# Brown bear mortality on roads and railways in Slovakia: patterns, trends, factors

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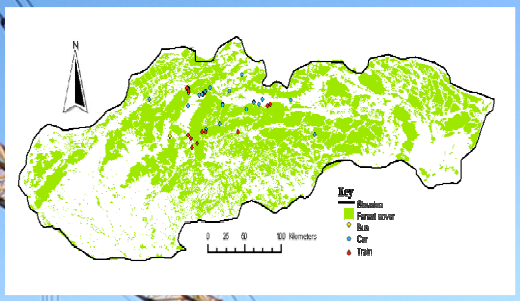
## Summary & Conclusions

Thirty-two (68%) of collisions involved a road vehicle and 15 (32%) a train. Accidents most often occurred in June, October and September. They usually involved male bears up to the age of 3 years. Multivariable conditional logistic regression showed a strong association between collision sites and the presence of forest cover and arable land ($p < 0.05$). These factors were approximately eleven times more likely to be present at a collision site compared to a control site (OD 11.19, 95% CI 0.94 – 133.04). When developing measures and prioritising locations to decrease the number of bear-vehicle collisions, the presence of both forest cover and arable land should be considered. Possible mitigation measures include 'green bridges' to facilitate safe wildlife crossing of transport routes, electric or other wildlife-proof fencing in areas with a high risk of collision and, possibly, use of chemical or other repellents.

***Fig. 1*** *Point map showing the distribution of 47 bear-vehicle collisions in Slovakia between 2000 and 2010 (geographic coordinate system: WGS84) .*




## Background

The brown bear (*Ursus arctos*) has recovered in the Western Carpathian Mountains from a small relict population in the 1930s to a current estimate of several hundred individuals. Around 95% of the population is in Slovakia, where collisions with vehicles are now the second most common cause of known mortality after hunter harvest. At least 47 bears collided with vehicles in central Slovakia between 2000 and 2010 (***Fig. 1***).

## Methods

Records of bear-vehicle collisions were obtained from the State Nature Conservancy of the Slovak Republic. The spatial distribution of collisions was visualised using ArcGIS and kernel-smoothing using 0.17 bandwidth. Forty out of 47 (85%) sites of collisions in 2000-2010 were visited to measure variables relating to landscape features and anthropogenic factors. A matched-pair case-control study was performed to test the hypothesis that bear-vehicle collisions are associated with a) the presence of food sources, b) disturbance of biocorridors, c) low visibility due to the structure of travel routes and vegetation. Conditional logistic regression was used for univariable and multivariable analyses to identify risk factors associated with collision sites. An automated backwards stepwise procedure was used to fit the multivariable model.

## Literature

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## Results

### Distribution of collisions

Thirty-two (68%) of collisions involved a road vehicle and 15 (32%) a train. Accidents most often occurred in June, October and September (***Figs. 2 & 3***). A clustering of collision sites was observed, with some sections of road and railways particularly prone to accidents (***Figs. 4***).

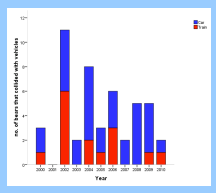


***Fig. 2*** *Yearly distribution of vehicle-bear collisions.*

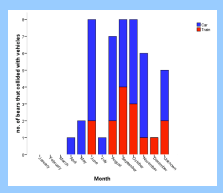


***Fig. 3*** *Monthly distribution of vehicle-bear collisions.*

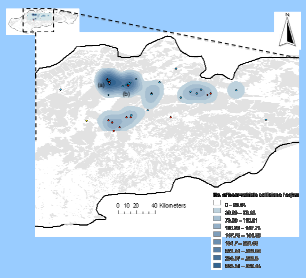


***Fig. 4*** *Kernel smoothed map representation of 47 bear-vehicle collision densities in Slovakia in 2000-2010 (geographic coordinate system: WGS84) .*

### Characteristics of bears involved

Collisions most often involved male bears (***Fig. 5***) up to the age of 3 years (***Fig. 6***).

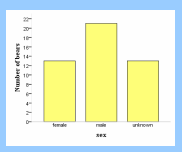


***Fig. 5*** *Sex ratio of bears involved in collisions.*

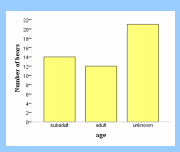


***Fig. 6*** *Proportion of subadults (≤3 years) and adult bears (>4 years) in collisions.*

### Characteristics of collision sites

Conditional logistic regression (***Tab. 1 & 2***) showed a strong association between collision sites and the presence of forest cover and arable land ($p < 0.05$). These factors were approximately eleven times more likely to be present at a collision site compared to a control site (OD 11.19, 95% CI 0.94 – 133.04).

***Tab. 1*** *Results of the univariable conditional logistic regression used to identify anthropogenic variables associated with collision sites.*

| Variable | Odds Ratio | 95% CI | p-value |
|---|---|---|---|
| Agricultural Field | 7.00 | 0.86 – 56.89 | 0.069 |
| Forest | 7.00 | 0.86 – 56.89 | 0.069 |
| Wall | 6.00 | 0.72 – 49.84 | 0.097 |
| Meadow | 5.00 | 0.58 – 42.8 | 0.142 |
| Visibility (Longitudinal) | 2.70 | 0.71 – 10.05 | 0.147 |
| Tunnel | 4.00 | 0.45 – 35.79 | 0.215 |

***Table. 2*** *Results of the multivariable conditional logistic regression used to identify anthropogenic variables associated with collision sites.*

| Variable | Odds Ratio | 95% CI | p-value |
|---|---|---|---|
| Agricultural Field | 11.19 | 0.94 – 133.04 | 0.056 |
| Forest | 11.19 | 0.94 – 133.04 | 0.056 |

*Canal – railway – road layout northeast of Turany – Ratkovo collision road stretch*


*A segment of the Žilina – Vrútky collision stretch with a wall running along side it.*


*Chain-linked fencing alongside the Žilina – Vrútky collision stretch*