# Ungulate-vehicle collisions in Catalonia:
## Identifying the main landscape and road-related variables describing the most hazardous road locations.

Integrating Transport Infrastructure with Living Landscapes 2016 IENE

IENE - 5th IENE International Conference on Ecology and Transportation - 30th August to 2nd September 2016 - Lyon - France

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## INTRODUCTION

In Catalonia (NE Spain), as in many other European countries, the number of accidents involving wildlife has been rising over the past years despite to the mitigation strategies applied.

**Ungulate-vehicle collisions (UVCs)** commonly show a **spatial** aggregated pattern along the road network and clusters could be identified as hotspots. Assessing the effects of road or landscape variables and distinguishing **the main explanatory variables associated to this clustered pattern** could help in designing more effective mitigation measures.

## METHODS

### Defining Ungulate-Vehicles Collisions (UVC) clusters

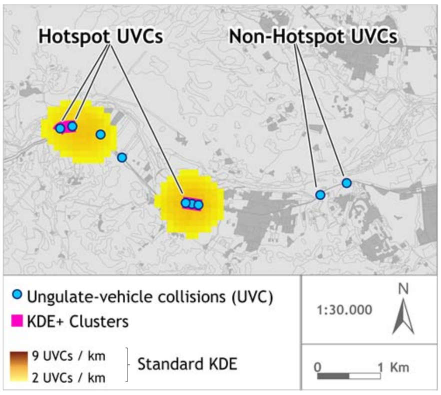
From a sample of 2.320 UVCs recorded during the period of 2007-2011 along 12.124 km of Catalan road network and mainly involving **wild boar (85%)** and other species such as roe deer (4,8%), a set of 124 high-risk UVC clusters were identified, containing 433 UVCs (18.7 % of all UVCs) and occurring within just 0.2 % of the road network length.

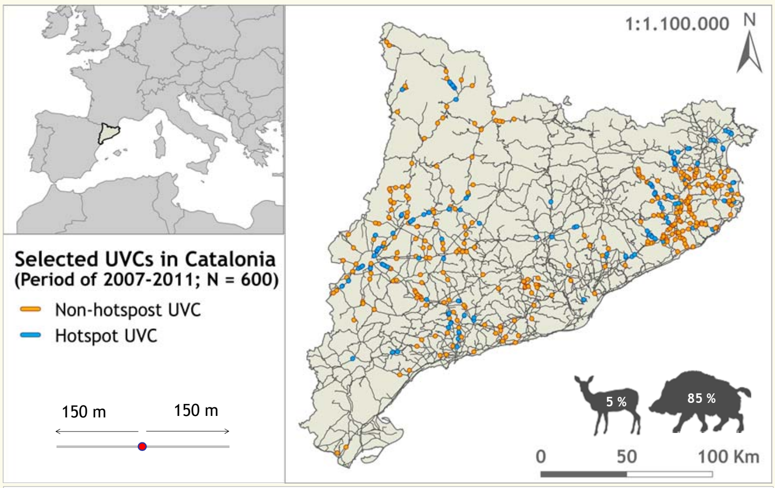
UVC clusters were identified using the one-dimentional **Kernel Density Estimation technique** named **KDE+** and developed by Bíl et al. (2013). The study focused on road sections with the highest frequency of UVCs, thus complementing the analysis using a standard two-dimentional KDE, we defined as high-risk clusters those KDE+ clusters containing ≥ 3 UVC/km per 5 years.

**The unit of study was the UVC**, and two classes were defined:

**Hotspot UVCs**
UVCs found within an identified high-risk cluster.

**Non-hotspots UVCs**
UVCs lying outside a high-risk cluster. Located more than 1 km away from any identified high-risk cluster and occurring on a road stretch of <3 UVC/km.




300 hotspots and 300 non-hotspot UVCs defined as **300-m long road segments centered on each UVC** were selected conducting a stratified random sampling and characterized according to different variables.

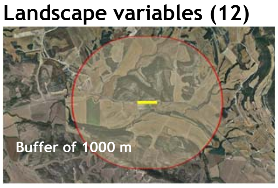
### 21 Predictor variables

Google Earth ®; Google Street View ® and SIG softwares were used.

**Road variables (9)**

- Road cross section
- Low barrier (≤ 1.5 m)
- Full barrier (> 1.5 m)
- Presence Median
- Presence Garbage container
- Road Speed (km/h)
- Traffic volume (v./day)
- Road straightness
- Road Verge vegetation (0/Partial/Continuous)

**Landscape variables (12)**




- Road junction (count)
- Water crossings (count)
- Ecotone (count)
- Forest distance (m)
- Shrub distance (m)
- Urban distance (m)
- % Built-up cover
- % Cropland cover
- % Coniferous cover
- % Broadleaved cover
- % Grassland cover
- Landscape diversity

## RESULTS

Using the **multiple logistic regression analysis**, 3 different reduced models were compared.

| Reduced Models | | k | AICc | $\Delta_i$ AICc | $w_i$ AICc | HL *P*-value | AUC |
|---|---|---|---|---|---|---|---|
| **Road Model** | | | | | | | |
| - Road Cross section<br>- Road Verge vegetation<br>- Presence Garbage container | - Speed<br>- Presence Median<br>- Road straightness | 9 | 556.44 | 6.62 | 0.003 | 0.399 | 0.744 |
| **Landscape Model** | | | | | | | |
| - % Built-up cover<br>- % Broadleaved cover | - % Grassland cover | 4 | 572.26 | 22.43 | 0.000 | 0.643 | 0.618 |
| **Mixed Model** | | | | | | | |
| - Road Cross section<br>- Road Verge vegetation<br>- Garbage container<br>- Speed | - Road Straightness<br>- Water crossing<br>- % Built-up cover<br>- % Grassland cover | 11 | 549.82 | 0.00 | 0.997 | 0.223 | 0.778 |

*The three reduced models and their validation. Hosmer-Lemeshow test (HL) shows the calibration; the area under the Roc curve (AUC) its discrimination. There reduced models were developed by generating all possible model formulations (without interactions) and the best ones were identified based on the Akaike's Information Criterion (AIC).*

The **Mixed Model** became the 'best model' and it was fitted to asses the relationship and effects between the **explanatory variables and the probability of UVC clustering.**

**Road variables:**
Road cross section, verge vegetation and speed limit had large effects on UVC clustering.

Presence of garbage containers nearby the road was correlated too.

**Landscape variables:**
Built-up areas surrounding the road resulted to be associated to UVC clusters.

| Variables | $B_A$ | Wald-Z |
|---|---|---|
| Verge vegetation - *Partial* | 0.469 | < 0.001 ** |
| Verge vegetation - *Continuous* | 0.400 | < 0.001 ** |
| Road Speed | 0.332 | < 0.001 ** |
| Road straightness | 0.308 | 0.014 * |
| Presence Garbage container | 0.279 | 0.003 ** |
| % Grassland cover | 0.279 | 0.003 ** |
| Water crossings | 0.032 | 0.718 |
| Part-raised road section ( / ) | - 0.363 | < 0.001 ** |
| Raised road section ( / ) | - 0.413 | < 0.001 ** |
| % Built-up cover | - 0.470 | < 0.001 ** |

PROBABILITY OF UVC CLUSTERING: Increasing / Decreasing

*Partial standardized logistic regression coefficient ($B_A$) (Menard 2011) and P-values (*P-value <0.05; ** P-value < 0.01) for the Wald statistics (Wald-Z).*

## CONCLUSIONS

- UVC clustering is related to multiple explanatory variables. Both, landscape and road features are relevant for understanding the aggregation pattern.
- Focusing future mitigation measures by managing road features such as clearing the roadside vegetation might be a good cost-effective approach for reducing wildlife-vehicle collisions in high hazard hotspots.
- The apparent association of garbage containers nearby the road with UVC aggregation is probably due to wild boar attraction for garbage. However, further research is need to evaluate more precisely the effects of this and other variables.

## REFERENCES

- **Bíl, M., Andrášik, R. & Janoška, Z., 2013.** Identification of hazardous road locations of traffic accidents by means of kernel estimation and cluster significance evaluation. Accident Analysis and Prevention, 55, pp. 265-273.
- **Menard, S., 2011.** Standards for Standardized Logistic Regression Coefficients. Social Forces, 89(4), pp. 1409-1428.

## ACKNOWLEDGEMENTS

This study was conducted as the final project of the Master's Degree Terrestrial Ecology and Biodiversity Management (Universitat Autònoma de Barcelona), and it was supervised by Drs. Carme Rosell (Minuartia) and Ferran Rodà (UAB). It was performed in the framework of the SAFEROAD *'Safe Roads for Wildlife and People'* project included in the Transportation Research Program of the Center of European Directors of Roads (CEDR). We acknowledge the Department of Territory and Sustainability (Generalitat de Catalunya) for providing the data.