

**ANIMAL-VEHICLE COLLISIONS:
A NEW COOPERATIVE STRATEGY IS NEEDED TO REDUCE THE CONFLICT**

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ABSTRACT

Animal-vehicle collisions are a major issue for traffic safety. Despite the measures applied to reduce the conflict, the numbers of accidents involving wildlife are still increasing in many European countries. Wild ungulates (mainly roe deer and, in Mediterranean countries, wild boar) are often involved in accidents. The road and environment administrations of the regional government of Catalonia (northeastern Spain) are carrying out a project that includes i) data collection on accidents involving animals, ii) the identification by GIS analysis of spatial clusters of accidents caused by animals (Kernel density estimation), and iii) the design and application of measures to reduce accidents at road hotspots. In 2007, an analysis was carried out of data from 3,057 accidents involving ungulates registered in the period 2000-2006. The data have now been updated and 6,123 animal-vehicle collisions registered from 2007 to 2011 have been analyzed. The effectiveness of measures applied at several hotspots that were identified 5 years ago has also been evaluated.

Some of the most effective measures to reduce the conflict have been the construction of wildlife passages combined with perimeter fences along main roads. However, these measures are frequently not applicable to secondary roads with low traffic intensities, where signs to raise awareness, speed limits or verge management have been introduced. Nevertheless, there has not been such a great reduction in the number of accidents involving wildlife on secondary roads.

A strategy for the management and reduction of the risk of animal-vehicle collisions must focus on stakeholders as well as on measures applied to roads. Traffic police who register accident data could help to improve the collection procedures that are the basis for correct identification and prioritization of the most conflictive points. Environmental administrations dealing with big game species and hunters must also be involved, as the management of deer and wild boar populations can also help to reduce the conflict. Transport and environment authorities take part in the design of local measures to be applied at the most conflictive points. Last but not least, drivers are key stakeholders because their awareness and behavior is a strategic factor in avoiding collisions. A new collaborative approach is the basis for improving practices to mitigate the conflict in the network of secondary roads. Sharing knowledge can help to identify the most innovative solutions. In addition, communication campaigns can contribute to achieving driver cooperation.

INTRODUCTION

In Europe, the number of animal-vehicle collisions (AVCs) is increasing, which has a major impact on road safety. Ungulates are the main group involved in the conflict and most of the accidents are caused by roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) daim (*Dama dama*) and moose (*Alces alces* in Scandinavian countries). Wild boar (*Sus scrofa*) is an increasing problem mainly in Mediterranean areas and other southern and central European countries. In 1996, it was estimated that half a million accidents a year were caused by ungulates in Europe, leading to 300 deaths and 30,000 injured victims, with a total cost of over a billion dollars (Groot Bruinderink & Hazebroek 1996). However, according to more recent estimates, around a million accidents a year are caused by ungulates on European roads (Langbein *et al.* 2011) and in some countries such as Germany the costs of accidents caused by wildlife are above 300 million euros a year (Seiler & Helldin 2006). The sharp increase in the problem is attributed to two main causes: the geographic and demographic expansion of ungulate populations, and the increase in the length of the road network and the speed of vehicles.

In Catalonia (northeastern Iberian Peninsula) AVCs represent only a small proportion (1.2%) of the total number of accidents that result in victims. Nevertheless, they warrant attention, due to the rapid increase in this type of accident, the cost of damages and the resources needed to remove carcasses and carry out repairs. These accidents also cause social conflicts, as drivers' insurance companies may claim damages from hunters and the road administration. Vehicle damage as a result of AVCs is not covered by car insurance and legislation establishes that costs can be claimed from road management agencies (when the accident can be attributed to insufficient signalization or road maintenance) and from hunters' associations (when it is a consequence of hunting activities).

In 2007, an analysis was carried out of data from 3,057 accidents involving ungulates from the period 2000-2006. Stretches of roads that are accident 'hotspots' were identified and several measures were applied; mainly signalization of conflictive stretches of secondary roads, the installation of perimeter fences, and the construction of wildlife passages over or under highways. In 2012, the effectiveness of the measures was evaluated, and data collection and analysis were updated by the Department of Territory and Sustainability (DG Roads). The goal was to characterize AVCs and to define an Action Plan to reduce the number of accidents along stretches of roads that are hotspots. The process is led by the road administration in cooperation with the environmental administration, but the involvement of other stakeholders is a key factor for conflict mitigation.

STUDY AREA AND METHODS

The study was conducted in Catalonia (northeastern Spain), which has a surface area of 32,107 km² and a 12,124 km road network. Data were analyzed from 6,123 AVCs that occurred between 2007 and 2011. Most of the data were compiled by traffic police, but other bodies, including the traffic management agency (the Catalan Traffic Service), road management teams and the wildlife management department (the Department of Agriculture, Livestock, Fishing and the Environment), contributed to completing the information. For each accident, data was registered on the location, date and time of day, species involved, vehicle type, victims and cost.

The cost of the accidents was estimated using data from the legal departments of the environment and road administrations, based on insurance company claims and the existing literature (Col·legi Enginyers CCP de Catalunya 2010; García-Altés *et al.* 2013).

Spatial clusters of animal-vehicle accidents were identified by GIS analysis (Kernel density estimation). Previously, the most conflictive 1-km stretches had been identified by comparing the data with a random situation in which the probability of occurrence along each stretch followed a Poisson distribution (Malo

et al. 2004). All the stretches with a higher accident occurrence than the expected mean were considered AVCs hotspots. Subsequently, stretches that were specifically ungulate-vehicle accident hotspots were identified.

The effectiveness of measures applied since the identification of conflictive stretches in 2007 has been evaluated (*DPTOP-DMA 2007*). The number of accidents registered per year in the period 2000-2006, before the application of the measures, was compared with the number during the period 2007-2011, once the measures had been implemented.

Finally, an Action Plan was drawn up to reduce the number of ungulate-vehicle collisions at accident hotspots. The Plan is based on analyses of the effectiveness of implemented measures and using information provided by technical prescriptions and literature on the design of conflict mitigation measures.

CHARACTERISING THE PROBLEM: THE BASIS FOR DESIGNING MEASURES

A mean of 1,225 accidents involving animals were registered each year along the 12,124 kilometers (7,517 miles) of roads in Catalonia (10.5% highways and 89.5% main and secondary roads that are usually not fenced). The sharp increase (41.6%) in the number of accidents involving animals over five years (see Figure 1) contrasts with the overall accident rate, which decreased by 14.5% on Catalan roads during the same period.

Only a low proportion of the total number of accidents resulted in victims (8%: 0.1% fatal, 0.3% serious injuries; 7.5% mild injuries). During the study period, a total of 619 victims of AVCs were registered.

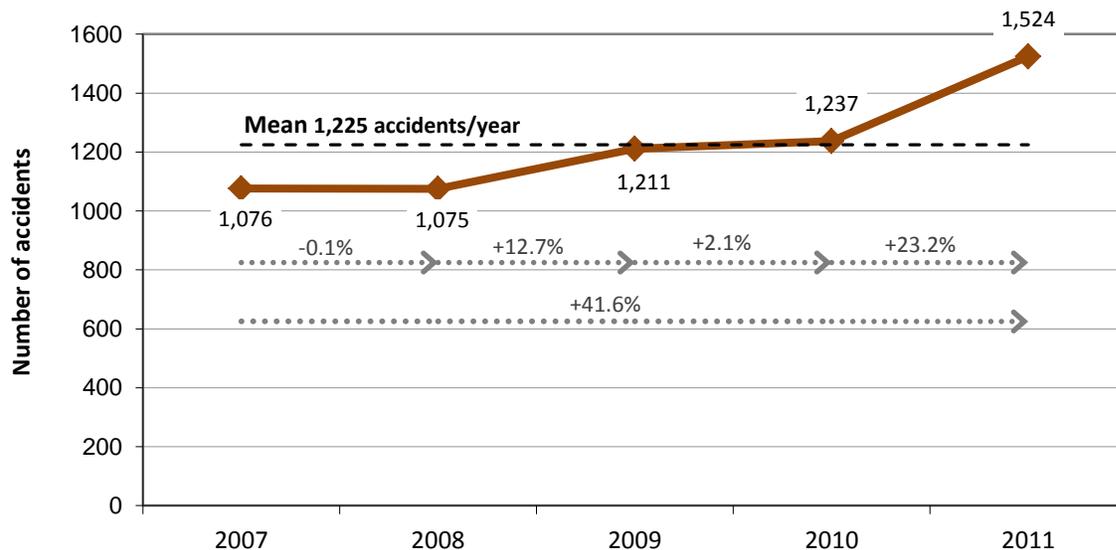


Figure 1 Evolution of AVCs in the interurban road network of Catalonia.

Ungulates are the most problematic group in relation to wildlife-vehicle collisions. Specifically, wild boar is the species involved in the majority of animal-vehicle collisions (see Figure 2). It caused 85% of the total accidents in which the species involved was registered and 59% of the total accidents causing

victims. Roe deer (3%) and red deer (1.8%) are other conflictive ungulate species. Stray dogs and horses have also been implicated.

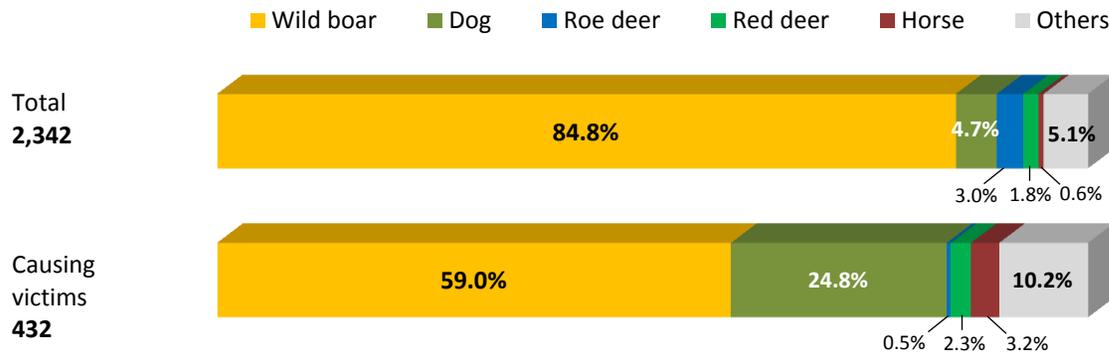


Figure 2 Species involved in AVCs in the interurban road network of Catalonia.

The conflict shows marked seasonality, with a conflictive period in which 60% of the accidents were registered that begins in September and ends in January. A marked peak around November and December was observed. These periods overlap with the hunting season (September to the end of February) and the wild boar main rut (September to December). This pattern has not only been described in the study area, but also in other European study sites (*Groot Bruindrenink & Hazebroek 1996; Markina 1999; Lagos et al 2012; Colino et al 2012*).

A mean cost of €10,785 /accident was estimated, including €6,215 (about \$8,080) related to the accident itself (damage to the car, administrative and legal costs, police involvement, and road maintenance) and €4,570 (about \$5,940) associated with the victims. An overall cost of €16.5 million (\$21.45 million) per year due to registered AVCs was estimated.

Regarding location, 16.2% of the accidents were registered on highways and 83.8% on secondary or main roads that were not fenced.

A total of 143 conflictive stretches that concentrate ungulate-vehicle collisions which together amounted to 75 km of road (1.3% of the total length of the road network), were identified. Thirty-one per cent of the total number of accidents took place along these stretches. Eighteen of them were qualified as ‘Priority’ due to the higher frequencies of accidents that took place along them.

Most of the conflictive stretches are located in areas of high wild boar density, more than 8 individuals/100 ha, where there has been a sharp increase in wild boar population over the last decade (data from the Wild Boar Monitoring Program, *Department of Agriculture, Foods and the Natural Environment 2011*).

An analysis of the effectiveness of measures implemented at stretches where there were a high number of ungulate-vehicle collisions, identified in 2007, shows that warning signs installed along 113 stretches of (mainly) secondary roads led to a mean reduction in accident rate of 59.2%, but with high variance (± 52.1 SD). Along 11.5% of the stretches, the number of accidents rise after the application of the measures. Perimeter fences combined with wildlife passages that were either installed or improved along 12 stretches of main roads and highways were highly effective, as they reduced the number of accidents by 92%.

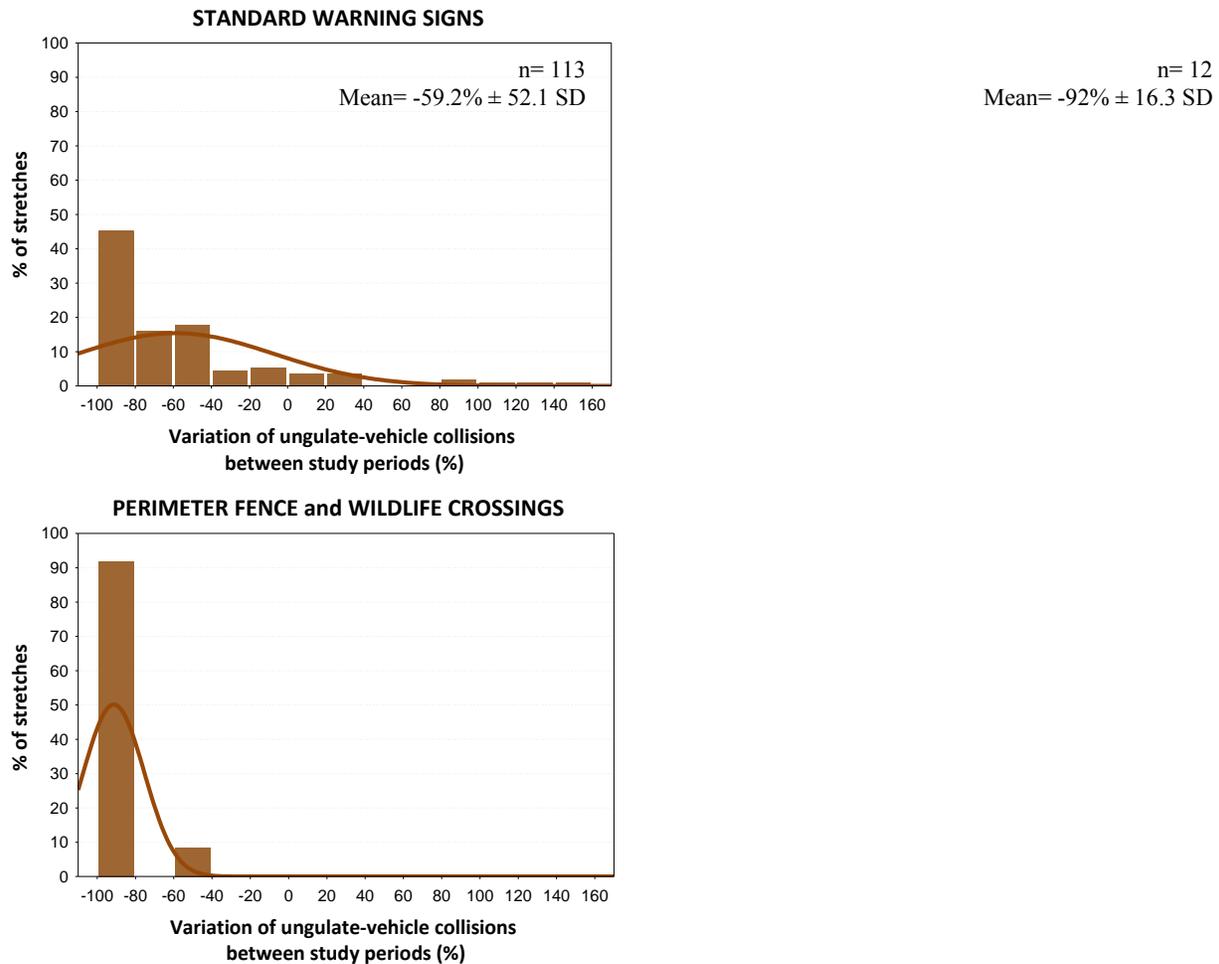


Figure 3 Variation in the annual number of ungulates-vehicle collisions in stretches with different types of measures applied. Comparison between period 2000-2006 (before the application of the mitigation measures) and the period 2007-2011 (after)

LOOKING FOR SOLUTIONS: THE ACTION PLAN

An Action Plan has been drawn up to improve road safety along the most conflictive stretches: the 143 with the highest number of ungulate-vehicle collisions. Action Plan measures were selected using the results of an analysis of the effectiveness of measures applied in 2007 and published data about risk reduction actions (e.g. *Rosell & Velasco 1999; Huijser & McGowen 2000; Clevenguer & Waltho 2000; Iuell et al. 2003; Rosell et al 2003; Ministerio de Medio Ambiente 2003*). The Plan combines several types of actions:

- i) Along highways and main roads, one general solution is to install or improve perimeter fences combined with wildlife crossings (see Figures 5 and 6). Along some stretches with perimeter fences, wild boar still manage to reach the road by lifting up the lower part of the wire mesh. In such cases, specific reinforcements along the bottom of the fence are required to prevent wild boar from entering. Wildlife crossings are mainly created by adapting existing structures, such as over- or underpasses used for forestry roads, livestock or drainage (box culverts).

- ii) Along conventional roads, the installation of fences is not an option for landscape or social reasons. Conflictive stretches are often located along secondary roads, with several road intersections leading to farmland, houses, etc. (Figure 4). In these cases, experimental measures will be applied using specific additional signalization and verge management, which consists of cutting existing vegetation in a 3-m strip along both sides of the road and eliminating obstacles to prevent animals from finding refuge beside the roads and to make them more visible to drivers (see Figures 7 and 8). As the conflict is seasonal, with most AVCs occurring from September to January, the measures will also be applied following the same pattern, with verge maintenance activities and the installation of additional signalization at the beginning of the critical period.
- iii) A driver awareness campaign is a new but important measure to contribute to the effectiveness of the overall Action Plan. Driver behavior is a crucial factor to avoid wildlife collisions. However, excessive standard signalization has made drivers less alert. A campaign will be carried out at the beginning of the conflictive period to alert drivers to the risks of colliding with a wild boar or other wildlife, to the existence of hotspots where risk is very high, and to the need to adapt driver behavior when a signal is seen.
- iv) Maintenance and monitoring procedures have been designed to improve the detection of conflictive stretches and to improve data registration about AVCs and about wildlife behavior along verges.

All these actions are the responsibility of road and traffic management administrations. However, measures to control ungulate populations, particularly those of wild boar, are also needed to reduce the conflict. This area is the responsibility of the game management administration. A series of measures can be implemented to help reduce the wild boar population, including extending the hunting period, capturing wild boar in traps, and other methods in areas where hunting is forbidden.

Accompanying this pack of mitigation measures the road management administration organizes workshops with the participation of the main stakeholders (road maintenance teams, traffic policy managers, big game managers and hunters). These meetings are also an important part of the strategy to improve cooperation and to share knowledge and perspectives.



Figure 4. Most accidents involving animals occur on secondary roads, with low traffic volumes and without perimeter fences.



Figure 5. On stretches with fences that are not buried, specific reinforcements can be added to the bottom of the fences to prevent wild boar entrance.



Figure 6. Wildlife crossings could be specific for wildlife (underpass, left) or multifunctional, created by adapting existing structures (overpass, right).



Figure 7. Specific additional signalization, installed during the critical period (September to January) at ungulate-vehicle collision hotspots that are qualified as a ‘priority’ (left). Along other conflictive stretches, standard warning signs (right) are installed.



Figure 8. Verge management consists of cutting existing vegetation and eliminating animal refuges in a 3-m strip along both sides of the road.

INVOLVING STAKEHOLDERS: A COOPERATIVE STRATEGY

The strategy adopted to reduce wildlife-vehicle collisions requires good understanding and cooperation between several stakeholders, to integrate the positions of road/traffic managers, wildlife/big game managers, hunters and drivers. All these stakeholders play key roles in the process. The main roles of each stakeholder in our case study are described below (see Figure 9):

- Road managers. As the road is the site of the problem and where most mitigation measures must be applied, the Directorate General of Roads is the overall leader of the Action Plan. This stakeholder is responsible for road safety policies and the application of mitigation measures. Road maintenance teams play an active role, not only in the maintenance of the mitigation measures, but also in data collection. Specific procedures have been established to report any incidence with wildlife, with specific monitoring at conflictive stretches. The removal of carcasses, as well as frequent observation of animals crossing the road and wildlife trails, is important, as it provides complementary data for accident records. Maintenance team training will contribute to improving the quality of the data collected
- Traffic policy and traffic management administration. AVC data collected by the *Mossos d'Esquadra* police force provide the basis for the whole process. High quality data provides accurate diagnoses of the conflict and the identification of the most conflictive stretches and help identification of mitigation measures needed (*Green et al. 2011*). To improve data collection, it is essential to precisely record the location of accidents and the species involved. The Catalan Traffic Service is also involved in regulating traffic speed and in accident data collection, as well in all aspects related to traffic regulation and safety.
- Drivers. Many drivers habitually do not respond to information on standard advisory signs. Therefore, it is essential to adapt driving behavior to the risk of wildlife irruption on the roadway. A lack of information about wildlife, and especially about wild boar behavior around roads, contributes to underestimations of the risk. To overcome this, the Catalan government planned an awareness campaign to provide more information about the problem and the measures that have been applied. The main goal is to get drivers involved, so that they are more alert to the situation when they are driving and adapt their speed accordingly. This is particularly important in the main AVC hotspots, where special signs will be posted during the critical period.
- Big game managers. The expansion of the wild boar population is one of the main causes of the sharp increase in the conflict. Therefore, big game managers must be involved to reduce wild boar numbers. The wildlife administration (the Directorate General of the Environment and Biodiversity) is already carrying out a wild boar population monitoring program. The results show a high population and increasing wild boar numbers, which has led to the extension of the hunting period and other measures to allow for a higher number of captures and for diminishing the population level.
- Hunter. Hunter teams cooperate by organizing battues to capture the animals. They also have an economic interest in reducing big game vehicle collisions, as insurance companies often hold them responsible for accidents and liable to pay the associated property damages and personal injury costs. Therefore, hunters' federations are actively promoting a change in legislation to avoid claims against them, except in the case of accidents caused by animals escaping from hunting battues.

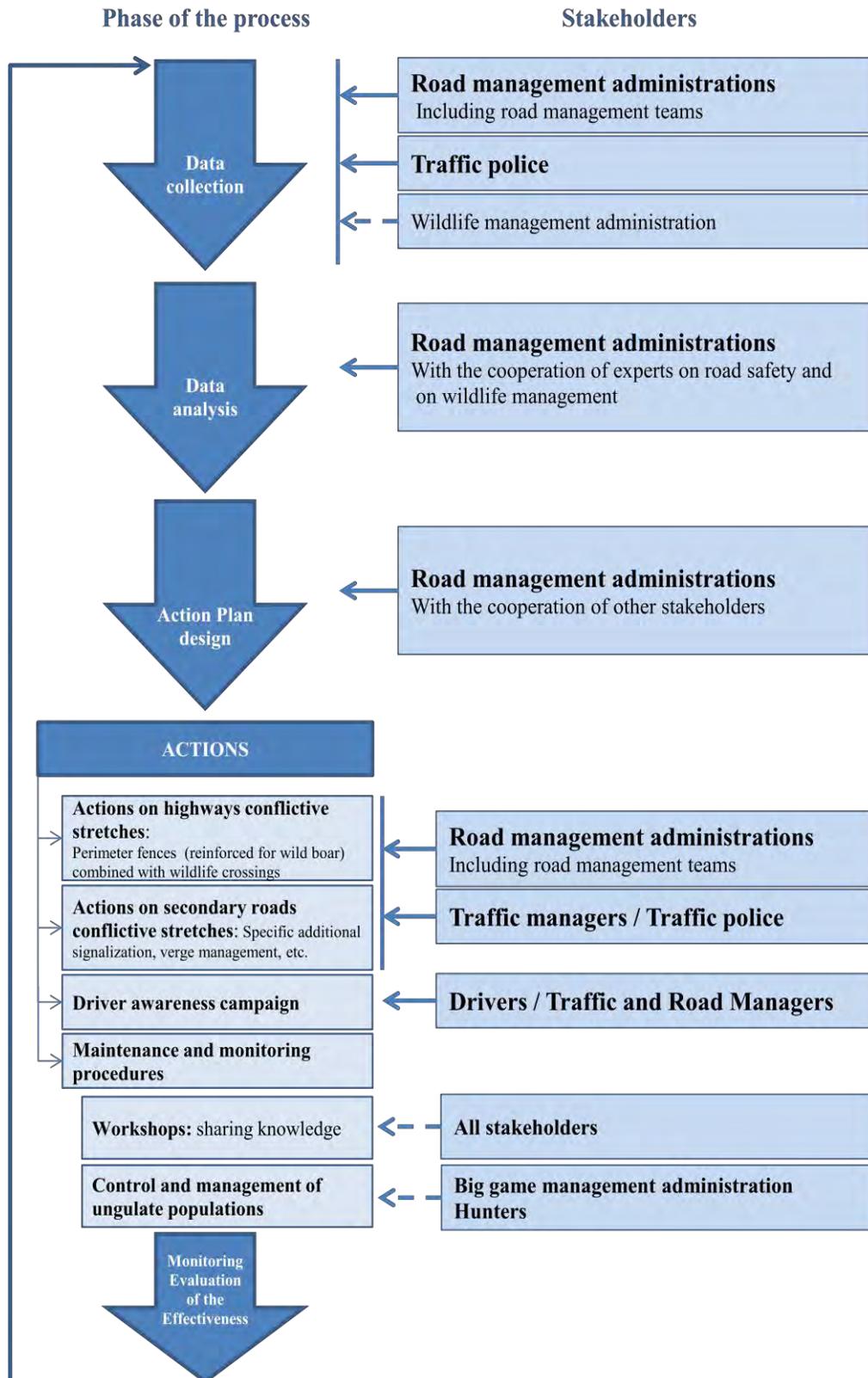


Figure 9. Procedure chart applied to reduce AVCs risk and stakeholders involved.

Insurance companies are another stakeholder that must be taken into account in the strategy for reducing AVCs. Current legislation causes a lot of administrative conflicts in road administration, due to the frequent claims made by insurance companies. A legislative change could help to increase the involvement of drivers and to reduce the high administrative and legal costs. It would also increase the involvement of these companies in the risk reduction measures.

CONCLUSIONS

AVCs on highways can be reduced by improving or installing suitable perimeter fences, and constructing wildlife crossings or adapting existing structures. However, a cooperative strategy is essential to achieve the goal of reducing the number of accidents involving wildlife on secondary roads, where the magnitude of the conflict is greater.

A crucial step for success is to integrate the positions of road, traffic and policy managers with those of big game managers and hunters. Drivers and insurance companies are also important stakeholders who should be involved in action plans to reduce the number of AVCs.

Working together will contribute to better understanding of the problem and to sharing knowledge to identify the most effective measures. The improvement and integration of data collection is a key step in the whole process, as it is the basis for determining which stretches are most conflictive. Mitigation measures can then be focused on these stretches to ensure that the actions are cost effective. Data collection is also the basis for evaluating the effectiveness of implemented actions.

Road managers are responsible for leading the process and coordinating the actions of the stakeholders. Periodic workshops must be organized to exchange information, improve data collection and identify the most effective mitigation measures. This is essential for the process of adaptive management of the conflict and continuous improvement, which will help to achieve the common goal of increasing road traffic safety and reducing wildlife mortality.

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