last standard SN 640 694 lists the possible mitigation measures with quality requirements. A selection grid facilitates the choice of the optimal type of passage for each given situation.
3. **Overview of mitigation measures in Switzerland**

The VSS standards clearly differentiate between fauna specific passages and non specific passages, also called mixed-use passages. If the first are built specifically designed to address the needs of wildlife with human access prohibited, the second use existing agricultural over- or underpasses. The fauna specific passages have a high success rate. The mixed-use passages are unaccountable.

The narrowness and darkness of agricultural road over- or underpasses repel most species. However with some adjustments, such as a green stripe or a unpaved surface, they can be adapted for the use by the less demanding species, such as fox, marten and sometimes local roe deer. The adaptation of existing infrastructure can decrease the overall barrier effect by enhancing local exchanges of animals such as fox, marten and other small mammals.

Large overpasses are needed when main wildlife corridors are affected and for demanding species such as wild boar, red deer and brown hare. The VSS standards develop criteria to guide the choice of the most appropriate measures. The selection of the most appropriate measures depends on the habitat affected and target species. In general a combination of different kinds of passages targeting different needs is necessary.

**Figure 3** Mixed-use passages: an agricultural road with a green stripe provides passage for small animals. A badly designed underpass for forestry need is shuned by most animals, except fox and marten

Source: Photo to the left A. Righetti, photo to the right M. Trocmé
3.1 Underpasses

3.1.1 Culverts, bridges and viaducts

Culverts are classified among the mixed-use passages and are the most frequent underpasses. It is essential that they guarantee the passage of aquatic and terrestrial animals. In the past, theses structures were often poorly designed, with obstacles for fish and no dry ledge permitting terrestrial animals to follow the stream. A small culvert is sufficient for the local exchange of small animals. A bridge is necessary when multiple species are targeted, with large game and/or particularly vulnerable species such as the European beaver.

Figure 4 Two types of wildlife underpasses: To the left a minimal stream culvert with dry ledges for terrestrial animals under a new high speed railtrack. To the right a bridge spans a stream along a supraregional wildlife corridor along the T10 between Morat and Neuchâtel, where many collisions had affected the European beaver as well as wild boar, creating safety issues for motorists.

Source: photo M. Trocmé
Figure 5 An optimal design for a mixed use underpass permitting continuity of the streamside ecosystem.

Source: Drawing from EIS N16 Tavannes-Court, Bureau Natura, Les Reussilles

Only wide bridges and viaducts are able to actually avoid fragmentation. The choice of these structures rather than embankment permit to reduce overall fragmentation. Mixed-use stream underpasses do not completely avoid fragmentation, but are permeable to a number of species. Natural habitat should be restored underneath after construction. This depends on the height of the bridge, whether light and rainfall reach underneath. In any case landscaping needs to be carefully planned below so as to attract wildlife.

Figure 6 Two viaducts: on the left the A5 lacks undercover for small animals and is suboptimal for wildlife, on the right the A1 the natural setting is optimal and attractive to wildlife.

Source: Photo M. Trocmé
3.1.2 Fauna specific underpasses

Small animals with limited home ranges need the availability of regular passages. When culverts are rare the infrastructure can be supplemented with underpasses for small animals implanted at regular distances along the road. Diameter go from 60 cm to 1.5 m depending on target species.

Figure 7 Underpass for small mammals such as fox and badger

Source: Photo M. Trocmé

Installations designed to protect amphibians constitute a special case among wildlife passages. The very specific behavior of these animals in relation to the environment and in particular, the road, has made it necessary for complex guiding structures to be developed. Also amphibians are sensitive of drying out, so that long dry tunnels are unsuitable. Temporary measures can also be used with the setting up of fences and buckets at the migration periods.

Overpasses for large game are more suitable than underpasses. However topography may not always allow to build such passages. In this case a fauna specific underpasses can be used. The minimal height depends on the target species, and is for instance 3.5 m for roe deer. The optimal width is 15 m.
Figure 8  Underpass for large mammals under the A1

Source: photo M. Trocmé

Figure 9  Amphibian passage à Arcegno, Switzerland
3.2 Overpasses

Overpasses are necessary for larger game, such as roe deer, red deer or animals, such as the brown hare, that shun dark closed in spaces. A standard width of 40-50 m is recommended. The guiding structures to the overpass, such as hedges and other natural elements are important. The vegetation on the overpass should reflect the neighboring habitats. 24 such overpasses have been built to date in Switzerland.

Figure 10  Wildlife overpass over the A4 at Feusisberg

Source: photo Peter Schlupp)
3.3 Avoiding and reducing animal mortality

Measures reducing animal mortality were the first type implemented in Switzerland. The fencing in of highways began before first concerns over fragmentation. The motivation was driver safety. Fencing should only be used in combination with fauna passages, as otherwise it creates a completely ecological barrier. It is an important part of mitigation, helping to guide animals towards the passages.

Figure 11  Fencing for roe deer and wild boar along a swiss main road and railway leading to a wildlife passage. Fine mesh at the bottom is for amphibians.

Source: photo M.Trocmé

Other measures to reduce collisions have shown much little effectiveness. Warning signs are rarely headed and reflectors require much maintenance with low effectiveness. Other deterrents such as olfactory repellents have shown mixed results. Wildlife warning systms with sensors have shown excellent results in case where the wildlife corridor is narrow and exchanges well funnelled.

Other road or rail structures can also be a important source of mortality and need to be mitigated. Noise screens are an example. Transparent ones should be avoided or marked with verticla stripes to prevent bird collisions.
Figure 12  Transparent noise screen with vertical markings to prevent birds collision

Source: photo M. Trocmé
4. Beyond mitigation, promoting a national defragmentation program

The survey of bottlenecks (Holzgang et al., 2001) where infrastructure intercepts important wildlife corridors identified a total showed 51 spots interrupted by infrastructure needing constructive measures to restore permeability. Many 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.

A federal level working group between the Swiss Agency for Environment and the Swiss Federal Roads Authority (UVEK, 2002) 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 more than 20 years.

4.1 First results of the defragmentation program

To date 5 locations have been retrofitted: Grauholz (BE), Neu-Ischalg (BE), Birchiwald (BE), Baregg (AG) and Hirschsprung (SG).
Like the passage shown in figure 14, most of these 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.
Defragmentation also implies softer measures such as the ones suggested for the highway N5 by Cressier. This stretch will soon undergo major maintenance work. The so called UPlaNS (maintenance plan) underwent an impact assessment (Aquarius, 2004). Figure 15 shows the networking measures planned so as to guide wildlife to the viaduct through agriculture land. The project has not yet passed authorization as opposition from farmers has to be addressed.
4.2 Conclusions

Engineers and biologists have learned to work together and have developed an efficient array of mitigation measures permitting to address fragmentation problems. However fragmentation is already very extensive. Transport planning needs to take this into account and channelize new projects through existing infrastructure corridors in order to avoid new fragmentation. Beyond mitigation defragmentation is a priority. Success depends on careful spatial planning to keep wildlife corridors free of encroaching settlements or very intensive forms of agriculture. A multidisciplinary and wide-based approach is essential.
5. References


VSS (2004) Swiss Standards 640 691a to 640 694 *Fauna and Traffic*, VSS Seefeldstrasse 9, 8008 Zürich