ASF BIODIVERSITY CONSERVATION PROGRAMME

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ABSTRACT

The leading cause of biodiversity erosion is habitat fragmentation. Connectivity barriers created by linear infrastructure such as motorways are one contributing factor.
ASF has initiated a biodiversity conservation programme aimed at studying regional ecosystems, understanding motorway impact and implementing upgrades designed jointly by stakeholders.
In the first part of the programme, the ASF Infrastructure Technical Department drew up an analytical method based on landscape ecology, GIS tools and government studies.
The second part of the programme then got under way in June 2009. It covers 420 km of the 2,633 km ASF network and focuses on five French departments.
This is the first application of the "Green and Blue Network" called for by the French Grenelle Environment Forum.
The programme is overseen by a Scientific and Technical Committee set up by ASF.
ASF will be investing €15 million to carry out 19 upgrades, including construction of ecoducts, culverts and hydraulic structure benches; conversion of motorway overpasses to dual road / wildlife crossings; creation of a fish ladder; and testing of experimental systems.
Biodiversity conservation upgrades are an integral part of sustainable motorway design. They offer a way to adapt motorway infrastructure to the changing needs of regions as they develop.

1. BACKGROUND AND ISSUES

Biodiversity determines our quality of life, sustains planetary equilibria and constitutes a crucial guarantee for the future.
But around the world, biodiversity is eroding. The leading cause of this erosion is habitat fragmentation. Linear infrastructure such as motorways, which create barriers across the areas through which they run, are one of the factors.
In France, The Grenelle Environment Forum and the Green and Blue Networks call for infrastructure to take on board the need to conserve outstanding natural environments (biodiversity cores) and the biological communication corridors that link them.
The pro-active Grenelle Environment Forum process set up by the French government is covered by two laws, the second of which sets out a framework for implementing these Networks across France.
The Green and Blue Networks made up of biodiversity cores and corridors conserve biodiversity by maintaining and restoring ecological function.
By 2012, Green and Blue Networks will have been set up across France, influencing future infrastructure projects. Existing infrastructure will also have to be upgraded.
Motorways remain a visible part of the landscape and constitute a good starting point for restoring ecological connectivity and establishing synergies with effects reaching far beyond the motorway perimeter fence.
But while motorways generate unintended harmful effects, their land take can also in some cases constitute refuges and even longitudinal corridors for wildlife. It is therefore essential that all impacts, both negative and positive, be identified.

How can existing motorways be upgraded to protect biodiversity and adapted to the ecological needs of the surrounding regions?
To answer this question, two major difficulties will have to be resolved: i) we must be able to identify the sectors to be upgraded among the thousands of kilometres of existing motorways; ii) the upgrades must take on board the constraints of the motorway in operation, be accepted locally and be consistent with expected future regional development.

2. A TWO-STAGE METHOD

As a responsible motorway developer, ASF (Autoroutes du Sud de la France) included biodiversity in its overall environmental policy along with such issues as water, air and noise.
ASF, which has always paid particular attention to blending its motorways into their landscapes, is now focusing on solving difficulties relating to the restoration of ecological connectivity and on providing impetus for a biodiversity programme aimed at promoting sustainable regional development.
The ASF biodiversity conservation programme thus has two complementary objectives:

- To develop a spatial analysis methodology for identifying sensitive motorway sections along its 2,633 kilometre network;
- To implement concrete conservation projects in five French geographical departments that include field studies, stakeholder consultations, implementation of jointly designed upgrades and follow-up monitoring of the latter over time.

In aiming to achieve the first objective, ASF worked on the assumption that the use of multi-disciplinary landscape ecology science and a cross-comparison of available GIS databases would make it possible to develop a standard method adapted to linear infrastructure.

In targeting the second objective, ASF's basic assumption was that by working with local stakeholders and restoring ecological connectivity at several sites, it would be possible to initiate a process, demonstrate the feasibility of such projects and impel a broad move to upgrade existing infrastructure. In addition, the concrete projects carried out at pilot sites would test the efficiency and effectiveness of the methodology established in the first part of the programme.
Aware of the importance of carrying out ecological upgrades to adapt motorways to the life of the regions through which they run, ASF sought to meet a number of criteria in order to achieve these objectives:

- The development of the spatial analysis methodology and the ecological conservation programme in the five French geographical departments was to be carried out under shared scientific oversight.
- All effects generated by the motorway were to be taken into account to avoid focusing on the best-known impacts such as the infrastructure's barrier effect on large wildlife species. The focus was therefore to be on studying all biological pathways to identify impacts on infrequently studied groups of species, such as insects.
- The work was to use existing references such as COST 341 [1] and recent work on the Green and Blue Networks and the corridors already mapped in that context.
- The principles underpinning the work were to be reproducible, so that they can be applied to a long-term programme and ultimately used by other stakeholders.
- Lastly, the emphasis was on consultations with a broad group of stakeholders, since local acceptance inevitably determines the long-term effectiveness of the programme.

2.1 Spatial analysis of the motorway network as a whole

The first part of the programme, which got under way at the end of 2008, consisted in developing the analytical methodology based on landscape ecology, GIS tools and the recommendations of the Green and Blue Network Operations Committee (COMOP) [2].
This methodology, worked out in-house by the ASF Infrastructure Technical Department, was then published as a guide [3] for circulation to and use by other stakeholders.
The method makes it possible to identify sensitive sections of the network, determine needs and draw up a preliminary estimate of the work required.
There are four main stages:
i) Cross-comparison of various layers characterising the area studied: linear transport infrastructure, hydrographic data and protected inventoried natural areas. This information is used to draw up a provisional list of sensitive motorway sections.
ii) Use of the European “Corine Land Cover (2006)” database to display land use and pinpoint four target ecological systems (forest, grass, water and wetland). A “dilation-erosion” analysis was carried out for each system to identify the most direct connectivities between the individual ecosystems and the nature of these connectivities. This stage of the project shows whether a given connectivity can be functional. A comparison of this ecological systems map with the map of the motorway is used as a different way to identify, provisionally, the sensitive motorway sections as a supplement to the previous stage.

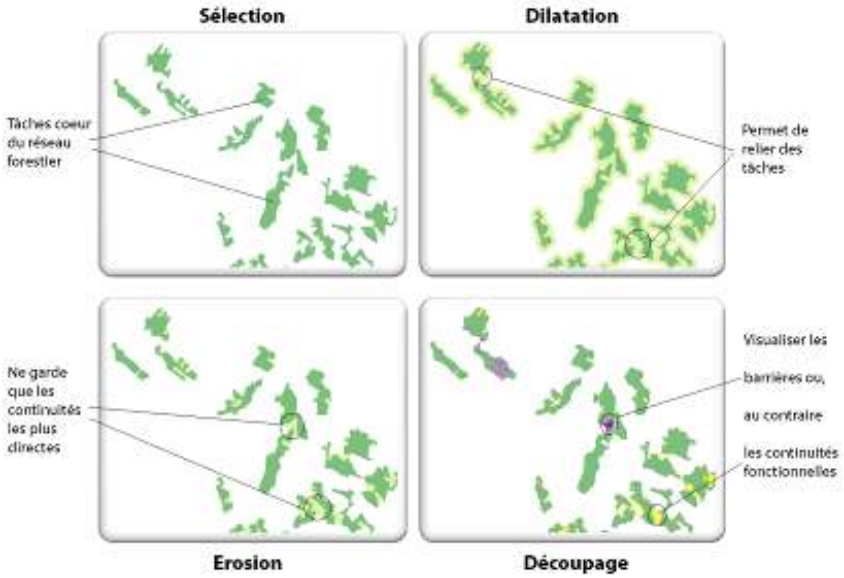

Figure 1 – Core area dilation and erosion

iii) Overall description of the landscape and inclusion of relief, based on orthographic maps draped over a digital terrain model. This confirms the precise positioning and length of the sections to be upgraded.

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Figure 2 – 3D modelling

iv) Cross-comparison of this information makes it possible to identify priority sections for action. These are then compared with ASF's in-house GIS data covering existing motorway structures that are potentially permeable to wildlife: engineering structures and hydraulic structures. A critical analysis of the infrastructure is performed and a theoretical pre-estimate of measures to be taken is drawn up.

Figure 3 – Illustration of information overlay

2.2 Concrete biodiversity conservation projects in five pilot French geographical departments

In June 2009, ASF initiated a concrete programme in five pilot French geographical departments (Drôme, Hérault, Hautes Pyrénées, Gironde and Charente-Maritime) covering 420 km of its 2,633 km motorway network. The five sites were selected as representative of the ecological areas and landscapes encountered along the network, and included forests, agricultural land, lowlands and mountainous areas, large and small wildlife species, outstanding and ordinary fauna, dense hydrographic systems, etc. In addition, the motorways running through each of these five French geographical departments are different in terms of their age, which has a major effect on environmental measures taken, and in terms of traffic, which may constitute major constraints for the implementation of ecological upgrades. Lastly, the five French geographical departments have progressed to differing degrees in their work on the Green and Blue Networks.

Figure 4 – Location of the five pilot French geographical departments and characteristics of the motorways running through them

This programme mobilises non-profit conservation groups and design offices. In each French geographical department, one conservation group and one design office were appointed as operators.
The conservation group handles the fieldwork phase, which takes more than a year to complete. It proposes upgrades, monitors the project, draws up protocols and takes charge of follow-up monitoring. The design office, for its part, consults with other developers and stakeholders in the department, performs additional investigations and works with the conservation group to define technical proposals. The operator tandems in the five French geographical departments were: in the Drôme, LPO 26 and Naturalia; in the Hérault Ecologistes de l'Euzière and Biotope; in the Hautes Pyrénées, Nature Midi Pyrénées and Ecotone; in the Gironde, Cistude Nature and Oréade-Brèche; and in the Charente Maritime, LPO France and Oréade-brèche.

Figure 5 – Operator maps: non-profit conservation groups (left) and design offices (right)

The programme is overseen by the ASF Infrastructure Technical Department with the support of a Scientific and Technical Committee set up at the initiative of ASF and comprising representatives of businesses, research organisations, Regions, Departments and government departments and administrations. Operating as a genuine steering committee, it is made up of some thirty members (representing the DREAL (Direction Régionale de l'Environnement de l'Amenagement et du Logement), the General and Regional Councils of the five french geographical departments, IMEP/CNRS (Institut Méditerranéen d'Ecologie et de Paléoecologie/Centre National de la Recherche Scientifique), the National Natural History Museum, CEMAGREF (Centre d'Etudes du Machinisme Agricole du Génie Rural des Eaux et Forêts), ONCFS (Office National de la Chasse et de la Faune Sauvage), ONEMA (Office National de l'Eau et des Milieux Aquatiques) , IMFT (Institut Mécanique des Fluides de Toulouse), the various CETE

(Centre d'Etudes Techniques de l'Equipement) organisations, SETRA (Service d'Etudes sur les Transports les Routes et leurs Aménagements), and the CGDD (Commissariat General au Développement Durable) and DGITM (Direction Générale des Infrastructures de Transports et de la Mer) of the Ministry for Ecology, Energy, Sustainable Development and the Sea) and stays in close touch with ASF and its operators by means of annual meetings and local meetings.

Table 1 – Composition of the Scientific and Technical Committee

ORGANISME	LOCALITE	CONTACT
DREAL	Rhône-Alpes	Yves MEIMER
	Languedoc-Roussillon	Pierre DROSS
	Midi-Pyrénées	Stéphanie FLOD
	Aquitaine	Michel SACHERE
	Poitou-Charentes	Cyril GOMEL
Conseil Régional	Rhône-Alpes	Hélène GUILLOT
	Languedoc-Roussillon	Simon WOODSWORTH
	Midi-Pyrénées	Laure ELISSALDE
	Aquitaine	Sophie KERLOCH
	Poitou-Charentes	Anne Sophie CHAPLAIN
Conseil Général	Drôme	Nicolas GOGUE-MEUNIER
	Hérault	Michel SIEYPE
	Hautes-Pyrénées	Jean Manuel DELEUZE
	Gironde	Frédéric DUPUY
	Charente-Maritime	Chrystelle CERVONI
IMEP	Institut Méditerranéen d'Ecologie et de Paléoécologie	Thierry TATONI
CEREGE/ IRET	Centre d'Aix en Provence	Philip RODIC
MNHN	Département Ecologie et Gestion de la Biodiversité UMR CESCO	Philippe CLERGEAU
ONCFS	CNERA Cervidés - Sanglier	Christine SAINT-ANDRIEUX
ONEMA	Délégation Rhône Alpes	Pascal ROCHE
	Délégation Languedoc-Roussillon PACA, Corse	Dominique BAREL
	Délégation Aquitaine, Midi-Pyrénées	Véronique DE BELLY
ONEMA / IRSTEA	Toulouse	Philippe BARAN
SETRA	Paris	Sabine BIELSA
CETE	Est	Jean CARBONEL
	Lyon	Virginie BELLON
	Méditerranée	Samuel PAUVERT
	Ouest	Eric GUINARD
MEDDTM	DGITM / Bureau de l'Environnement	Marie Lilian HAAT-PETURAUD
	CGDD / SEEDD / DRVT	Pierre POTEVIN

The goal of the programme is to validate the spatial analysis methodology developed previously and to implement appropriate upgrades based on consultations to better conserve biodiversity.
The participation of ASF motorway operators is necessary to implement the programme and to ensure that their constraints and needs are taken on board.
Project operators, local ASF motorway operators and regional ASF departments attend monthly project review meetings organised in each of the pilot French geographical department.

Figure 6 – The second meeting of the Scientific and Technical Committee

Over a period of more than 14 months, in-depth field studies were carried out using innovative techniques such as cameras, photographic traps, ANABAT recorders, capture and telemetric monitoring of bats, installation of PIMUL air traps for insects and installation of nesting boxes to track the dispersion of gliridae. These studies provided information about the rich natural heritage in the vicinity of the motorway and identified impacts.
The studies covered the motorway and its associated structures, green spaces in the land take (inside the perimeter fence) as well as land reserves, i.e. land belonging to ASF lying outside the motorway fences.
All linear infrastructure was studied. The issues recorded along the sensitive sections identified in each of the five French geographical departments following the first stage of the spatial analysis were compared with the issues identified in the remaining sections. This comparison will subsequently make it possible to assess the effectiveness of the spatial analysis method that identified between three and six sections in each pilot French geographical department.
The studies focused on analysing ecological connectivities, describing wildlife use of existing structures and above all proposing upgrades to restore or create land or water based connectivity along and across the motorway.

Figure 7 – Illustration of several techniques used in the ecological studies

To upgrade infrastructure and ensure that it no longer impedes the movement of wildlife species and to restore ecological function beyond the motorway perimeter, a dialogue with all regional stakeholders is required. This dialogue ensures programme consistency.

More than 250 people were involved in devising the upgrade proposals.

Figure 8 – Consultation meeting with local elected officials (A9 motorway)

3. RESULTS

3.1 Spatial analysis of the entire network

In early 2010, ASF applied its method over the entire 2,633 km network in operation, to obtain an overall map and locate the sections to be upgraded in the 29 French geographical departments served by its motorways.
92 sections representing a total of 780 km of linear infrastructure, i.e. 29.6% of the network in operation, were identified and spatially defined.
Of these sections to be upgraded, the potential for existing structure upgrades and new crossing construction to ensure ecological connectivity was pre-estimated and budgeted.
Nearly one hundred structures, most of them hydraulic, could potentially be upgraded to allow or facilitate the passage of wildlife.
In terms of new crossings, some 60 potential structures, mainly culverts, were identified.
Alongside this information, this stage of the analysis identified local organisations (managers of natural spaces, Natura 2000 operators, other developers) dealing with these issues that were able to interact with the ecological conservation projects.
The distribution of the sensitive sections on the network varies. There were fewer sensitive sections along the newer stretches of motorway and more along the older ones. Changes in regulations and improved motorway design have resulted in better environmental accommodation in recently built motorways, especially in those built after 2000-2002. Similarly, geographic and weather-related differences among the regions explain the fact that land and semi-aquatic wildlife experience fewer problems crossing the motorway via hydraulic structures in a Mediterranean environment. These structures are generally designed to be large enough to handle high water at certain times of the year and for most of the year provide dry passage for wildlife, unlike structures located in Atlantic or continental environments.
This analysis provided ASF with the qualitative and quantitative data needed to technically and financially plan future upgrades.

3.2 Concrete biodiversity conservation projects in five pilot French geographical departments

The ecological investigations identified both functional and interrupted ecological connectivity in the five French geographical departments.

The crossings used by wildlife were surveyed and a study of the strategies used by the various biological groups to cross the motorway or to use green areas along the motorway land take provided further useful information. The thousands of recordings made and images collected, the hundreds of captures, markings and monitoring of specimens made it possible to characterise the crossings.
The various crossing structure configurations were studied to gain an understanding of their use by mammals (including bats), insects, reptiles, amphibians, and fish. Monitoring of viaducts that are home to bats showed that a number of species occupy these structures in different ways, either as stopping-off points along migratory routes or for reproduction.
The study of the movements of insects and birds above motorways showed the importance of the surrounding habitat structures along the corridors. Roadkill counts (carried out by vehicle and on foot) provided qualitative and quantitative data on direct fatalities over a full year.
An assessment of the biodiversity effects of motorway fences showed the need to make improvements in fence systems. Lastly, the botanical and wildlife investigations in the green areas of the motorway land take and land reserves identified species and stopping places previously unknown in the French geographical departments.
On average, 20% of the land reserves associated with these five motorways have strong or very strong ecological value as refuges. These investigations further bolster the conclusions of the ASF-CNRS [4] [5] study carried out between 1994 and 1997, to the effect that the more built-up the area through which the motorway runs, the more important the ecological role of the motorway land take.
Overall, the results of all these investigations improve knowledge of the issues and point to new avenues for research.
In terms of validating the methodology, a comparison between the spatial analysis and the results of the investigations shows a good fit, since nearly all the significant issues were located along the sections identified. Only two sections out of the 20 would have warranted a slight extension to include nearby issues.
In operational terms, the investigations above all made it possible to propose upgrade projects and define priorities for mitigation.
Each project was the subject of broad consultations among the local stakeholders (municipalities, urban communities, *syndicats mixtes*, hunting associations, fishing associations, etc.) aimed at ensuring consistency and acceptance and at enabling the stakeholders to take the project on board. Restoration of ecological connectivity may generate conflicts of interest among stakeholders if they are not brought together through such consultations.
Ultimately, 24 ecologically appropriate and locally acceptable proposals had already been identified when the “Motorway Green Package” was launched in the spring of 2010.
This French government recovery plan acted to accelerate the ASF programme, enabling ASF to carry out its projects earlier than planned.
ASF invested €15 million and made a commitment to carry out 19 of the 24 upgrades identified, which included:

- two ecoducts to facilitate motorway crossing by most animal species,
- eight culverts to create crossings for meso- and micro-fauna
- four benches to facilitate movement of otters and European mink through hydraulic structures
- three conversions of road underpasses and overpasses to combined “road and wildlife crossings”
- construction of a fish ladder to restore upstream-downstream fish passage, which can also be used by semi-aquatic mustelidae

- an experimental daylight backlighting project in a hydraulic structure to eliminate the light barrier that prevents insects from crossing, and a study of the effects of this project.

Figure 9 – Views of an ecoduct over the A7 (top) and of possible upgrades to a hydraulic structure on the A10 (bottom)

In addition to defining the characteristics of the projects, the investigations made it possible to define environmental measures to be carried out on future projects and to perform the initial survey needed for the ecological monitoring protocols that will follow up the projects.
All works are to be completed by the end of 2012. The first operations got under way in the autumn of 2010.
Projects currently under way:
-Two of the eight culverts have now been completed. Located on the A7 in the geographical department of Drôme, the structures create connectivity for small wildlife, especially amphibians. These culverts have vertical interior walls to facilitate amphibian crossings, since it was observed in a number of culverts that some animals were not succeeding in making the crossing because they exhausted themselves climbing the rounded walls inside the structure.
Construction of the first structure, with a diameter of 800 mm, was subject to constraints including limited land take and low fill height through which to tunnel. The operation required instrumentation to monitor possible pavement deformation in real time.

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Figure 10 – Construction of an 800 mm culvert (left)
and finished structure (right) on the A7 motorway

The second has a diameter of 1,200 mm, which facilitates passage of medium-sized wildlife. Ecological monitoring of these two structures, starting in February 2011, will provide information on their utilisation and their effectiveness.

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Figure 11 – Construction of a 1200 mm culvert (left)
and finished structure (right) on the A7 motorway

The Sétra guide for small wildlife structures [6] recommends a minimum culvert diameter of 600 mm. For these operations, ASF employed larger diameters, with two 800 mm and six 1,200 mm structures.

- In addition, one of the two ecoduct projects is under way at the Col du Grand Boeuf pass on the A7 motorway in the geographical department of Drôme. This is an ambitious structure designed to restore connectivity between the Alps and the Ardèche mountains previously identified in the Rhône-Alpes ecological network (RERA) [7] map. There are major large and small wildlife issues, and a need to provide crossings for species such as the common dormouse, the yellow-bellied toad and the great crested newt. Consultations with government departments, the Drôme departmental hunting federation and local municipalities were highly instructive. To ensure its ongoing success, the Rhône Valloire urban community wants to include preservation of this ecological connectivity in its Local Urban Development Plan.

The construction of the large ecological engineering structure requires special adaptation of the worksite to accommodate the large volume of traffic on the A7 and to safeguard protected species present during the various project phases.

In October 2010, a herpetofauna protection plan was implemented in the land take of the future Col du Grand Bœuf ecoduct worksite. Government departments and local administrations participated in this preparatory stage.

The prefecture issued a permit to displace individual animals and thus avoid their destruction during the works, which got under way in January 2011.

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Figure 12 – Protection measures (left) and start of works on the ecoduct over the A7 motorway

- Lastly, two of the three conversions of existing structures to combined road and wildlife crossings are currently under way on the A9 motorway in the geographical department of Hérault. Based on their geographical locations and configurations, these structures (an overpass and an underpass) are being partly transformed to wildlife crossings through elimination or modification of their surfacing, overplanting and ecological engineering upgrades.

Figure 13 – Conversion work on an underpass (left) and an overpass (right) on the A9 motorway

The third conversion project will soon be getting under way on the A9 in the geographical department of Hérault. ASF has signed an agreement with the Hérault General Council to carry out the works. The structure to be converted is a bridge carrying the A9 over the RD 28 departmental highway. The conversion will make the structure into a combined passage to reduce the barrier effect of the A9 motorway and the D28 highway, especially for amphibians in the area, where there are a large number of Mediterranean temporary ponds. To carry out the ecological works, ASF will call on Agents du Littoral Méditerranéen, a local company specialised in managing natural environments that helps disadvantaged people find employment, in order to promote this type of useful and beneficial social structure.

4. DISCUSSION

The two complementary stages of the ASF programme provide feedback that makes it possible to improve both stages. The good fit between the sections identified and the

issues revealed by the field studies should not obscure the potential for optimising the spatial analysis methodology.
There is a bias, related to variation in the investigative effort, which may explain this good correlation. Overall, the sensitive sections identified were more extensively studied and therefore had a greater chance of exhibiting issues.
However, because few issues were identified outside the sections to be upgraded and because similarly detailed studies cannot be carried out along all 2,633 km of the ASF network, this bias was disregarded.
Despite the contrast between old infrastructure and new motorways with fewer sections requiring upgrades, it must be remembered that there is scope for improving new motorways to foster ecological connectivity. The distinction is currently being used to define priorities in work needed on older motorways. The priority assessment changes as knowledge is expanded. Today's new motorways will be tomorrow's old motorways and will require a continuous improvement approach.
In upgrade projects, work on existing infrastructure is subject to many constraints related to maintaining traffic flow and to the characteristics of the structures. These limit the opportunities for upgrades, make operations more complex and generate costs that are significantly higher than in new infrastructure construction.
The experimental nature of this programme makes it possible to test innovative solutions, but there is a risk that they may prove ineffective. Although the effort may appear in such cases to be wasted, it nevertheless provides valuable feedback.
The presence of a motorway constituting a biological barrier may be perceived as a good thing by those who fear predatory animals or invasive species. In such cases, connectivity restoration requires substantial consultations, since these perceptions are often emotional and subjective.
Lastly, the results of surveys of motorway fences and their role in biodiversity have shown that their management dovetails with maintenance and safety operations. Given the needs that have been demonstrated, ASF launched an operational programme in June, separate from the initial conservation programme, with a budget of €2.8 million devoted exclusively to optimising the fence systems in the five French geographical department. This work, begun in the summer of 2010, consists in re-positioning fences to make use of longitudinal corridors and limit maintenance, creating connections with the crossings to encourage wildlife to use them, reinforcing fences with small mesh to protect small species, and lastly installing escape openings for fauna trapped in fenced land takes.

5. CONCLUSION AND OUTLOOK

The ecological conservation programme made it possible to develop new skills and a form of project governance that is fully in line with the Grenelle Environment Forum.

ASF has decided to extend this programme to cover all operations carried out as part of its environmental management system.
VINCI Autoroutes has placed a priority focus on the environment and ASF is committed to making its motorways more and more environmentally friendly.
The entire programme has made it possible to create a basis for exchanging information with the government concession grantor about future extensions of “Green Motorway Package” actions as part of the master plans and thus to promote biodiversity conservation.
More broadly, environmental upgrades are a principle of sustainable development and a way to adapt infrastructure to the changing needs of regions as they develop.

REFERENCES

1. Billon, V. & Carsignol, J. (2000). Fragmentation de l’habitat due aux infrastructures de transport. COST 341. French report, 196 pages
2. Vanpeene, S. *et al*. (2009). Prise en compte de la TVB dans les infrastructures linéaires de l’Etat. COMOP, 53 pages
3. Heurtebise, C. & Molières, A. (2009). Présentation de la méthode SIG. Programme de requalification en faveur de la Biodiversité. 29 pages
4. Meunier, F. (1999). Biodiversité et dynamique écologique des dépendances vertes autoroutières comparées aux milieux traversés. University of Paris VI.
5. Meunier, F., Corbin, J., Verheyden, C. & Jouventin, P. (1999). Effects of landscape type and extensive management on use of motorways roadsides by small mammals. Canadian Journal of Zoology. Pages 97-111
6. Carsignol, J. (2005). Aménagements et mesures pour la petite faune. Guide technique. Sétra, 264 pages
7. Asconit & Biotope. (2009). Cartographie du Réseau écologique de Rhône-Alpes. Région Rhône-Alpes.