

UC Davis

Recent Work

Title

Inventory and Typology of Fauna Passages on French Transport Infrastructures

Permalink

<https://escholarship.org/uc/item/3nh1n50v>

Authors

Bielsa, Sabine
Pineau, Christophe

Publication Date

2007-05-20

INVENTORY AND TYPOLOGY OF FAUNA PASSAGES ON FRENCH TRANSPORT INFRASTRUCTURES

Sabine Bielsa (+33 1-46-11-31-31, sabine.bielsa@equipement.gouv.fr) and

Christophe Pineau (+33 1-46-11-31-31, christophe.pineau@equipement.gouv.fr), Environmental Engineers, Technical Department for Transport, Road and Bridges Engineering and Road Safety (SETRA), Ministry for Transport, Infrastructure, Tourism, and the Sea, 46 Avenue Aristide Briand, BP 100, 92225 Bagneux cedex, Fax: 01 46 11 31 69 France
<http://www.setra.equipement.gouv.fr>

Abstract: French transport infrastructures network increased significantly since 1980th. The french roads network is one of the densest in the world, nearly 1 million kilometres long. Habitat fragmentation by transport infrastructure is recognised as one of the prime cause of eroding biodiversity in the industrialized countries. Providing links between habitats can directly reduce fragmentation. Thus, fauna passages need to be built to mitigate the increasing negative barrier effect of infrastructures on wildlife and maintain connectivity.

In 2000, 400 crossing structures (fauna passages and others structures of permeability) were inventoried on French transport infrastructures. In 2006, more exhaustive surveys listed 399 structures only in Nord-Pas-de-Calais and Picardie regions, both described in the present paper. Therefore, a tool becomes necessary to evaluate the transparency for wildlife of the whole French transport infrastructures.

The main objective of the study is to carry out a database to inventory the structures of transparency, define their effectiveness as fauna passage and share comparable information amongst transport stakeholders. This project responds to one of the actions of the linear transport action plan adopted by France in November 2005, planned within the framework of the preservation of biodiversity (French strategy adopted in 2004). The aim is the implementation of appropriate measures for preservation of biodiversity during construction, maintenance and exploitation phases.

In this paper, we describe the first stage of work conducted to identify the number and type of fauna passages (via-duct, bridge, pipe conduit, mixed, specific, overpass, underpass, etc.) on the French transport network (roads, railways and waterways). First results concern a pilot area - Nord-Pas-de-Calais and Picardie regions - which presented the most exhaustive data. They show many difficulties related to data heterogeneity, to old and partial data, and to distinguish structures and integrate them in the typology. Moreover, this step had to be delay because of the new management organization of the national road network (decentralization and reorganization of public authorities in charge).

Once the geo-localised database will be achieved, we will try to implement a monitoring system on field to specify the effectiveness of different types of passages. In addition, comparison between crossing structures map, biological corridor maps at departmental and regional scale, and non-fragmented territory map (MEDD, 2007) will allow us to identify future fragmentation black spots.

Introduction

One of the densest network in the world

The French roads network is one of the densest in the world with 1 million kilometres long, and an average of 1.8 km/km². 600.000 km of municipal roads and 380.000 km of departmental roads are managed by local authorities. 20.000 km of roads and motorways are placed directly under national authority, among which 8.000 km are conceded to private companies.

The railway network has 30.000 km of commercial lines primarily managed by RFF - Réseau Ferré de France (French Rail Network). It includes 1.550 km of High-Speed Link-HSL (LGV in French) (additional 450 km under construction), 16.104 km of double tracks or wider and 14.778 km of electrified lines.

The waterway network cover 8.500 km, primarily managed by Voies Navigables de France - VNF (French Inland Water, public organisation).

The expansion of the transport infrastructures greatly accelerate the habitat fragmentation, which is generally recognised as one of the prime cause of eroding biodiversity in the industrialized countries. Habitats isolated by barrier effect are "insularised", creating continental islands. A direct consequences for wildlife is an increase of mortality during migration, affecting the dynamic of the population. Examples of others consequences are habitat degradation, habitat loss, pollution, change of microclimate, increase or human activity around infrastructures.

According to the French strategy for biodiversity (adopted in 2004), which ambitious objective is to stop the depletion of biodiversity by 2010, a specific action plan was made for linear transport infrastructures and adopted in November 2005. Its purpose is the implementation of appropriate measures for preservation of the habitats and species during construction, maintenance and exploitation phases. In addition, it imposes the biodiversity preservation and ecological engineering training for staff in charge of infrastructures.

The present study carried out by SETRA responds to the plan's guideline no. 3 - "Knowledge of biodiversity" - which aim is to improve knowledge of biodiversity (fauna, flora, ecological corridors), according with those of the Ministry for Ecology. In addition, it also coincides with the more territorial ecological policies (region, county (French department), municipality) in favour of corridors conservation and rehabilitation.

The aim of the first step is to provide a tool improving biological connections on linear transport infrastructures, in particular by setting up a reliable database on crossing structures that can be use as fauna passages.

A clear improvement in fauna passages in France

When infrastructures alter biological continuums, fauna passages and other structures adapted to enhance their use by animals can mitigate the barrier effect of transport infrastructures. These structures, which must be adapted to the species encountered, have undergone numerous changes in France since their first built in the 60's (SETRA and CETE, 2006). Logic of conception have evolved from a logic of "game passages", based on road safety and cynegetic interest, to a much global approach of biodiversity conservation. In France, many innovative territorial policies are also locally developed in favour of an increase of the permeability concept, based on multiplication of fauna passages and adaptation of old crossing structures.

Every year, 200 to 300 serious accidents involving fauna on network (less than 1% of road fatalities on French roads) (SETRA data, 2005). Total collisions caused by large fauna are estimated at 20 000 a year (ONCF, 2005). It's worthy of note that the population of large wild mammals (stags, roe deer and wild boar) has increased fivefold since the 1980's. The crossing structures, which were initially designed as game passages, now satisfy a more wide-ranging demand for conservation of biodiversity while continuing to play their part in road safety.

With development of scientific knowledge and information about habitat fragmentation, density of fauna passages have increased in parallel of the significant increase of French transport infrastructures. In France, two handbooks published by SETRA for large fauna (SETRA-MEDD, 1993) and small fauna (SETRA-MEDD, 2005) have been published in order to provide the principles, methods and management processes helpful to define appropriate solutions for construction and maintenance of fauna passages.

1st generation of fauna passages (1960–1970)

Large fauna passages have been created a long time ago (figure 2). The first passage in France was built on the A6 motorway (in the forest of Fontainebleau, near Paris). These 1st generation of passages, undersized and often badly located were underused. Measures for fauna taken during 1960-1970's period responded to a necessity of maintaining habitat connectivity, but lacked of appropriate recommendations as those accumulated in existing handbook.

2nd generation of fauna passages (1970–1980)

Their features were improved but lacked of completion. Despite their well-adapted characteristics to large fauna requirements, they still lacked of attractivity and effectiveness (figure 3). In addition, new materials were tested (such as wood) with mitigated results.

3rd generation of fauna passages (1980–today)

The last generation show more suitable characteristics, forms, and roadsides. New forms such as "parabolic shape" (figure 4) designed to minimise the tunnel effect for large fauna are favourable to a wide range of species.

The small fauna is gradually take account since the 1980's. Pipes (Type I) designed for a large number of species show their effectiveness and are located every 300 metres (taking account of other structures usable by small fauna such as hydraulic widened passages, large fauna passages, agricultural or forestry passages). Specialized passages (Type II), are built for target species (otter, beaver) or a group of species (amphibian tunnels).

These structures can be used by several species, providing diversified crossing conditions.

The **notion of managing** fauna passages emerged only in the 1980's, with the first management plans that allow to check the effectiveness of measures. Experience has demonstrated the importance of monitoring and quality control to guarantee their sustainability and effectiveness and maintain their first purpose. Fauna passages are usually monitored by recording footprints wich provide indicators about the use of structures but not about the fauna behaviour. Photo- and video-surveillance offer interesting indications about the behaviour of animals using the structures. Currently, specialized passages are fairly well monitored, others more occasionally.

Significant progresses have been made in terms of location and construction of fauna passages. They are more integrated into the surroundings and built for local/regional target species in priority. Improvements need to be made about monitoring, roadsides facilities, their design and some methodological basis. In particular, it is recommended to erect fences as near as possible of the track to maintain a wide area for the animals, where vegetated roadsides may serve as movement corridor and habitat. They have an important function to guide the animals towards

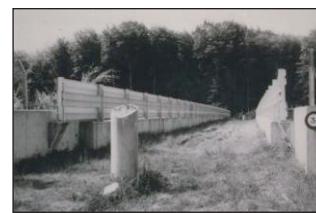


Fig. 2. 1st generation of fauna passages. Overpass at the A13.



Fig. 3. 2nd generation of fauna passages. Underpass at the A5.



Fig. 4. 3rd generation of fauna passages. Parabolic shape at the A36. (Source: SETRA and CETE, 2006)

passages. Similarly, the placing of screening parapets that ensure animal and human safety, may be of different forms and improve the effectiveness of the passages.

New materials reveal to be very interesting for the construction as well as economic. Prefabricated elements offer an interesting option for fauna overpasses due to their greater resistance to soil and vegetation weight pressure. In addition, they present a better water drainage system than vegetated bridges.

The Wood and Furniture Technical Centre (CTBA) project the construction of large fauna passage made with wood. A wood overpass is faster to erect and it's also a sustainable source that traps carbon dioxide (CO₂), one of the main cause of climate changes. However, technical specifications still need to be drawn up (durability, waterproofing, cost). Current and future constructions must ensure guarantees sustainable structures. Experiments are being made to test this new materials and their environmental impact (wood treatment).

A fauna passages network still little known

Surveys have been carried out across France during the last 20 years. The data on crossing structures (specific and potential), too old and/or partial, are insufficient to make a reliable assessment of the situation. Nevertheless, certain qualitative and quantitative items have been used.

In 2000, the number of crossing structures on French transport infrastructures was estimated at 400. In fact, 192 road passages and 12 railway passages could be inventoried in only 1/3 of France (Auvergne, Bourgogne, Franche-Comté and Rhône-Alpes areas).

The French transport infrastructure network continue to increase since 2000, so an additional assessment seemed necessary to evaluate the transparency for wildlife of the whole French transport infrastructures. Responding to the transport infrastructure action plan adopted by France in November 2005, planned within the framework of the national strategy of biodiversity, the aim of the present study is to locate fauna passages and specify the effectiveness. Comparison between locations of passages, biological corridor and non-fragmented territory will allow us to identify future fragmentation black spots.

This article describes the results obtained on a pilot area including the Nord-Pas-de-Calais and Picardie regions. First, we focused on main road and rail infrastructures, with an emphasis on the national network.

Methodology

Study Area

We focused only on conceded motorways, national roads, and new High Speed Lines - HSL. Waterways were not taking account in this paper. The departmental road network, that comprises recently built infrastructures, will be included soon. Additional results on national roads network recently devolved to the departments should be available later.

The study area investigated here, Nord-Pas-de-Calais and Picardie regions includes:

- National road network: 1.300 km of national roads managed by an Interdepartmental Highway Directorate (DIR); 800 km of conceded motorways managed by SANEF (private motorway company);
- High Speed Lines: 320 km between Paris and Lille, and Eurostar lines managed by Réseau Ferré de France - RFF (French Railways Network, public organisation);
- Waterways: 1.350 km managed by Voies Navigables de France - VNF (French Inland Water, public organisation).

Methods

The inventory of fauna passages uses different sources of data. A bibliographic inventory was made; database and asset management of the national roads (Infracoût, LAGORA...) were consulted. Seven CETE (Public Works Engineering Centres) interviewed the local infrastructures managers (Works Department Direction - DDE, DIR). The inventory of fauna passages located on conceded motorways was drawn up from surveys (see appended survey sheet) of the concessionary companies. RFF was contacted for similar information on the HSL network. The waterways were not specifically surveyed, the initial assessment being carried out using only biographical data.

Data were compared with old inventories, recently collected data and outputs retrieved from other databases. The precise location of fauna passages was confirmed with SETRA's geo-navigator (SIRNET). No quantitative comparison between the various transport networks was envisaged due to the disparity of the data. Indeed, the motorways or high-speed lines networks are recent infrastructures (motorways in the 60's; HSL in the 90's), whereas the other roads are essentially based on a very old network, as the Roman roads.

Identification of fauna passages types was made using the classifications contained in the French handbooks for large and small fauna (SETRA-MEDD, 1993 and 2005), and the European handbook *Wildlife and traffic - A European handbook for identifying conflicts and designing solutions* (luell and al. 2003). The structures taken into account include specific passages for wildlife but also other passages that could be used to restore ecological connections between habitats (mainly hydraulic structures) (table 1).

Table 1: Typology of fauna passages (SETRA-MEDD, 1993 and 2005, modified)

Type of passage	Structures	Typology		S/M	I/S	Structural characteristics of the passage				Fauna category*			
		RST*	Cost 341**			L (m)	l (m)	H (m)	Ø (mm)	PFa	PFb	MF	GF
Single passage	Duct, box culvert	I	7.3.4	S	I	<80	0.6 (box culvert)	1 (box culvert)	400-2000 (duct)				
Batrachian passage	Duct, box culvert with drainage collection system	II	7.3.7	S	I	<80	1 (box culvert)	0,7 (box culvert)	400-600 (duct)				
Combined passage (hydraulic passage)	Duct, arch, box culvert, bridge	III	7.3.5 7.3.1	M	I		1 medium=7						
	Submersible bench 0.4m	IIIa					=2	=2	=2				
	Bench 0.5-0.7m	IIIb						>0.7					
	Dry-standing areas 1.50m	IIIc					2<l<7						
	Extra widening of bank =3m	IIId					7<l<25						
	Dry pipe	IIIe							=600				
Agricultural or forestry passage	Bridge	IVa	7.2.2	M	I		<7 (incl. = 3m stabilized)	H>L/10 (min. 4m)					
	Bridge	IVb	7.3.3	M	S								
Large fauna underpass	Bridge	V	7.3.2	S	I		7<l<12-25	H>L/10 (min. 4m)					
Large fauna overpass	Bridge Parabolic shape	VI	7.2.1	S	S		7-12<l<25						
Viaduct	Viaduct	VII	7.3.1	M	I		>25	> 8					
Ecological bridge	Cut-and-cover structure Tunnel	VIII	7.2.1	S	S	>25							
Overhead passage	Open rope, walkway	IX	7.2.3	S	S					Climbing animals			
Ladder for canals	Ladders, ramps	Crossing structure		S	S		0.40-1.5	0.8-1.5					

Grey background: new types of structures identified in this inventory.

RST: Scientific and Technical network (RST in French).

Cost 341: Cost 341 Habitat fragmentation due to Transportation Infrastructure. Fauna and traffic.

S/M: Specific (dedicated) / Mixed (common).

I/S: underpass / overpass.

Fauna category: PFa: small land fauna avoiding underground environments

PFb: small and medium fauna using underground passages

MF: medium and large fauna

GF: large fauna

Usage of passages by fauna:

impossible	random	possible	optimal
------------	--------	----------	---------

Information Sheet

The density of fauna passages, their types (viaduct, bridge, duct, etc.), their specific purpose (multifunctional, large fauna, small fauna, etc.), their position (overpass, underpass), their dimension (length, width, diameter) and their management were collected. This step is necessary to assess the effectiveness of the structures, before a definition of appropriate solutions for construction or adaptation of the structures to increase the crossing by animals.

The information sheet used for the inventory of 2000 was modified to satisfy the requirements of the present study. All the data collected was first entered in a spreadsheet and will be soon entered in a geo-located database. The main interest of this tool is to share comparable information amongst transport stakeholders (structures of transparency, management, monitoring and modification). Three areas of interest were selected: identification and location of the structures, quantitative and qualitative characteristics and their monitoring and effectiveness. The effectiveness of the structures is not given here, but will be assessed later.

Results

A very exhaustive inventory was carried out by DIREN Picardie (Regional Environmental Agency) in 1997, collecting key information on the description of structures. It covered all types of infrastructure, including the waterways, which are not specifically surveyed here. Few additional data was collected during the inventory in 2000. In 2006, 399 structures have been inventoried, doubling the previous counting made in 1997 and 2000 (145) (table 2 to 4). These variations can be explained by a significant increase of prospecting effort rather than an increase of constructions. Thus, the structures brought into service since 2000 make up only less than 10% of the total inventory (table 3).

Conceded Motorways Network

The monitoring of structures located on conceded network (include in their statutory controls) provides detailed results on motorways. We can notice that the structures were gradually brought into service at the time of the construction of motorway sections: the A1 motorway in the 60's, the A4 motorway in the 70's, the A26 in the 80's, the A16 in the 90's, and the A29 in the 2000's. Almost all specific or mixed fauna passages of the SANEF network (60 structures) are (or have been) monitored in collaboration with hunting federations (public organisation). Screening parapets for overpasses, vegetated strips and recording footprints have been installed, thereby improving the effectiveness and the monitoring of structures.

The first wildlife-specific passages (type V or VI) were created in the 70's, with metallic pipes of 4 metres diameter. Current structures are more diversified and better suited to various types of fauna: parabolic shape 15 metres wide, cut-and-cover tunnels 800 metres wide for mixed use, creating an ecological bridge. The latest sections developed on motorways A16 and A29 guarantee great ecological transparency, in particular over valleys with construction of specialized passages or large viaducts (over 500 metres).

Table 2: Overview of fauna passages (mixed and specific) inventoried on Nord-Pas-de-Calais and Picardie transport infrastructures network

Source	Total number	Conceded motorways	Non-conceded motorways and national roads	Departmental roads	Railway tracks	Inland waterways
		(A)	(RN)	(RD)	(VF)	(VN)
RST inventory * (2000)	13	12	1	NC	NC	NC
DIREN Picardie inventory (1997)**	144	41	6	1	6	90
TOTAL Previous inventories (1997, 2000)	145	42	6	1	6	90
TOTAL Current inventory (2006)	399	201	77	4	27	90

*: Scientific and Technical network (RST in French)

** : DIREN Picardie, 1997. Inventory of fauna passages in Picardie

Table 3: Historical background when structures were brought into service on Nord-Pas-de-Calais and Picardie transport infrastructure network

Period	A	RN	RD	VF	VN	Total
1960-1970	14					14
1970-1980	14	3				17
1980-1990	71	13			15	99
1990-2000	78	12	1	27	35	152
Since 2000	24	3	3			30
Unknown		46			40	86

Table 4: Typology of fauna passages on Nord-Pas-de-Calais and Picardie transport infrastructure network – Current inventory (2006)

Name	RST Type	A	RN	RD	VF	VN	Total
Single passage	I						-
Batrachian passage	II						-
Mixed hydraulic passage	III	93 (01)	38	1	17 (2)		149 (03)
Mixed agricultural or forestry passage	IVa	41 (10)	27	1			69 (10)
	IVb	23 (18)			1 (1)		24 (19)
Underpass for large fauna	V	7 (7)	3 (3)	1			11 (10)
Overpass for large fauna	VI	13 (13)	3 (3)	1 (1)	2 (2)		19 (19)
Viaduct	VII	23 (10)	6		5 (1)		34 (11)
Ecobridge	VIII	1 (1)			2 (2)		3 (3)
Overhead passage	IX						-
Exits from waterways	X					90 (90)	90 (90)
Total		201 (60)	77 (6)	4 (1)	27 (8)	90 (90)	399 (165)

Grey: Wildlife-specific passages.

() : Number of structures effective for wildlife. Include only checked and available information. Remaining structures are potential structures; their effectiveness must be confirmed.

National Road Network

The recent decentralization and reorganization of public authorities in charge introduced a new national road network management system. Non-exhaustive data could be collected and further information should be provided in due course.

In the present state of our knowledge, 77 structures have been inventoried, including 6 passages (game, large or small fauna) having been monitored punctually. The state of other structures has not been estimated until now. The inventory includes agricultural or hydraulic passages (bridges or viaducts) that can be used by animals.

Departmental Road Network

No particular survey of the departmental road network has been carried out. The data solely comes from the recently decentralized network, an old network reserved for secondary traffic on which a very few number of fauna passage structures were built. No structure intended for mitigate habitat fragmentation has been inventoried on the old network; only few passages (in particular 2 specific passages, 1 parabolic-shaped overpass 18 metres wide) are located on recent infrastructures such as urban bypasses.

Railway Network

The construction of two HSL (LGV in French) in the 90's involved the creation of 27 potential structures for fauna passages. Height of which (2 specific and 6 mixed) have been monitored by departmental hunting federations. Two cut-and-cover tunnels and a specific passage 80 meters wide constitute remarkable permeability points. Many hydraulic structures are also included (17) but no data guarantee their effectiveness for fauna today.

Inland Waterways

There are no specific structures designed for fauna on inland waterways. Only adaptations of infrastructures have been built to prevent animals from drowning by offering exits (ladders, metal or concrete ramps).

90 fauna exits were just inventoried in 1997 by DIREN Picardie; no detailed description was made. The lack of animal mortality in the Nord-Pas-de-Calais and Picardie waterways suggests that fauna exits are effective, but results are not based on regular monitoring in situ.

Typology of Fauna Passages

The data obtained from the inventory of transparency structures for fauna in the Nord-Pas de Calais and Picardie regions enabled to test and adapt our previous typology (SETRA-MEDD, 1993 and 2005). A new type of over-pass, already described in a European handbook (luell and al. 2003, was added: the “overhead passage”. Fauna exit structures on waterways were also included as “ladder for canals”.

Most of the 400 structures inventoried in the Nord-Pas-de-Calais and Picardie regions are classified into type III (149 mixed hydraulic passages) and IV (93 agricultural and forestry passages). The ecological bridges type (VIII) is the fewest in number. Types I (single passage), II (batrachian passage) and IX (overhead passage) were not inventoried in these two regions.

Most of the hydraulic structures constitute potential crossing structures but have not been monitored. Their effectiveness must be proved yet. Similarly, types IVa and IVb (93 mixed agricultural or forestry passages) include many poten-

tial structures; only 29 have currently been identified as fauna passages. Out of the 34 inventoried viaducts (type VII), only 11 structures are recognized as fauna passages, whereas their dimensions would naturally be suited to great transparency.

Concerning the dimensions available, the span (width) of type V (underpass) varies from 2 to 10 metres (average noted in 2003: 7 m < width < 12-25 m), that of type VI (overpass) from 7 to 20 metres (average 2003: 7-12 m < width < 25 m) and is often parabolic-shaped. The cut-and-cover tunnels are 50-200 meters width, combine wildlife passages and human functions (road, agricultural or forestry tracks).

Managing and Monitoring the Passages

40% of the 400 potential fauna passages inventoried in the Nord-Pas-de-Calais and Picardie regions have been more or less diagnosed in terms of effectiveness (under 25% excluding exits from waterways). Specialized passages are particularly investigated and almost have been monitored: 11 of the type V, 19 type VI (large fauna passages) and 3 type VIII (ecobridges).

The management have been set up with an external manager (often the hunting federation or the ONF-French forestry commission), more particularly for structures on motorways. We have little information on maintenance of fauna passages.

Discussion and Conclusions

Inventory of Fauna Passages: First Results and Necessary Readjustments

The long-term purpose is to improve the effectiveness of the passages through a better conception, management and monitoring. The definition of appropriate measures guarantees minimum impact of the fragmentation by transport infrastructure.

The study consists in carrying out a geo-localized database that inventory the fauna passages (effective and potential) on French transport infrastructure networks in order to locate all crossing structures. This database will also contain information about their characteristics, which are used to identify the type of fauna passage, according to the French typology drawn up by the Scientific and Technical network – RST (SETRA-MEDD, 1993 and 2005).

The present paper describe the first bibliographical stage conducted on a pilot area - Nord-Pas-de-Calais and Picardie regions - who presented the most exhaustive data. The inventory, which began in 2006, has given a good picture of the transparency of the infrastructures, and have highlighted the difficulties to obtain reliable data.

The motorway concessionary operator, for instance SANEF was contacted during autumn 2006. Very exhaustive data on wildlife-specific passages were collected and supplemented with data on hydraulic passages as suitable structures for fauna crossing. The CETE survey, conducted at the end of 2006 did not provided enough data as a result of the new organization of management of the national road network (decentralization and reorganization of public authorities in charge). Data on the railway network was obtained solely from bibliographical sources. Supplements from RFF and SNCF should be provided shortly.

The available results of our inventory of fauna passages have given an overview of the quality of data, the pertinence of the typology of passages and showed the necessary readjustments to give a reliable inventory of transparency structures.

This work reveals the facility to obtain detailed characteristics on the specialized fauna passages but the inventory of other structures remains complex. The general approach to evaluate the transparency of the infrastructures must be carried on and extended. Indeed, monitoring is currently limited to specific passages, while other facilities (viaducts, hydraulic structures) offer real potential for wildlife crossing. On the other hand, non-specialized structures can be adapted to increase the probability to be used by animals. Thus, 150 hydraulic structures and 93 mixed structures could be modified in the pilot region.

The inventory have also showed that additional field data should be collected, in particular to define the effectiveness of the passages or to set up monitoring systems. In addition, it appears necessary to clearly identify local correspondents that would provide comparable information usable by all the various organisations in charge. The personnel in charge of managing the national road network will update in situ the future-computing tool. It will require the development of a software interface compatible with existing systems (concessionary system; national road network management system), which allow the addition of a fauna passage's parameters.

The first typology applied to mixed structures has shown the difficulties to make the classification due to the lack of precision of the available data. There remain some difficulties in distinguishing certain structures: distinction between the sub-types of mixed hydraulic passages (type III), or distinction between types IIId (hydraulic passage with extra widening of bank) and VII (viaducts). So, we have fixed a maximum width limit of 25 meters for type-IIId passage and grouped all the hydraulic passages in the generic class III (150 units concerned).

This first step of the project was based on inventories of potential crossing structures and on wildlife-specific passage monitoring. The subsequent steps will be extended to all structures that should enable us to confirm the benefits of non-specific structures (mainly hydraulic) for wildlife.

Preliminary questions that should be clarified

Some preliminary questions summarized in recent SETRA and CETE report (2006) still need to be clarified in this initial stage of the inventory process.

What objectives for fauna passage?

The question is how the fauna passage and other potential crossing structures are used. They must be used for daily crossings (frequent go back and forth), or only for occasional crossings of a few individuals.

What is the minimum rate of use to be considered effective?

To answer this question, we should first clarify the purpose of the structure. The objective of frequentation can be very low with only few animals crossing during the year, or more ambitious with a daily crossing. The definition of the level of effectiveness is therefore a delicate practise. Moreover, we have noted a technical limit of the monitoring tools; the recent development of video- or photo-surveillance systems could answer such questions.

Passages for which species?

Ungulates (stags, roe deer and wild boar) are usually chosen as target species for fauna passages. But these species are among the less vulnerable species, colonise a large area and some of them are even growing rapidly (wild boar and roe deer). Passages built for large fauna are clearly a suitable measure; however the transparency should be extended to all groups of fauna. In this new approach, the recommendations and methods established ten years ago for ungulates remain valid and should be expanded.

Frequency of passages?

The decision of the number of passages required remains a major question in planning measures. It depends on the behaviour of species (covering great distances or smaller areas).

For small fauna, one passage every 300 metres is recommended (catchment area is at most 200-300 m). However, their vulnerability and the type of area can reduce this interval up to 30 metres. The probability of joint-use of agricultural, forestry or hydraulic structures must be assessed, particularly for small fauna. For large fauna, in woodland or highly diversified landscape, a crossing passage must be available every 2 kilometres. This may appear a costly measure, but this additional cost can become acceptable when existing structures (forestry and hydraulic structures), which can effectively replace the overpass and limit their construction. It is recommended to prefer existing structures and improve their attractiveness for fauna, less costly than specific passages.

Acknowledgements: We would like to thank the environmental engineers Agnieszka Bugajska-Rouzeau (SANEF), Jean Noël Saussol (CETE) and Jean Carsignol (CETE) who have participate to this work. Agnieszka Bugajska-Rouzeau who provide data on conceded-motorways, Jean Noël Saussol who have surveyed national roads, and Jean Carsignol (CETE) who contributed to this paper by his experiences on fauna passages.

References

- CETE Est, SETRA and COST 341. 2001. Fragmentation de l'habitat due aux infrastructures de transports. Rapport de la France. (Habitat fragmentation due to transport infrastructures. Report from France). 170 pp.
- CETE Nord-Picardie and USTL. 1999. Les corridors biologiques liés aux problèmes de la fragmentation des espaces et des milieux naturels (tome 1). (Biological corridors and landscape fragmentation (vol. 1)). 85 pp.
- CETE Nord-Picardie and USTL. 2001. Les corridors biologiques liés aux problèmes de la fragmentation des espaces et des milieux naturels (tome 2). (Biological corridors and landscape fragmentation (vol. 2)). 45 pp.
- MTETM. 2005. Stratégie Nationale pour la Biodiversité. Plan d'action infrastructures de transports terrestres. Novembre 2005. (French Strategy for Biodiversity. Action plan for linear infrastructures (roads, railroads, navigable waterways). November 2005.). 19 pp.
- SETRA and MEDD. 1993. Passages pour la grande faune (Passages for large mammals). 121 pp.
- SETRA. 1996. Instruction, Prise en compte de l'environnement et du paysage dans les projets routiers. (Recommendations and factoring environment and landscape into road infrastructure project). 61 p.
- SETRA and MEDD. 2005. Aménagements et mesures pour la petite faune (Facilities and measures for small fauna). 264 p.
- SETRA and CETE Est. 2006. Route et passage à faune. 40 ans d'évolution. Rapport. (Roads and fauna passages. 40 years of change. Report). 57 p.
- DIREN Picardie. 1997. Inventaire des passages à faune en Picardie (Inventory of fauna passages in Picardie). 140 p.
- Iuell, B., Bekker, G.J., Cuperus, R., Dufek, J., Fry, G., Hicks, C., Hlaváč, V., Keller, V.B., Rosell, C., Sangwine, T., Tørsløv, N., and B. le Maire Wandall. 2003. Cost 341 - Habitat fragmentation due to Transportation Infrastructure. Wildlife and traffic. A European Handbook for identifying Conflicts and designing solutions. 20 p.
- Cramer, P.C. and J.A. Bissonette. 2005. Wildlife crossing in North America: The state of the science and practice. In Proceedings of the 2005 International Conference on Ecology and Transportation 9: 442-447.
- ONCFS. 2005. Réseau ongulés sauvages (Wild ungulate network). Newsletter 10. 11 pp.
- VNF. 2004. Statistiques de la navigation intérieure (Inland navigation statistics) 2004. CD-Rom.