

# IENE 2014 International Conference on Ecology and Transportation

*Life for a **Greener** Transport infrastructure*

September 16-19, 2014  
Malmö, Sweden

## Programme & Abstracts

*- updated online version*



IENE 2014  
International Conference



IENE

Infra Eco Network Europe

**IENE 2014 International Conference**

September 16 – 19, 2014

Malmö, Sweden

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**Updated online version**

The book was printed prior to the conference, and handed out to all participants. This is the updated version of the book, which only will be available for download online at the conference website: <http://iene2014.iene.info>.

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# IENE - Infra Eco Network Europe

## What is IENE?

IENE is a network of experts working with various aspects of transportation, infrastructure and ecology. The network was initiated in 1996 to provide an independent, international and interdisciplinary arena for the exchange and development of expert knowledge – and with the aim to promote a safe and ecologically sustainable pan-European transport infrastructure. IENE arranges international conferences, workshops and symposia, initiates collaboration projects and helps answering questions that require a joint international expertise.

IENE international conferences on ecology and transportation provide a recurring interdisciplinary forum for the exchange of current research, knowledge and practical experience between the sectors of environment and transport, between scientists and practitioners, in Europe and worldwide. The conferences aim at presenting cutting-edge research, identifying urgent questions and problems, discussing effective solutions, and outlining the paths for upcoming activities in transport and infrastructure ecology. Each IENE international conference develops its specific thematic focus, but also allows discussions on a broader spectrum of topics from within the general scope of IENE.

## Become a member of IENE

An IENE membership can be both individual and/or as representatives of organisations (governmental or non-governmental, research institutions, private companies, NGO:s etc.) that support the overall goals of IENE. The IENE membership is entirely free of charge.



To become a member of IENE, a membership form on the website has to be filled in (<http://ieneconferences.iene.info/become-a-member/>). Follow the QR-code here to go directly to the page about membership.

## More information

Visit our website: [www.iene.info](http://www.iene.info) or contact the IENE Secretariat: [info@iene.info](mailto:info@iene.info)



**IENE**  
Infra Eco Network Europe

# Welcome

## “Life for a greener transport infrastructure”

The IENE 2014 conference puts emphasis on the “greening” of transport infrastructure: both in respect to a wiser use of marginal infrastructure habitats to favour biodiversity and certain ecosystem services, and in respect to a more permeable and safer infrastructure that minimises the direct impact on wildlife.

Transportation and infrastructure are recognised as significant drivers in the global loss of biodiversity. Their impacts on nature are well described and there is ample evidence for the negative effects of traffic and transportation infrastructure on nature. Even though roads and railroads may occupy but a small proportion of an area, they affect the entire landscape, cause the death of millions of wild animals, and disturb surrounding habitats through pollution, noise and alien species. The overall impact is evident, but there are means to minimise the pressure, to adjust infrastructure facilities and, to some degree, introduce beneficial services for wildlife.

Such measures can and should be implemented as a standard in infrastructure development and maintenance. Knowledge about their functionality and efficacy is, however, not always satisfying. Technical innovations and new mitigation concepts need to be tested and evaluated. Their functionality and effectiveness also depends on the interplay between the transport sector and other sectors of society. Communication, knowledge transfer, and public education are just as essential here, as legal frameworks, policy, technical development and environmental science. European policy (e.g., Green Infrastructure) is developing clearly in this direction, recognizing the transport sector and transportation facilities as important players in the endeavour towards a greener and sustainable future.

Obviously, this calls for international collaboration in research and practice, for enhanced exchange of knowledge between disciplines, and for the development of harmonised standards and procedures that can be referred to by international actors. IENE provides this interdisciplinary arena through its conferences and workshops.

The IENE 2014 international conference emphasises that transport infrastructure can be planned and designed as an ecologically well-adopted, safe and efficient system, while acknowledging that certain impacts can never be avoided.

IENE, together with the Swedish Transport Administration, the Swedish University of Agricultural Sciences, the Danish Road Directorate and numerous other partners, invites scientists, practitioners and planners, governmental agencies and private companies, NGO's and anybody with an interest in the above to the IENE 2014 conference in Sweden. We welcome new partner- and sponsorships and offer a well-approved and international network for communication and presentation.

Welcome!

### Lars Nilsson

Swedish Transport Agency,  
Chair of Organisation Committee of  
IENE 2014 International Conference



### Andreas Seiler

SLU - Swedish Agricultural University,  
Programme Director of IENE 2014  
International Conference



### Anders Sjölund

Swedish Transport Agency,  
Chair of IENE Steering Committee





# Information about the Conference

**General information**

**Organisation**

**Sponsors & exhibitors**

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**Detailed programme**

**IENE Awards**

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the conference

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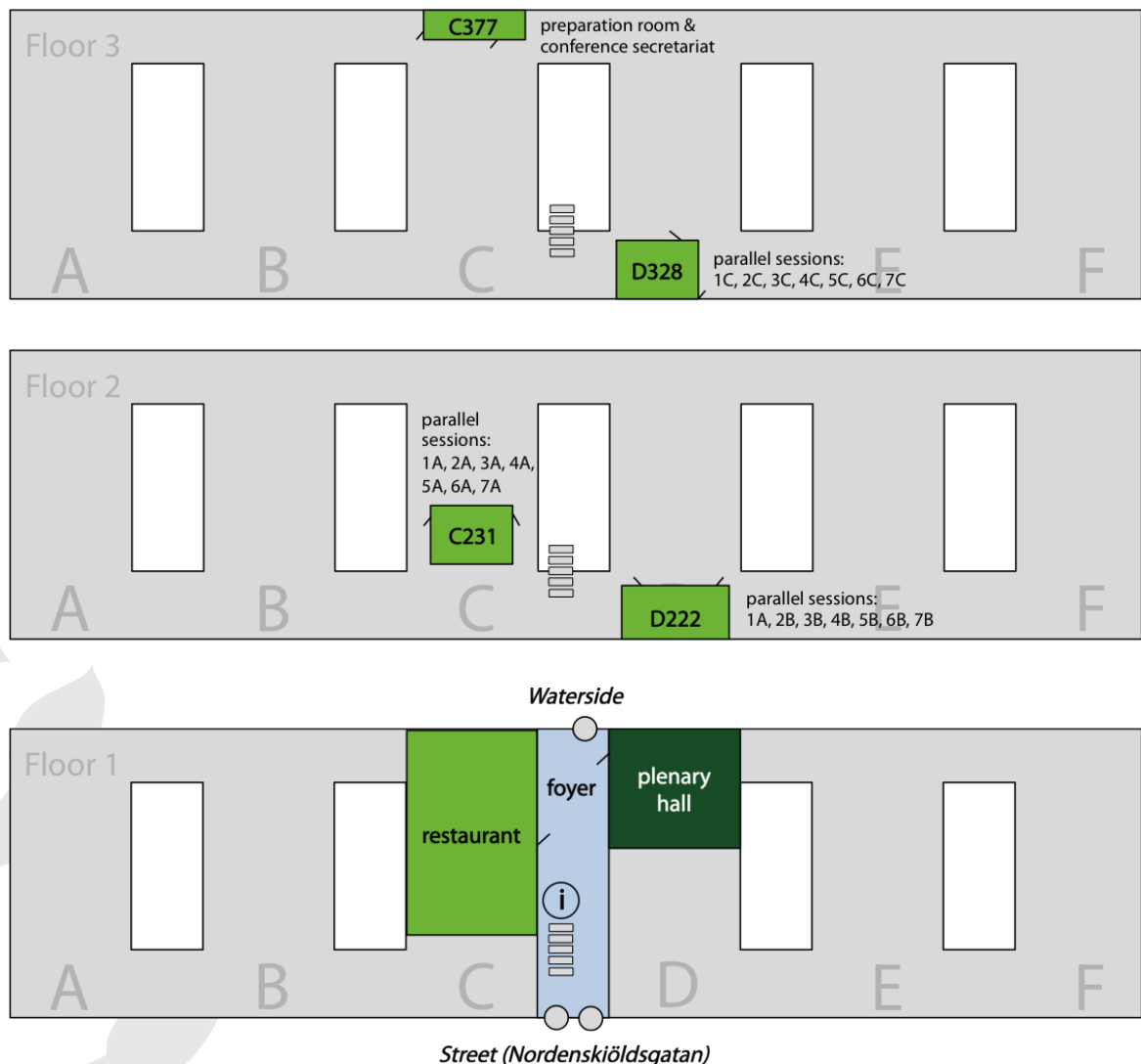
# General information

## Conference venue

The conference takes place in Malmö, the third largest city in Sweden. Malmö is situated in the southernmost part of Sweden, near Copenhagen in Denmark.

The conference venue is at Malmö University, in the building *Orkanen* located in central Malmö (at the address *Nordenskiöldsgatan 10*).

The rooms that are available for the conference are spread over three floors and mainly located around and above the foyer, restaurant and plenary hall (D138).



## Registration and information desk

The registration and conference information desk is located in the foyer of the conference building (marked with i on the picture above), right outside the plenary hall and the restaurant.

## Badges

All registered participants will receive a name badge upon registration. These **badges shall be worn at all times** while in the conference area and will serve as your ticket to meeting rooms etc.



## Useful information

### **Personal insurance**

The organisers of the conference will not provide insurance and do not take responsibility for any loss, accident or illness that might occur during the conference or in the course of travel to or from the meeting site. It is therefore the responsibility of the participants to check their coverage with their insurance provider.

### **Electrical equipment**

The normal electric current in Sweden is 220 volts AC in 50 cycles, and plugs and sockets may differ from those in other parts of the world, so travellers should bring adapters or transformers for electrical appliances such as shavers, computers etc.

### **Telephone numbers**

Emergency (ambulance, police, fire brigade): 112

### **Currency, credit cards, payment**

The monetary unit in Sweden is the krona (plural "kronor"), denoted as "kr" by the Swedes. Bank notes are printed in values of 20, 50, 100, 500 and 1 000 kronor, coins in 1, 5 and 10 kronor. You can get cash with your Visa, MasterCard, Maestro or Cirrus card at any ATM, called "Bankomat" or "Uttagsautomat". ATM:s are available all over the city.

Major credit cards (some restriction may apply to American Express) are widely accepted throughout Sweden at banks, hotels, stores, restaurants, taxis, car rental companies, and for air, ship and rail tickets. Please note that in order to pay or withdraw cash with your credit card it requires that you have a card with chip and PIN (Personal Identification Number). The older magnetic-stripe cards won't work.

Travellers' cheques are generally accepted as payment throughout Sweden, and change will be given in Swedish kronor. Please note that a nominal fee is charged when using the cheques as payment.

Also note that banks in Sweden are only open until 15.00.

### **Tourist information**

For more information about Sweden, travel advices etc, visit the website [www.visitsweden.com](http://www.visitsweden.com).

Tourist information in Malmö is located at the address *Skeppsbron 2*. They can also be reached on telephone: +46 40 - 34 12 00.

## Website



The conference website:

<http://iene2014.iene.info/>

# Organisation

## Host

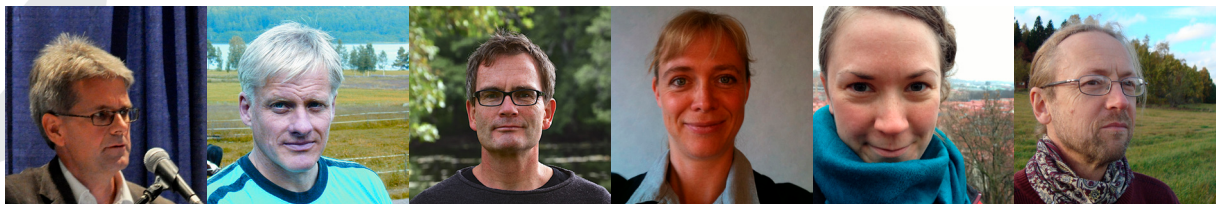
The conference is hosted by IENE and funded and organised by the Swedish Transport Administration in collaboration with the co-organisers the Danish Road Directorate, the Swedish University of Agricultural Sciences and Calluna AB.



## Organisation committee (OC)

The Organisation committee contains members of the hosting and funding partners of the conference, the IENE Steering Committee, the IENE Secretariat, the Program Committee and the Conference Secretariat.

- **Chair:** Lars E. Nilsson (Swedish Transport Administration)
- **Vice chair:** Anders Sjölund (Swedish Transport Administration)
- Andreas Seiler (SLU) - programme director
- Annika Stål-Delbanco (Calluna AB) – chair of conference secretariat
- Tove Adelsköld (Calluna AB) – conference secretariat
- Jan Olof Helldin (Calluna AB) - conference secretariat: field trips



## Conference Secretariat

The Conference secretariat (CS) is responsible for all practical, economical and technical tasks within the conference.

- **Chair:** Annika Stål Delbanco (Calluna AB)
- Tove Adelsköld (Calluna AB)
- Jan Olof Helldin (Calluna AB)
- Andreas Seiler (SLU)

## Programme committee (PC)

The PC contains members of the IENE Steering Committee and selected experts from different disciplines and countries, whose combined experiences cover all relevant topics of the conference.

- **Chair:** Andreas Seiler (SLU – Swedish University of Agricultural Sciences, SE)
- Alex Bager (Brazilian Road Ecology Center, BR)
- Anders Sjölund (Swedish Transport Administration, SE)
- Annika Jägerbrand (VTI, SE)
- Antonio Mira (University of Evora, PT)
- Carme Rosell (Minuartia, ES)
- Charlotta Faith-Ell (WSP, SE)
- Christer Moe Rolandsen (Norwegian Institute for Nature Research, NO)
- Clara Grilo (University of Aveiro, PT)
- Edgar Van der Grift (Alterra, NL)
- Elke Hahn (Federal Ministry for Transport, Innovation and Technology, AT)
- Eric Guinard (CEREMA, FR)
- Fraser Shilling (Road Ecology Center, UC-Davis, US)
- J-O Helldin (Calluna AB, SE)
- Jochen Jaeger (Concordia University, CAN)
- Jörgen Wissman (Swedish Biodiversity Centre, SE)
- Lazaros Georgiadis (ARCTUROS, GR)
- Manuela Panzacchi (Norwegian Institute for Nature Research, NO)
- Marco Dinetti (Ecologia Urbana, IT)
- Marianne Lund Ujvári (Danish Road Directorate, DK)
- Marita Böttcher (Federal Agency of Nature Conservation (BfN) DE)
- Mark Hörstermann (BUND, DE)
- Mathias Herrmann (OEKO-LOG, DE)
- Mattias Olsson (Enviropanning AB, SE)
- Miklós Puky (Hungarian Academy of Sciences, HU)
- Nuria Selva (Polish Academy of Sciences, and Society for Conservation Biology – Europe section, PL)
- Perrine Vermeersch (CEREMA, FR)
- Rodney Van Der Ree (University of Melbourne, AUS)
- Tom Langton (Herpetofauna Consultants International, UK)
- Tony Sangwine (Highways Agency, UK)
- Wendy Collinson (Endangered Wildlife Trust, ZA)
- Yannick Autret (Ministry of Ecology, Sustainable Development and Energy, FR)

## Partners

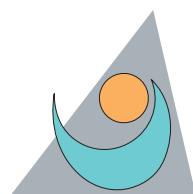
The partners of the conference participate in the organisation of the conference in different ways, eg by being part of the Programme Committee or taking responsibility for a special topic, workshop, session, field trip or social arrangement.



**TRAFIKVERKET**  
SWEDISH TRANSPORT ADMINISTRATION



**Nature  
Conservation**



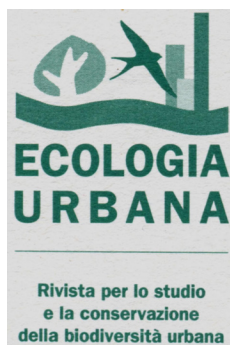
**NINA**

Norwegian Institute for Nature Research



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Umwelt und  
Naturschutz  
Deutschland



Rivista per lo studio  
e la conservazione  
della biodiversità urbana



Society for Conservation Biology  
Europe Section



Australian Research Centre  
for Urban Ecology





## Sponsors & exhibitors

### Sponsors

Sponsoring is a valued component of the IENE conference and the 2014 conference is proudly sponsored by the two silver sponsors:

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### Exhibitors

The exhibition space is in the foyer, the natural meeting place, situated next to the plenary lecture hall and the restaurant. It is combined with the space used for scientific poster sessions and is available throughout all breaks and sessions.

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Swedish Council on Wildlife Collisions



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# Programme overview

| Time        | Tuesday,<br>16th   |              |              | Wednesday,<br>17th             |  | Thursday,<br>18th                              |    |    | Friday,<br>19th       |             |                        | Saturday,<br>20th          | Time  |           |  |
|-------------|--|--------------|--------------|--------------------------------|--|--|----|----|-----------------------|-------------|------------------------|----------------------------|-------|-----------|--|
|             | Field trip 1   | Field trip 2 | Field trip 3 |                                |  |  |    |    |                       |             |                        | Post-conference field trip |       |           |  |
| 8:00        |  |              |              |                                |  |  |    |    |                       |             |                        |                            | 8:00  |           |  |
|             |  |              |              | Registration                   |  | Plenary 2                                      |    |    | Plenary 3             |             |                        |                            | 9:00  |           |  |
| 9:00        |  |              |              | Opening                        |  |  |    |    |                       |             |                        |                            | 9:00  |           |  |
| 10:00       |  |              |              | Break                          |  | Break  |    |    | Break                 |             |                        |                            | 10:00 |           |  |
|             |  |              |              | Plenary 1                      |  | 3A   | 3B | 3C | 6A                    | 6B          | 6C                     |                            | 11:00 |           |  |
| 11:00       |  |              |              |                                |  |  |    |    |                       |             | 11:00                  |                            |       |           |  |
| 12:00       |  |              |              | Lunch<br>& IENE Awards         |  | Lunch  |    |    | Lunch                 |             |                        |                            | 12:00 |           |  |
|             |  |              |              | 1A                             |  | 1B   | 4A | 4B | 4C                    | 7A          | 7B                     |                            | 7C    | Departure |  |
| 13:00       |  |              |              |                                |  |  |    |    |                       |             |                        |                            |       |           |  |
| 14:00       |  |              |              |                                |  |  |    |    |                       |             |                        |                            |       | 14:00     |  |
|             |  |              |              | Break                          |  | Break  |    |    | Break                 |             |                        |                            |       |           |  |
| 15:00       |  |              |              | 2A                             |  | 2B   | 2C | 5A | 5B                    | 5C          | Closing & Poster Award |                            |       | 15:00     |  |
| 16:00       |  |              |              |                                |  |  |    |    |                       |             | Break<br>/ Departure   |                            |       | 16:00     |  |
|             |  |              |              | Poster session 1               |  | Poster session 2                               |    |    | IENE General Assembly |             |                        |                            |       |           |  |
| 17:00       |  |              |              |                                |  |  |    |    |                       |             |                        |                            | 17:00 |           |  |
| 18:00       | Registration<br>& informal<br>get-together<br>with light<br>food & re-<br>freshments |              |              | Free time<br>(eg for meetings) |  | IENE Declaration                               |    |    | IENE General Assembly |             |                        | 18:00                      |       |           |  |
|             |  |              |              | Conference<br>Dinner           |  | Free time<br><br>(Urban Drinks<br>17:00-20:00) |    |    |                       |             |                        | 19:00                      |       |           |  |
| 19:00       |  |              |              |                                |  |  |    |    | 19:00                 |             |                        |                            |       |           |  |
| 20:00       |  |              |              |                                |  |  |    |    | Departure             |             |                        | 20:00                      |       |           |  |
| open<br>end |  |              |              |                                |  |  |    |    |                       | open<br>end |                        |                            |       |           |  |

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# Detailed programme

| ID:                            | Start:    | Session name:   | Title & Authors:   |
|--------------------------------|-----------|---|--|
| <b>Tuesday, September 16</b>   |           |   |  |
|                                | 08:00     | <b>Field trip 1</b>   | Railway tunnel and environmental monitoring at the beautiful Hallandsås  |
|                                | 07:30     | <b>Field trip 2</b>   | Crossing structures, land use and constructed habitat in the heart of Scania   |
|                                | 07:30     | <b>Field trip 3</b>   | Roads, unique glacial landscapes and a taste of Danish summer at the beach   |
|                                | ca. 18:00 | <b>Welcome reception</b>  | Registration & informal get-together with light food & refreshments  |
| <b>Wednesday, September 17</b> |           |   |  |
|                                | 08:30     | <b>Registration</b>   |  |
| OP                             | 09:00     | <b>Opening</b>  | Welcome and opening notes:<br>- Kerstin Åkerwall (City of Malmö)<br>- Ebba Lisberg Jensen (Malmö University)<br>- Lars E. Nilsson (Swedish Transport Administration)<br>- Anders Sjölund (IENE Steering Committee)<br>- Andreas Seiler (IENE 2014 Program director)  |
|                                | 10:00     | <b>Break</b>  |  |
| PL1                            | 10:30     | <b>Plenary 1</b><br>(Chair: Andreas Seiler)   | A history of landscapes, biodiversity and infrastructure - Urban Emanuelsson<br>From Landscape Connectivity to Permeability: Linking Theory to Practice in Road Ecology Mitigation - John Bissonette   |
|                                | 12:00     | <b>Lunch buffet &amp; IENE awards</b>   |  |
| 1A                             | 13:00     | <b>Workshop: CEDR projects</b><br>(Chairs: Edgar van der Grift & Eugene O'Brien)      | Workshop: I have a dream - Chairs: Edgar van der Grift, Eugene O'Brien<br>Presentations and Panel discussion:<br>- Safe roads for wildlife and people - Research to support cost-efficient mitigation strategies and maintenance practices - Edgar van der Grift, Andreas Seiler, Carme Rosell, Vanya Simeonova<br>- Procedures for the Design of Roads in Harmony with Wildlife - Eugene O'Brien, Lennart Folkesson, Dennis Wansink, Miklós Puky  |
| 1B                             | 13:00     | <b>Wildlife accidents, traffic safety and mitigation 1</b><br>(Chair: Mattias Olsson) | Impact of wildlife-vehicle collisions on people in Brazilian highways - Simone Freitas, Leonardo Barszcz<br>Good enough, or room for improvement? Testing alternative designs for a roadside animal detection system using a driving simulator. - Molly Grace, Daniel Smith, Reed Noss<br>Mitigating wildlife-vehicle collisions in Kootenay National Park, Canada - Alan Dibb, Trevor Kinley<br>Methods for cost-efficient mapping of winter food for moose at a detailed scale - Leif Kastdalen, Karianne Thøger-Andresen<br>-<br>-                        |
|                                | 14:30     | <b>Break</b>  |  |
| 2A                             | 15:00     | <b>Wildlife accidents, traffic safety and mitigation 2</b><br>(Chair: Mattias Olsson) | A new LIFE Project for the development of an innovative system to prevent road mortality in central Italy - Annette Mertens, Simone Ricci, Umberto Sergiacomi, Roberta Mazzei<br>Technical mitigation measures for ungulate-vehicle-collisions in Germany - Facts vs. Guesswork - Christian Trothe, Marcus Meißner, Sven Herzog<br>Wildlife-Vehicle-Collision (WVC) avoidance by cooperative smart ITS-sensor/actuators - Andreas Schalk<br>GPS-based real-time application to warn drivers of high risk of animal-vehicle collision - Víctor Colino-Rabanal |



| ID: | Start: | Session name:   | Title & Authors:  |
|-----|--------|---|---|
|     |        |   | Costs on car repairs due to wild animals accidents - Fredrik Valgren  |
|     |        |   | Effectiveness of acoustic wildlife warning devices to reduce risk of animal-train collisions - Karolina Jasinska, Dagny Krauze-Gryz, Joanna Babinska-Werka, Michal Wasilewski   |
| 2B  | 15:00  | <b>International case studies</b><br>(Chair: Lars E. Nilsson)                           | South Africa: The road ahead - Wendy Collinson, Claire Patterson-Abrolat  |
|     |        |   | Environmental aspects in national plan on logistics and transportation plan of Brazil - Simone Freitas, Silvana Zioni   |
|     |        |   | Green Belt: 25 Years in Germany – 10 Years in Europe - Mark Hoerstermann  |
|     |        |   | The BioREGIO Carpathians project: aims, methodology and results from the “Continuity and Connectivity” analysis - Filippo Favilli   |
|     |        |   | A method for establishing the landscape as regional platform for cooperation between national and regional authorities (Integrated landscape character assessment ILCA) - Lars Nilsson                                |
|     |        |   | Handbook of Road Ecology - Rodney van der Ree, Daniel Smith, Clara Grilo  |
| 2C  | 15:00  | <b>Workshop: Best practice in maintenance</b><br>(Chair: Carme Rosell & Dennis Wansink) | Road maintenance practices to improve wildlife conservation and traffic safety - Chairs: Carme Rosell & Dennis Wansink  |
| P1  | 16:30  | <b>Wildlife accidents, traffic safety and mitigation</b>                                | How traffic mortality affects four ungulate species in southern Finland? - Milla Niemä, Juho Matala, Markus Melin, Hannu Järvenpää  |
|     |        |   | Road sites selection for primates crossings: factors for the black-tufted-ear marmoset ( <i>Callithrix penicillata</i> ) - Alex Bager, Helio Secco, Hariagnes Dias  |
|     |        |   | The effects of roads on demography and genetic structure of expanding bobcat ( <i>Lynx rufus</i> ) populations in New Hampshire, USA - John Litvaitis   |
|     |        |   | Raccoon dog: relationships between roadkill numbers, traffic intensity, the hunting bag and climate change - Linas Balčiauskas, Laima Balčiauskienė   |
|     |        |   | Wildlife road traffic accidents: a standardised protocol for counting flattened fauna - Wendy Collinson, Daniel Parker, Ric Bernard, Brian Reilly, Harriet Davies-Mostert   |
|     |        |   | Mortality of vertebrates caused by traffic in Niepolomice Forest, southern Poland. - Katarzyna Trętowska  |
|     |        |   | Dear-Vehicle Collisions Situation Identified by Questionnaire Surveys to Drivers - Misako Noro, Fumihiro Hara, Toru Hagiwara  |
|     |        |   | Effect of tree clearance on ungulate-train collisions - Carin Eriksson, Andreas Seiler  |
|     |        |   | Temporal and spatial patterns of deer-vehicle collisions in intensively managed landscapes in Denmark - Morten Elmeros, Peter Sunde, Poul Andersen, Aksel Madsen  |
|     |        |   | The influence of spatial units to identify factors explaining wildlife vehicle collisions - Alex Bager, Thálita Cardoso, Clara Grilo  |
|     |        |   | A new method for identification of clusters of animal-vehicle collisions on road networks - Michal Bíl, Richard Andrášik, Jirí Sedoník  |
|     |        |   | Differences in the variables related to animal-vehicle collisions between livestock and wildlife - Víctor Colino-Rabanal  |
|     |        |   | Island biogeography and ungulate-vehicle collisions. Planning considerations for roads. - Víctor Colino-Rabanal   |
|     |        | <b>De-fragmentation</b>   | Inventory of connectivity structures in the road network in Catalonia - Antoni Sorolla, Jordi Solina, Raquel del Rosal, Sergi Rasero, Carme Rosell, Marc Fernández-Bou  |
|     |        |   | Large scale defragmentation plan for ungulates and large carnivores along E20 in southwestern Sweden - Mattias Olsson, Andreas Seiler, Kerry Nicholson, Mats Lindqvist  |
|     |        | <b>Impact and Mitigation</b>  | Escape rates and times of carabid beetles from various types of precast concrete roadside ditch blocks - Yoshiki Yamada, Hitoshi Sasaki   |
|     |        | <b>Communication</b>  | Youth Education for Sustainable Transport – increasing the public awareness of landscape fragmentation due to transport infrastructure : the Czech experience - Ivo Dostal, Marek Havlicek, Petr Anđel, Jiri Jedlicka |

| ID:                    | Start: | Session name:  | Title & Authors:  |
|------------------------|--------|--|---|
|                        | 18:00  | Free time (eg for meetings)  |   |
|                        | 19:00  | Conference dinner (requires special registration made before the conference)   |   |
| Thursday, September 18 |        |  |   |
| PL2                    | 08:30  | Plenary 2<br>(Chair: Andreas Seiler)   | An experimental investigation into the effects of traffic noise on birds: The Phantom Road project - Jesse Barber   |
|                        |        |  | Why keep areas road-free? Roadless and low-traffic areas as conservation targets. - Nuria Selva   |
|                        | 10:00  | Break  |   |
| 3A                     | 10:30  | Wildlife accidents, traffic safety and mitigation 3<br>(Chair: Mattias Olsson) | Two spatial scales of moose-vehicle collisions - Milla Niemi, Antti Nykänen, Hannu Rita, Mikko Vastaranta, Veli-Matti Väänänen  |
|                        |        |  | Locations of the registered moose-vehicle collisions and their spatial relations with green network in Estonia - Maris Kruuse, Tõnu Oja   |
|                        |        |  | Clusters of traffic accidents caused by ungulates: identification and evaluation of their significance in the Catalonia road network - Carme Rosell, Michal Bíl, Ferran Camps, Richard Andrášik, Marc Fernández-Bou, Zbyněk Janoška |
|                        |        |  | The effect of the moon in wildlife-vehicle collisions - Victor Colino-Rabanal, Miguel Lizana, Tom Langen, Salvador Peris  |
|                        |        |  | Quantification of railroad-related barrier effects on the movements of ungulates and medium-sized mammals in southern Sweden - Mattias Olsson, Andreas Seiler   |
|                        |        |  | -   |
| 3B                     | 10:30  | Roadless areas<br>(Chair: Nuria Selva)   | Indices for the spatial assessment of road and traffic impacts on ecosystems - Stefan Kreft, Lisa Freudenberger, Julia Sauermann, Monika Hoffmann, Guy Pe'er, Peter Hobson, Nuria Selva, Pierre Ibisch                              |
|                        |        |  | Identifying Roadless Areas In Europe - Maria Psaralexi, John Pantis, Nefta-Eleftheria Votsi, Antonios Mazaris   |
|                        |        |  | A global assessment of roadless areas - Monika Hoffmann, Pierre Ibisch, Lisa Freudenberger, Stefan Kreft, Guy Pe'er, Vassiliki Kati, Peter Hobson, Kriton Arsenis, Nuria Selva  |
|                        |        |  | A Spatial Assessment of Fragmentation and Disturbance Effects of the Swedish Road Network - Mårten Karlson  |
|                        |        |  | An approach to road networks and soundscapes - Víctor Colino-Rabanal  |
|                        |        |  | -   |
| 3C                     | 10:30  | Road kill observation and reporting<br>(Chair: Fraser Shilling)                | Wildlife-Vehicle Collision Observation Collection and Hotspot Identification at Large Scales - Fraser Shilling  |
|                        |        |  | Motorways and vertebrates traffic casualties: comparative methodology study in obtaining unbiased number of roadkills - Éric Guinard, Aurélien Besnard, Christophe Barbraud   |
|                        |        |  | Citizen science and smartphones take roadkill monitoring to the next level - Diemer Vercayie  |
|                        |        |  | Intelligent systems for mapping amphibian mortality on Portuguese roads - Neftalí Sillero, Mark Franch, Cristiano Silva, Luís Gonçalves-Seco, Gil Lopes   |
|                        |        |  | -   |
|                        |        |  | -   |
|                        | 12:00  | Lunch buffet   |   |
| 4A                     | 13:00  | Workshop: Animal reporting system<br>(Chair: Fraser Shilling)                  | Systematically reporting live and dead wildlife on and near roads - Chair: Fraser Shilling  |
| 4B                     | 13:00  | Infrastructure habitats<br>(Chair: Jörgen Wissman)                             | High environmental values __in biotopes on railway stations. A method to identify and rank nature conservation values. - Magnus Stenmark, Marie Johnsson  |
|                        |        |  | The Ecology of Large Infrastructure Embankments: From Heritage to Diversity The Example of the Likoto Eurometropoli - Denis Delbaere  |

| ID: | Start: | Session name:   | Title & Authors:  |
|-----|--------|---|---|
|     |        |   | Evaluation of faunistic richness of Hungarian highway verges - Balázs Kiss, Réka Lupták, Éva Szita, Diána Vona-Túri, Ferenc Kádár, Miklós Puky  |
|     |        |   | The importance of infrastructure for biologically important trees - Jörgen Wissman  |
|     |        |   | Minor rural road networks: values, challenges, and opportunities for biodiversity conservation. - Peter Spooner   |
|     |        |   | -   |
| 4C  | 13:00  | <b>Biodiversity Off-setting</b><br>(Chair: Anders Enetjärn)                           | Biodiversity offsetting in context of the mitigation hierarchy - Anders Enetjärn  |
|     |        |   | Mitigation by avoidance in infrastructure planning - Anders Enetjärn, Anders Sjölund  |
|     |        |   | Mitigating large-scale infrastructure impact on reindeers in northern Sweden and on plant diversity along roadsides - Maria Bergstén  |
|     |        |   | Ecological restoration as a part of a road building process - Astrid Skringö  |
|     |        |   | Offset- how to balance losses and gains of biodiversity - Josefin Blanck, Anders Enetjärn   |
|     |        |   | A national survey of environmental compensation in infrastructure projects and its implications for policy development - Jesper Persson, Anders Larsson, Ana Villarroya Ballarín  |
|     | 14:30  | <b>Break</b>  |   |
| 5A  | 15:00  | <b>Workshop: NVR - Swedish National Council for WVC</b><br>(Moderator: Fredrik Bergh) | Managing Wildlife-Vehicle Accidents in Sweden - Moderator: Fredrik Bergh  |
|     |        |   | Panel discussion:<br>- Background of the NVR or why it needed a multi-organisational network to deal with wildlife-vehicle collisions. - Håkan Karlsson<br>- Presentation of the Swedish National Council for Wildlife-Vehicle Accidents – a unique organisation. - Lars-Erik Nilsson<br>- Data management of accident reports and usage in research and prevention approaches. - Marcus Alsér<br>- Practical experiences with taking care of and hunting of animals wounded in traffic. - Torkel Norling |
| 5B  | 15:00  | <b>Impact and Mitigation</b><br>(Chair: Eric Guinard)                                 | Understanding roadside salt exposure - Göran Blomqvist  |
|     |        |   | Mitigation measures to enhance the ecological value of strongly human influenced navigable waterways in Flanders (Belgium) - Andy Van Kerckvoorde   |
|     |        |   | Movement behavior of Montane Akodont near roads: pavement or edge effect? - Fernando Ascensão, Priscila Lucas, Aline Costa, Alex Bager  |
|     |        |   | An artificial canal limits movements and causes a greater genetic divergence than a major road for the threatened western ringtail possum ( <i>Pseudocheirus occidentalis</i> ) in Western Australia: a need for mitigation measures - Kaori Yokochi, Winn Kennington, Roberta Bencini  |
|     |        |   | Mitigating the impact of noise barriers on reptile populations on rail and road verges - Christian Mayer, Christof Elmiger, Marguerite Trocmé   |
|     |        |   | -   |
| 5C  | 15:00  | <b>Road mortality and population effects</b><br>(Chair: Jan Olof Helldin)             | Roadkill influence on mammal diversity and sustainable use - Linas Balčiauskas, Laima Balčiauskienė   |
|     |        |   | Traffic mortality – a growing threat to wildlife conservation - Jan Helldin, Andreas Seiler   |
|     |        |   | Global impact of roads on carnivores: which species and where? - Ana Ceia-Hasse, Luís Borda-de-Água, Clara Grilo, Henrique Pereira  |
|     |        |   | The mortality rate of amphibians killed by motor traffic during their spring migration across the E22 express road between Elbląg and Kaliningrad - Bogusław Bobek  |
|     |        |   | The effect of major roads on bat activity and diversity, and the effectiveness of current mitigation practice - Anna Berthinussen, John Altringham  |
|     |        |   | Potholes on the way to effective mitigation measures for bats - Claude Steck, Fabio Bontadina, Martin Biedermann, Inken Karst, Wigbert Schorch, Robert Brinkmann  |

| ID: | Start: | Session name:  | Title & Authors:  |
|-----|--------|--|---|
| P2  | 16:30  | <b>Wildlife accidents, traffic safety and mitigation</b> | Costs and effects of deer-train collisions in Sweden - Andreas Seiler, Pär Söderström, Mattias Olsson, Anders Sjölund   |
|     |        |  | Brown bear ( <i>Ursus arctos</i> ) road mortality data in the Region of West Macedonia, Greece in the framework of development of Hellenic Roadkill Observatory - Lazaros Georgiadis, Dimitris Bousbouras, Nikos Panagiotopoulos, Lambros Krampokoukis, Giorgos Papakostas, Kostas Stefanidis, Alexandros A. Karamanlidis |
|     |        |  | Results from a drivers' questionnaire about wildlife-vehicle accidents in Sweden - Andreas Seiler, Marianne Hjältfors, Annika Jägerbrand, Christiane Seiler, Lennart Folkesson, Mats Lindkvist, Marit Thorin, Ingrid Hugosson, Niclas Dahl  |
|     |        | <b>Infrastructure habitats</b>                           | Help, where are my trees and shrubs? The 'Green inventory'! - Sandra Vandewiele, Mieke Hoogewijs  |
|     |        |  | Abundance of red-listed species in infrastructure habitats – "responsibility species" as a priority-setting tool for transportation agencies' conservation action - Jan Olof Helldin, Jörgen Wissman, Tommy Lennartsson   |
|     |        |  | Conclusions of new strategies for improved inventories of species-rich roadsides in Southwest Sweden - Mats Lindqvist, Johanna Borlid   |
|     |        |  | Potential of linear infrastructures verges for conservation and dispersal of wild pollinators - Éric Guinard, Denis François, Violette Le Féon, Mickaël Henry, Bernard Vaissière, Jean-François Breteau, Christophe Pineau  |
|     |        |  | Work group for infrastructure grassland management – a cross-disciplinary forum promoting efficient biodiversity conservation in "new" grasslands - Sofia Gylje Blank   |
|     |        |  | Infrastructures in arid environments: water cisterns as death traps for amphibians and reptiles in south-western Morocco - Neftalí Sillero, Luís García-Cardenete, Juan Pleguezuelos, José Brito, Francisco Jiménez-Cazalla, María Pérez-García, Xavier Santos,   |
|     |        | <b>Planning for better infrastructure</b>                | A new highway in Brazilian central west: aspects of Environmental impact assessment to support best project's choice for BR-080/MT construction. - Raquel Lacerda, Juliana Rocha, Tatiana de Souza  |
|     |        |  | Biodiversity taken into account by a road network manager: a global approach, from diagnosis to continuing education - Jean-François Breteau  |
|     |        |  | Institutional framework for integrated research on infrastructures, landscapes and biodiversity - Judith Raoul-Duval  |
|     |        |  | Methodology for identifying and assess geo-related ecological and cultural values - Mats Gustafsson   |
|     |        |  | On the scales of ecological and environmental impacts on islands - Shyh-Chyang Lin  |
|     |        |  | Genetic Database of Selected Species of Mammals of the Czech Republic - Tomáš Libosvár, Tomáš Šikula, Martin Ernst  |
|     |        | <b>Wildlife passages</b>                                 | Greenbridges as crossovers for bats - Lothar Bach, Petra Bach, Heiko Müller-Stieß   |
|     |        |  | Monitoring the infrastructure transparency for Bats by a 3 dimensional Flight Path Tracking - Olivier Tasse, Hippolyte Pouchelle  |
|     |        |  | Monitoring the use of existing crossing structures by mammals along a fenced motorway section in the Swiss lowlands - Kim Krause, Joggi Rieder  |
|     |        |  | New developments in wildlife crossings. Monitoring of an animal-activated electronic wildlife-crossing-system. - Christian Trothe, Marcus Meißner, Sven Herzog  |
|     |        |  | Road ecology in a Neotropical biodiversity hotspot: monitoring effectiveness of wildlife crossings in the Atlantic Forest, Argentina - Diego Varela   |
|     |        |  | Structures to mitigate the habitat fragmentation of the Siberian flying squirrel in Japan - Yushin Asari  |
|     | 17:00  |  | Optional: Urban Drinks at M.E.C.K. 17:00-20:00  |
|     | 18:00  | <b>Plenary discussion</b> (Chair: Anders Sjölund)        | IENE 2014 Declaration - presentation and discussion   |

| ID:                         | Start: | Session name:   | Title & Authors:  |
|-----------------------------|--------|---|---|
| <b>Friday, September 19</b> |        |   |   |
| PL3                         | 08:30  | <b>Plenary 3</b><br>(Chair: Andreas Seiler)                           | Implementation of Green Infrastructure in the EU. - Marco Fritz<br>Reducing Decision Making Risks of Highways Projects Design and Implementation in Ecosystems on the base of IT adaptive model and Friendly Interface - Dmitry Kavtaradze, Larissa Gagarina, Alexey Mordovin, Yana Teplova, Victoria Kukhtjaeva  |
|                             | 10:00  | <b>Break</b>  |   |
| 6A                          | 10:30  | <b>Communication and public involvement</b><br>(Chair: Tom Langton)   | Parkways and Landscapes - Critical assessment of the ecological impact of the cultural rhetoric of parkways in North America - Aisling O'Carroll<br>Integrated Landscape Character Assessment ILCA- a methodology for including landscape in long term spatial planning - Emily Wade, Tobias Noborn, Bengt Schibbye, Mia Björkebaum, John Askling, Eva-Lisa Anderson, Malin Andersson,<br>Perceived landscape values and public participation in a road-planning process in Sweden - Marianne Henningson, Malgorzata Blicharska, Hans Antonson, Grzegorz Mikusinski, Görgen Göransson, Per Angelstam, Lennart Folkeson, Sofia Jönsson Ekström<br>Fauna brigdes, public emotions and Road Agency communication– lessons learned - Marianne Lund-Ujvári<br>Addressing biodiversity conservation on roads in South Africa - Wendy Collinson, Marie Parromon-Gurney, Claire Patterson-Abrolat, Harriet Davies-Mostert<br>Progress with Green Infrastructure across the Council of Europe area. - Tom Langton              |
| 6B                          | 10:30  | <b>De-fragmentation</b><br>(Chair: Marguerite Trocmé)                 | Defragmentation of the Belgian Sonian Forest - Anouschka Kuijsters, Steven Vanonckelen, Patrick Huvenne<br>The results and lessons after 10 years Long Term De-Fragmentation Program in the Netherlands - Hans Bekker<br>A life cycle approach to defragmentation - Marguerite Trocmé<br>Integrating decision planning tools into road mitigation planning for small and large animals in Ontario, Canada - Kari Gunson, Brenda Carruthers<br>Green infrastructure: from policy to tailor-made action! - Sandra Vandewiele, Mieke Hoogewijs<br>Wetland fragmentation due to the road construction - Isin Barut  |
| 6C                          | 10:30  | <b>Wildlife movement and connectivity</b><br>(Chair: Daniel Smith)    | Using multiple research methods to understand movement patterns and choices in road crossing locations by black bears for mitigation planning - Daniel Smith<br>Identifying the optimal locations for new habitat creation in ecological compensation - Céline Clauzel<br>Does daily movements can predict the genetic structure of small mammal populations? - Clara Grilo, Irene Del Cerro, Victor Ramiro, Guillem Molina-Vacas, Xavi Fernández-Aguilar, Flavia Porto Peter, Fernando Ascensão, Jacinto Román, Carlos Fonseca, José Godoy, Eloy Revilla<br>Using Circuit Theory to Rewire Roads for Wildlife - Kerry Nicholson, Andreas Seiler, Mattias Olsson, Mats Lindqvist<br>Integrating landscape connectivity analyses into the decision making process of linear infrastructure track location - Xavier Girardet<br>A unifying framework to define and identify movement corridors and barriers using Step Selection Functions and Randomized Shortest Paths - Manuela Panzacchi, Bram Moorter, Olav Strand |
|                             | 12:00  | <b>Lunch buffet</b>   |   |
| 7A                          | 13:00  | <b>Workshop: Railways and Wildlife</b><br>(Moderator: Andreas Seiler) | Railways and wildlife - conflicts and solutions - Moderator: Andreas Seiler<br>"Panel discussion:<br>What is known about train and wildlife accidents? How are they perceived and studied? - Mattias Olsson<br>How are wildlife-train collisions dealt with in Sweden? - Ulrika Lundin<br>What are the consequences of wildlife-train collisions to corporate economy and traffic flow? - Pär Söderström<br>High speed railways and wildlife - Michael Below "  |

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|-------------------------------|--------|---|---|
| 7B                            | 13:00  | <b>Wildlife passages</b><br>(Chair:<br>Miklos Puky)                       | Wildlife crossings through existing culverts and bridges, at grade crossings and road mortality along the Ring Changbai Mountain Scenic Highway, China - Yun Wang, Jiding Chen, Zhengji Piao, Lei Guan, Marcel P Huijser, Yaping Kong |
|                               |        |   | Wildlife fauna pipes efficiency in two motorways located in Western France studied during a two years survey with infra-red-operated cameras - Sylvain Fagart, Cedric Heurtebise, Philippe Jourde, Thierry Micol, Gwenaël Quaintenne  |
|                               |        |   | Getting the full story: evaluating the impact of crossing structures on the movement, gene flow and survival of the squirrel glider - Kylie Soanes  |
|                               |        |   | Vegetated fauna overpasses enhance crossing rates by small forest birds - Darryl Jones, Stuart Pell   |
|                               |        |   | Amphibian rescue at a narrow-gauge railway - wetland area conflict area at Bala-tonfenyves, Hungary - Miklos Puky, András Buskó, Balázs Kiss  |
|                               |        |   | Effectiveness of wildlife passage and new monitoring techniques on the road - Yoichi Sonoda, Masao Kurihara, Utsuke Ueno, Masahiko Matsue   |
| 7C                            | 13:00  | <b>Planning for better infrastructure</b><br>(Chair:<br>Lennart Folkeson) | A standard methodology to be used for fauna survey and monitoring in Brazilian roads' and railways' environmental licensing - Juliana Rocha, Raquel Lacerda   |
|                               |        |   | SUNRA—a tool to assess the sustainability of road administrations and road projects - Lennart Folkeson, Clare Harmer  |
|                               |        |   | Assessing the Ecosystem Service loss due to new alignments, using a spatial analysis toolkit - Olivier Tasse, Lea Tardieu, Dorothee Labarraque  |
|                               |        |   | Managing a green infrastructure in planning, building and maintenance of roads and railroads. - Anders Sjölund  |
|                               |        |   | Project Laxå - mitigation measures on existing road and railroad - Åsa Röstell  |
|                               |        |   | Increasing ecological value in a tender for a design, construct, finance and maintain contract for a Dutch road expansion - Victor Loehr  |
|                               | 14:30  | <b>Break</b>  |   |
| CL                            | 15:00  | <b>Closing</b> (Chair:<br>Andreas Seiler)                                 | Conclusions from the conference and Poster Awards   |
|                               | 16:00  | <b>Break</b>  |   |
| GA                            | 17:00  | <b>IENE GA</b>  | IENE general member assembly 2014   |
| <b>Saturday, September 20</b> |        |   |   |
|                               | 07:30  | <b>Field trip</b>   | Post-conference field trip, arranged by Enetjärn AB   |
|                               | 12:30  |   | End of Post-conference field trip   |



## IENE Awards

IENE recognizes and awards outstanding efforts made to reduce the detrimental effects of transport infrastructure on nature and enhance its potential for a positive influence.

Such efforts may appear as extraordinary impact assessments, mitigation plans or technical measures at local, national or regional scale; research achievements, information, education or promotion activities.

IENE awards are given in two variants:

- The **IENE Personal Award** appreciates outstanding engagement and special achievements made by individuals that are not necessarily related to a particular activity.
- The **IENE Project Award** appreciates extraordinary work accomplished by initiatives, activities or plans.

### Personal Award 2013 - Marguerite Trocmé

"For her long-term commitment to reduce the environmental impact of transportation infrastructure, for supporting colleagues, new ideas and projects and contributing fundamentally to establish the state of the art in Switzerland."

### Personal Award 2014 - Wendy Collinson

"For her long-term commitment to road ecology and wildlife-traffic conflicts in South Africa, her achievements in communication, awareness raising and mitigation of the impact of traffic and roads on African wildlife."

### Project Award 2014 - Ecoduct Kempengrens

"The cross-border Ecoduct Kempengrens, a cooperation between Flanders and The Netherlands, represents an excellent example of cooperation between countries and institutions in cross-border defragmentation."



At the prize ceremony. From left to right: Wendy Collinson (Personal Award 2014), Liesbet Van Laer (Ecoduct Kempengrens), Marguerite Trocmé (Personal Award 2013), Katja Claus (Ecoduct Kempengrens), Marleen Moelants (Ecoduct Kempengrens), Elke Hahn (IENE SC), Anders Sjöund (IENE SC) and Rob van Ruremonde (Ecoduct Kempengrens).

# IENE 2014 declaration

## Protect remaining roadless areas

### **We, the participants of the IENE 2014 International Conference, acknowledge that**

- the mobility of people and goods is important for economic development; transportation facilities such as roads, railroads and canals bring benefit to people and are essential components of present-day human societies,
- transportation infrastructure with its associated traffic exerts substantial pressures on biodiversity that extend far from individual transportation corridors and may interact and even accumulate at network level ,
- even minor infrastructure is of significance as it prepares for exploitation of natural resources and secondary development,
- the detrimental environmental impacts of traffic and transportation infrastructure can only in part be mitigated effectively, but not entirely avoided.

### **Roadless areas (RLA) are of particular importance for biodiversity conservation, because they**

- are the least disturbed natural areas in the world,
- are characterized by high ecological value, integrity and connectivity,
- act as refuges for native and endangered wild animals and plants,
- provide vital ecosystem services such as clean water and air, opportunities for recreation, and protection against pests and invasive species,
- are more resistant to and resilient from catastrophic events,
- help species to adapt to new conditions created by climate and landscape change.

Thus, roadless areas far exceed roaded areas in the ecological benefits they provide.

Europe has been fragmented by transportation infrastructure for a long time. Accordingly, preserving the continent's last remaining roadless areas will significantly contribute to prevent further loss of biodiversity. Preserving roadless areas is hence necessary for reaching the UN Aichi strategic goals and EU biodiversity targets.

*Therefore we, the participants of the IENE 2014 International Conference, call for a pan-European strategy to protect roadless areas.*

### **We urge that such areas are given a stronger conservation status in policy, planning and practice, both nationally and internationally, by**

- mapping and monitoring roadless areas at national as well as European level,
- incorporating roadless areas explicitly as conservation targets in national and European policy and legislation,
- avoiding infrastructure development in roadless areas,
- identifying areas of particular value for restoration as roadless areas,
- regularly monitor and evaluate the efforts to protect roadless areas,
- re-creating roadless areas by means of road closure and removal.

*The IENE 2014 International Conference has highlighted the ecological and social benefits of roadless areas, outlined solutions for how transportation infrastructure can be developed without compromising these benefits, and shown that the transport sector is able and willing to contribute substantially to implementing these solutions.*







# Abstracts: Wednesday, September 17

## Plenary session

## Parallel sessions

**1A - Workshop: CEDR (chair: Edgar van der Grift)**

**1B - Wildlife accidents, traffic safety and mitigation 1 (chair: Mattias Olsson)**

**2A - Wildlife accidents, traffic safety and mitigation 2 (chair: Mattias Olsson)**

**2B - International case studies (chair: Lars Nilsson)**

**2C - Workshop: Best practice in maintenance (chair: Carme Rosell)**

## Poster session

**Wildlife accidents, traffic safety and mitigation**

**De-fragmentation**

**Impact and mitigation**

**Communication**

Information about  
the conference

Wednesday  
September 17

Thursday  
September 18

Friday  
September 19

Index of authors &  
List of participants





## Plenary session 1

### Urban Emanuelsson



Professor, Swedish Biodiversity Centre, Sweden.

Urban Emanuelsson is a plant ecologist with a special focus on cultural and historical issues related to ecology. He is a professor at the Centre for Biological Diversity (SLU & Uppsala University), and at Kristianstad University College. Urban is working on environmentally oriented planning issues and landscape ecological problems in Europe, Northeast Asia, and East Africa. In Sweden, he predominantly works in the southernmost provinces and Upper Norrland, with a special focus on cultural issues in the mountains.

## A history of landscapes, biodiversity and infrastructure

Author(s): Urban Emanuelsson

Contact: Urban Emanuelsson, Swedish Biodiversity Centre, email: [Urban.Emanuelsson@slu.se](mailto:Urban.Emanuelsson@slu.se)

Land surfaces, in general terms, are formed by geological processes and modified by biotic and abiotic factors. However, much earlier than what often is suggested, humans have interfered in this process and shaped the land. Large herbivores played an important role for the vegetation in pre-agrarian landscapes. Human pressure and climate changes then reduced the mega fauna, but the domestication of aurox (cow), horse, pig, goat and sheep created browsing systems that to some degree mimic the wild mega-herbivore landscape. Human transformation of the European landscape intensified, however, as farming was introduced. Farming took many different shapes through history, creating various different landscape types. Most important was probably the way farmers interacted with the biogeological cycles of nitrogen, phosphorus and potassium. Introduction of artificial fertilizers in the late 19th century became an enormous transforming factor for the whole landscape, also indirectly the forests of the landscape was affected. Already in very early times, during the pre-farming Stone Age, the possible means of transportation played a very important role in how landscapes were developed. Waterways played for a long time the most important role, and humans have ever since sought to improve waterways for better transportation. In Central and Western Europe, canalisation of rivers triggered regional economic development, but those projects also transformed many wet river valleys into dry but productive agricultural areas. Surface transportation, however, was problematic and had often

little influence on broad landscape transformation processes. But where waterways were insufficient, roads were built eventually. Roman roads in particular provided reliable infrastructure for local as well as long distance transportation. Yet, many fell into disrepair as they were neglected during early medieval time, a period of general population decrease. Another type of infrastructure used by different ethnic groups specializing in herding, for example sheep or reindeer, were transhumance tracks. Such track systems were also used by other people and became sometimes important general infrastructure systems. As railroads were developed in the late 19th and early 20th century, a new wave of landscape transformation began, sometimes in a negative impact on biological as well as cultural diversity. Yet, the railroad tracks had still a limited physical impact on the landscape if compared with the later highways and motorways. Modern highways and high-speed railways are no longer an integrated part of the landscape but superimposed features that disrupt natural processes and pollute the surrounding environment. Different infrastructure and transport systems have significantly contributed to the spread of wild animals and plants as well as fungi. This process has probably enriched the (scandinavian) landscapes with many new plant species in historical times, but there are a numerous other and more recent examples, where human transportation introduced invasive species and caused dramatic effects on native ecosystems. Future transport systems will have to decouple the adverse side-effects and minimize the direct impact on the environment. This is possible, but requires a thorough understanding of the effects of transportation and infrastructure and, most likely, new approaches on mitigation.

## Plenary session 1

### John A. Bissonette



Professor Emeritus, Department of Wildland Resources, College of Natural Resources, Utah State University, USA

John A. Bissonette is a Certified Wildlife Biologist® and was appointed a Fellow of The Wildlife Society in 2004 and is a member of the Editorial Board of the European Journal of Wildlife Research. He retired as Leader of the U.S. Geological Survey, Utah Cooperative Fish and Wildlife Research Unit in June 2012 and is Professor Emeritus in the Department of Wildland Resources at Utah State University, USA. John had various professional collaborations with Universities in Europe and Australia, has authored, co-authored, and edited 5 books related to landscape ecology theory and practice and road ecology as

well as many peer reviewed papers. When not working or traveling, he rides his horse, Smarty Pants Too, in the mountains of Utah and his Harley on the back roads of the West.

## From Landscape Connectivity to Permeability: Linking Theory to Practice in Road Ecology Mitigation

Author(s): John A. Bissonette

Contact: John A. Bissonette, Department of Wildland Resources Utah State University Logan UT 84341, email: john.bissonette@aggiemail.usu.edu

This plenary talk will address the interface between necessary concepts of landscape ecology and essential road ecology data needed for managing both traffic safety and wildlife mitigation. It is my working hypothesis that road ecology mitigation (the activities we do on the ground) should be based on accurate data, informed theory, and an organized method for addressing the problem. This is my basic operating principle. Others no doubt will organize these components differently.

### ACCURATE DATA

In this presentation, I address the recent advances in accurate data gathering for road-kills by listing many of the smartphone applications

in existence today. There has been a virtual explosion of smartphone apps developed over the past few years. Almost all involve citizen science, where the idea is to engage the public to help report animal observations of presence/absence and distribution for atlas data sites as well as for road-related animal observations. The benefits of using a citizen science approach include low cost and usually a rich data set. However, there are at least 3 problems evident with this approach. First, double counting of observations, (viz., road kills) can be a problem and skew data results when the primary purpose of using the app includes obtaining a reasonably accurate account of road-kill number. When the purpose is to identify presence/absence, distribution data, or hot spot areas of kill, then double counting is less important. A second problem involves accurate identification of not only the species, but also age and sex, when those variables are included in the smartphone app. Accurate identification is much more of a problem with smaller wildlife species than for

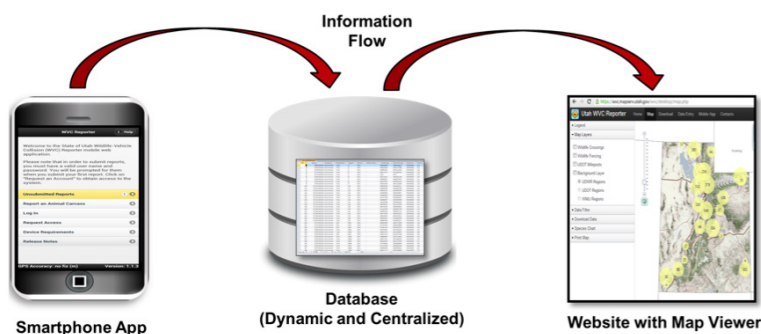


Figure 1. Flow of information through the WVC Reporter system. Using the WVC Reporter system, data are collected in the field using smartphones and a mobile web application. Collected data are then transferred via mobile broadband internet to a centralized database that is dynamically linked to a desktop web application where WVC locations can be viewed. Development of the system was a collaborative effort between the AGRC, the Utah Division of Wildlife Resources, and the Utah Department of Transportation. SOURCE: Olson DD, Bissonette JA, Cramer PC, Green AD, Davis ST, et al. (2014) Monitoring Wildlife-Vehicle Collisions in the Information Age: How Smartphones Can Improve Data Collection. PLoS ONE 9(6): e98613. doi:10.1371/journal.pone.0098613.





history in ecology and has been a particularly successful tool for investigating animal movements. The general form of the scaling equation is:  $Y = aX^b$ . Bowman et al. (2002) showed that dispersal distance (response variable  $Y$ ) was closely related to home range area (explanatory variable  $X$ ). They found that when body size effects were removed, the slope of the relationship of the residuals of dispersal distance regressed against the residuals of home range area was not significantly different from 0.50, a result with very important ramifications. The significance is this: dispersal distance is a linear measure, while home range area is a squared linear measure. Because  $X^{0.5}$  is equal to  $\sqrt{X}$ , and because  $X$  in the scaling equation is equal to home range area, taking the square root of the home range area yields a linear dimension of home range, allowing dispersal distance to be related to home range size by a single scaling constant and with the same unit of measurement. Additionally, the relationship is linear and proportional (isometric, slope = 1). The linear home range metric ( $\sqrt{HR} = HR^{0.5}$ ) is a good approximation of daily animal vagility.

Given these developments, the problem of placing crossings can be addressed by answering two questions. Is it possible to develop scaling domains based on normal movements of animals across their home ranges? Can ecologically relevant metrics that characterize movement distances be developed?

Effective mitigation that employs wildlife crossings involves both their placement and spacing. However, it is unreasonable from a management perspective to attempt to space wildlife crossing structures for each individual species. Some grouping of species is desirable. Hence, an important first task is to translate movement distances characteristic of a community of species into useable, data-based scaling domains,

e.g., ecological neighborhoods (Addicott et al. 1987). Ecological neighborhoods are defined for individual species by three properties: (a) an ecological process (e.g., dispersal, inter-patch movement); (b) a time scale relevant to the process; and (c) an organism's activity during that time period. The most appropriate indicator of activity may be a measure of net movement of individuals, i.e., some measure related to home range (HR) dynamics. Home range area estimates for many species are readily available in the published literature enabling: (a) the identification and assignment of species to clustered movement domains (Figure 3); and (b) the development of scaled movement metrics based on ecological neighborhoods. These are the essential conceptual elements for deciding the scaled placement of wildlife crossings of appropriate type and configuration to promote landscape permeability. It is possible to use cluster analysis to develop domains of scale for mammalian species groups having similar vagility to develop metrics that reflect realistic species movement dynamics. In this presentation, I explain how we identified home range area domains and why we used  $HR^{0.5}$  to represent a daily movement metric. The placement of wildlife crossings based on the  $HR^{0.5}$  metric, along with appropriate auxiliary mitigation, will re-establish landscape permeability by facilitating wildlife movement across the roaded landscape and significantly improve road safety by reducing wildlife vehicle collisions.

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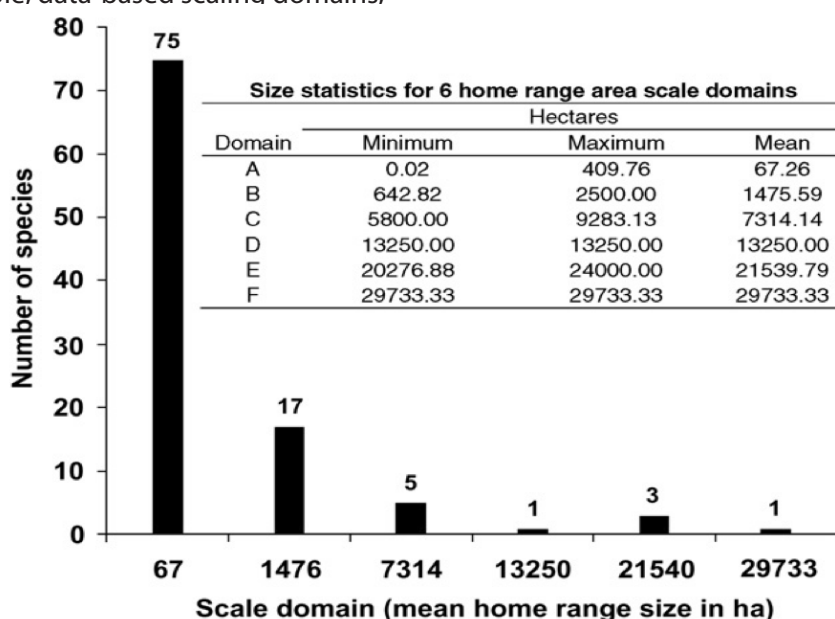


Figure 3. Distribution of 102 species among six home range area scale domains. Source: Bissonette, J. A., and W. A. Adair. 2008. Restoring habitat permeability to roaded landscapes with isometrically-scaled wildlife crossings. *Biological Conservation* 141(2):482–488. DOI: <http://dx.doi.org/10.1016/j.biocon.2007.10.019>

## Workshop: I have a dream

**Edgar van der Grift**

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In April/May 2014 two international research projects have been started, entitled SAFEROAD and HARMONY, which aim at improving our understanding of the functioning and effectiveness of road mitigation and maintenance strategies. The focus of these projects will be on measures that prevent wildlife mortality in traffic and/or reduce the barrier effect of roads on wildlife movements. The research is carried out as part of the CEDR Transnational Road Researchprogram Call 2013. The funding for the research was provided by the national road administrations of Austria, Denmark, Germany, Ireland, Netherlands, Norway, Sweden and UK. The aim of the workshop is to explore the needs of practitioners to be able to establish cost-efficient mitigation strategies and maintenance practices. What legislation, planning procedures or policies could be improved? What knowledge, guidelines or tools are currently missing? What can be considered fail and success factors in road mitigation projects? Furthermore, we would like to explore innovative ideas and opportunities to improve road mitigation initiatives across Europe. In this workshop we will use the 'pressure cooker' method, i.e. generating a high number of statements, thoughts and ideas

in relatively short time. To do so we will challenge the participants to express their ambitions, dreams and fears to different key issues in road mitigation projects and rank these in terms of importance. What would you change tomorrow in road planning or road mitigation, if you had plenty but limited resources? What would be the ultimate mitigation strategy to you and why? What opportunities do you see in achieving environmental policy integration in road planning? What problem should be dealt with first in order to increase our chances to establish successful road mitigation measures? Questions will be shortly introduced by the workshop leader and presented on posters. In a first round, participants will write down their comments and ideas in key words and stick them to the appropriate posters. In a second round comments and ideas will be prioritized. The findings of the workshop will be used to fine-tune the focus in the SAFEROAD and HARMONY projects. It will also help prioritizing research needs as well as needs for e.g. guidelines or planning tools. Our ambition is also to establish a network of practitioners for the duration of these projects that will help us to gather the necessary information as well as reflect on both output and outcome of the research.

- The workshop includes short presentations of the two CEDR financed projects SAFEROAD and HARMONY and continues with a plenary discussion.



## Safe roads for wildlife and people - Research to support cost-efficient mitigation strategies and maintenance practices

**Edgar van der Grift**

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Roads and traffic exert a variety of direct and indirect, mostly detrimental effects on nature. Transport authorities acknowledge such impacts and initiated programs and projects to mitigate them. In May 2014 a two-year research project was started, entitled SAFEROAD, which aims at improving our understanding of the functioning and effectiveness of road mitigation and maintenance strategies. The project shall identify the most cost-efficient ways to reduce the impact of roads on wildlife while simultaneously enhancing traffic safety. The focus of the research will be on measures that prevent wildlife mortality in traffic and/or reduce the barrier effect of roads on wildlife movements. The research project is funded by the Transnational Road Research program of the Conference of European Directors of Roads (CEDR). In this research project, we bring together existing knowledge and best-practices from across Europe and beyond, re-analyze existing data of multiple studies through meta-analysis, combine this new knowledge in simulation models and increase our understanding in road mitigation and road maintenance through selected case studies and demonstration projects. The research project will start by evaluating current laws and policies of the European Union with respect to mitigation demands for wildlife and developing outcome-based specifications for road mitigation that are in compliance with this legal and policy framework. It will further

identify mitigation strategies and maintenance practices that are most cost-efficient in reducing road-wildlife conflicts. And it will develop a set of practical guidelines for monitoring whether goals for road mitigation measures are being met or not. These guidelines will correspond with the new approach of providing outcome-based specifications in the procurement of road mitigation projects. Through a pro-active and end user-oriented communication approach, we will communicate the findings of this project to policy makers, road planners, road managers, researchers, consultants and, to some extent, the general public. The ultimate goal of our project is to provide clear and practical guidelines that help implementing cost-efficient mitigation strategies and maintenance practices that aim at reducing road-wildlife conflicts. To achieve this we will produce several technical reports, scientific papers and web-tools. Our main deliverable, however, is the production of a handbook that can be used as guidance and reference when dealing with the challenges that go along with roads and wildlife. The focus of the handbook will be on new developments in legislation, policy and procurement, as well as the cost-efficiency of different mitigation strategies, their effectiveness to maintain viable wildlife populations and improve traffic safety, and monitoring approaches to assess whether road mitigation goals have been achieved. This handbook shall ensure that all research findings and practical guidelines can be easily accessed and used by all road agencies and other stakeholders. Consequently it will help establish a road infrastructure across Europe that is safe for people as well as for wildlife.

## Procedures for the Design of Roads in Harmony with Wildlife

**Eugene O'Brien**

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Roads and their traffic cause fragmentation of habitats and form barriers to animal movement and can inadvertently cause the spread of invasive species. This research project, entitled Harmony, aims to develop ways for road authorities to address these issues in a balanced and cost-effective way. The project will develop simple, easy to implement procedures that address three key issues currently missing from the original COST 341 handbook: guidance on a consistent approach to Environmental Impact Assessment (EIA) and Appropriate Assessment (AA); guidance on methods of procurement and follow-up of road projects and mitigation measures; and strategies for the maintenance of roads and mitigation measures. While the recommendations will be practical and easy to use, they will be based on solid scientific foundations that can be defended against legal challenge and form the basis for decisions with huge financial implications. All EU countries carry out EIAs and AAs to comply with the Birds Directive and the Habitats and Species Directive. In some cases, there are national guidelines for environmental assessment of road projects. These guidelines will be reviewed in Ireland, The United Kingdom, The Netherlands, Norway, Sweden, Belgium, Hungary and Austria. A

review of more than 80 road projects, spread over these countries, will be used to seek commonalities in approaches between countries. A common framework using, for example, a 7-point scale for each assessment factor, will be developed that can be applied to all projects. On that basis, guidance on a common approach will be developed and trialed with stakeholders and experts to amend the assessment guidance. Existing approaches to procurement of road constructions, mitigation measures and maintenance will be reviewed, mostly in the eight reference countries, and a small number of outcomes-based approaches investigated in detail. A survey of experts will be conducted to identify procurement practices that give good ecological outcomes in a cost-efficient way. Recommendations will be given for best practice in a range of situations. A program of field studies on roadside maintenance is currently taking place in Hungary as part of another project. Harmony will extend the field study to do a comparison of the impact of alternative maintenance strategies on biodiversity. In a desktop study, the ecological function of roadsides (verges) will be investigated in the context of conflicting properties – e.g. road kill and safety versus ecological corridor. The maintenance of mitigation measures such as ecoducts will also be considered. Deliverables of Harmony will include input to three new chapters in the style of the COST 341 Handbook, relating to the three issues presented above. The chapters will focus on practical recommendations that can be implemented on the ground. For eco-friendly maintenance, a stand-alone maintenance handbook will also be delivered.

## Parallel session 1B

# Impact of wildlife-vehicle collisions on people in Brazilian highways

**Simone Rodrigues Freitas**

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**Introduction:** In Latin America, a high diversity of species are killed in vehicle collisions, most being small or medium-sized, causing less damage and severe accidents than typically found in northern hemisphere countries. Consequently, this safety issue has been less studied in the tropics than conservation issues, indicating a risk of population decline or biodiversity loss. However, large domestic animals, such as cattle, and wildlife, such as capybaras, could cause severe accidents and expensive repairs. To address the gap on this public safety issue, we evaluated the impact of animal road-kill on humans in Brazil. **Methods:** We searched the World Wide Web, using Google, for news of accidents between vehicles and animals recorded in Brazil in a 5-year period (2007-2012). We analyzed news identifying the animals (common name and quantity), dead and injured people (quantity), vehicle (type, quantity, and condition after the accident), and the accident (date, time, highway and region). **Results:** We found 125 accidents including 135 animals, resulting in 166 injured people, 73 dead animals, and 66 dead people. Most accidents included domestic animals, mainly cattle and horses, resulting in dead animals and injured people. However, most dead people were in accidents including wildlife, mainly capybaras (*Hydrochoerus hydrochaeris*) and giant anteaters (*Myrmecophaga tridactyla*). Most accidents involved one car, occurred at night, and caused damage to the vehicle. The majority of accidents with domes-

tic animals occurred in São Paulo and Minas Gerais States (southeastern Brazil), whereas those with wildlife occurred in Mato Grosso do Sul State (Pantanal region), mainly with giant anteaters, and in São Paulo State, mainly with capybaras. Most accidents were recorded after September 2010 with less news from the north of Brazil (Amazon region). **Discussion:** Wildlife-vehicle collisions resulted in more lethal accidents for people than accidents with domestic animals highlighting the relevance of the safety concern, as well as economic and health aspects. Capybaras and giant anteaters are large abundant mammals but they are short (about 60 cm high) and due to their dark fur, are not easily visible at night; hence drivers have difficulty seeing them in time to avoid a collision. Usually cattle are more visible by drivers resulting in less severe accidents, but involved in more accidents. São Paulo state had more accidents with wildlife and domestic animals probably because it has more vehicles and fast highways, with most being managed by private companies responsible for drivers' safety. Thus, road-kill mitigation measures should be financially supported by these companies to reduce the number of human deaths, costs related to safety and health services during accidents, and damage to the highway, as well as financially supported by life, health and vehicle insurance companies that pay for the accident expenses. Many highways managed by the government have been privatized, thus, probably; these findings will be applicable to more Brazilian regions in the coming years. We believe that the safety aspects of road-kill should be as relevant as biodiversity aspects in the tropics, and both approaches could increase concern for road ecology in the southern hemisphere.

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## Good enough, or room for improvement? Testing alternative designs for a roadside animal detection system using a driving simulator.

**Molly Kathryn Grace**

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**Objectives:** A Roadside Animal Detection System (RADS) was installed in January 2012 along Highway 41 through Big Cypress National Preserve in Florida, USA, an area of high Florida panther (*Puma concolor coryi*) activity and vehicle-caused mortality. The break-the-beam system uses flashing warning signs to alert drivers when a large animal is near the road. However, we suspect that the RADS warning signs could be ignored by drivers because they resemble other conventional warning signs. We hypothesize that word-based warning signs (current design) are less effective than picture-based signs would be at catching drivers' attention. **Methods:** We used a driving simulator to test (1) the effects of the RADS on collision rate and driver speed and (2) whether the RADS would be more effective if the warning signs were redesigned. In our study, 90 participants equally balanced among 3 age groups "drove" on a simulated road modelled after the RADS

installation area on Highway 41. During the simulation, a deer walked out in front of the driver, and we recorded whether they "crashed" or not. Participants were randomly assigned to 1 of 3 treatments: no warning (control), word-based RADS (current design), and picture-based RADS (proposed design). We used a logistic regression model to evaluate the effects of age and treatment on crash probability, and a multiple regression model for driver speed. Results: 30 participants "crashed." Subjects in the control group (who received no warning that an animal was near the road) were significantly more likely to crash than subjects in the other two treatment groups, but there was not a significant difference in crash rates between the picture-based and word-based RADS treatments (though this may be an artefact of the small sample size of crashes). For speed, however, participants in the control group drove significantly faster than those in the picture-based group, but not the word-based group. **Conclusions:** We conclude that the RADS, as it is currently designed, can be helpful in preventing dangerous wildlife-vehicle collisions, but that redesigning the warning signs could yield even greater benefits.

## Parallel session 1B

# Mitigating wildlife-vehicle collisions in Kootenay National Park, Canada

**Alan Douglas Dibb**

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Highway 93S in Kootenay and Banff National Parks, Canada is a 103 km highway corridor connecting the provinces of British Columbia and Alberta. The annual traffic volume for 2012 was 905,000 vehicles, but peaked in August at 5,000 vehicles per day. Although this highway is within national parks, it is a designated "through highway" and so commercial transport trucks are permitted. An average of 53.7 large mammal mortalities from wildlife-vehicle collisions (WVC) were recorded annually from 2004-2013, although it is highly likely that many additional mortalities occurred but were not detected. Ecological concerns included the effects that a declining ungulate populations could have on predator-prey systems as well as direct population effects on uncommon or at-risk species, including grizzly bear and wolf. Public safety concerns arose from the potential for high-speed WVCs to result in property damage, human injury, or even death. There were also concerns that continued high rates of WVCs could reduce wildlife viewing opportunities and thereby impact the quality of experiences of national park visitors. The Parks Canada Agency initiated a project in 2009 with the following objectives: (1) Reduce animal-vehicle collisions on Highway 93 to conserve wildlife and improve safety of the motoring public; (2) Maintain wildlife population connections across the highway; (3) Educate and engage park visitors in the wildlife crossing story. We used WVC data

collected on this highway from 1982-present and data conducted on weekly roadside wildlife surveys from 2007-present in order to prioritize segments of the highway for mitigation and to optimize crossing structure locations. This led to the installation in 2013 of wildlife exclusionary fencing along 4.7 km of highway with the highest rates of WVCs. The fenced section of highway was fitted with a buried apron to prevent animals from digging under the fence, 3 animal underpasses, 8 jump-outs, 13 wildlife gates, and angular rock fields at fence ends to prevent animal intrusions into the fenced zone. We installed remote cameras at underpasses, jump-outs, and fence ends to monitor animal response to these structures. We also fitted 18 white-tailed deer (the most common large mammal within the project area) with radio-collars in order to determine how their movement patterns would be affected by our project. We report on challenges that arose during planning and construction, including prioritization of highway sections for mitigation, where to locate crossing structures, shallow water tables at underpass locations, and animal intrusions at fence ends. We also report on post-construction WVC rates, results of radio-telemetry, roadside wildlife surveys, and camera monitoring, and the implications of the fenced highway section for white-tailed deer and other large mammals. Education of the public about the factors contributing to WVCs was an important component of this project, and we present some of the social media tools, on-site displays, and interpretive programs that we used to disseminate information to a broad audience. Finally, we discuss planning for a second phase of mitigation on an adjacent section of this highway.

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## Methods for cost-efficient mapping of winter food for moose at a detailed scale

Karianne Thøger-Andresen

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Animal-vehicle collisions occur most frequent where animals are crossing road and railroads on seasonal migration or on more daily movements between food and resting places. When attractive food is available close to road and railroads the number of wildlife crossings and accidents are known to increase. Clearing the vegetation close to roads and railroads for either increase visibility or remove attractive forage for deer has, in several studies shown to effectively reduce the risk for animal-vehicle collisions considerably, and is a recommended activity to reduce such collisions. The collision risks depends not only of the vegetation in close proximity to roads/railroad, but also on the habitat composition in a wider landscape context. Attractive browsing and resting areas for moose are distributed patchy and occur in both large and small patches, giving a mosaic like pattern mainly driven by forestry activities. The spatial pattern of attractive areas for browsing and resting change over time, as vegetation in new areas enter the right successional stage. The effect is that the collisions risk moves accordingly. Shoulder of roads and railroads include areas with rapid regrowth of trees, giving rail and road authorities difficulties to keep an overview of where vegetation managements

should be done. A cost-efficient method to map the attractive feeding sites at a spatial detailed level, will give the authorities a tool to identify areas along traffic corridors where vegetation clearance should be done and identify sections where the risk of deer-vehicle collisions is expected to increase. We have tested the possibilities to map winter food resources for moose at spatial details down to one square meter for large areas with an automated object oriented mapping approach using data from airborne LiDAR and optical satellite images in combination. Narrow corridors of young vegetation and areas with a well developed layer of young trees covered by larger trees can hardly be detected by image generating sensors (aerial photos, satellite images), but can be better identified by the light penetration sensor LiDAR. While LiDAR is suitable for mapping the 3D forest structure, it is not as good as multispectral images to distinguish forest types in younger generation of forest. The test is done in a 2300 km<sup>2</sup> area (Romerike) situated approx. 100 km north of Oslo (Norway). The first part include development of species-specific allometric equations to make it possible to calculate the dry weight biomass of twigs available for moose at the plot level (100m<sup>2</sup>). We measured all trees in 133 plots divided into different forest types and age classes. The plot measurements were later used to guide the selection of variables extracted from LiDAR and satellite data. The map identify attractive browsing areas close to roads/railroads.

## Parallel session 2A

# A new LIFE Project for the development of an innovative system to prevent road mortality in central Italy

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In Italy it has been estimated that round 1.5 million road kills occur each year (Guccione et al. 2008). The collisions that involve large animals are also a reason of concern for the safety of drivers, in fact in Italy from 1995 to 2005 over 150 persons have been killed due to an accident caused by wildlife (Cerfolini A., Ministry of Environment, pers. comm.). Furthermore, the phenomenon represents a severe economic problem for the authorities in charge of damage compensation. In this country several road kill prevention tools have been implemented in the last years but the problem is still increasing. This is also caused by the fact that in Italy no coherent regulations exist that support the appropriate management of the road kill phenomenon. The LIFESTRADE Project "Demonstration of a system for the management and prevention of traffic collisions with wildlife" (<http://www.lifestrade.it>), co-financed by the European Commission, wants to address these problems with the following two steps: 1. The implementation and large-scale demonstration of a newly developed sophisticated prevention system that simultaneously warns drivers and deters wildlife from crossing roads, in an interactive way. The system includes a series of infrared sensors that register the presence of an animal approaching the road and send the information to the electronic control unit. This unit activates an alert

signal for drivers, inviting them to slow down. A radar Doppler sensor, installed above the signal, measures whether the car actually slows down to the desired speed. If it does, the system stops to act. Otherwise the control unit activates an optical and/or acoustic scaring system, which shall drive the animal to escape. The advantage of this system is on the one hand that it does not represent a barrier for wildlife, and on the other hand that both drivers and animals are alerted only in specific critical conditions and therefore the risk of habituation is minimized. The project foresees the installation of 15 such prevention tools across central Italy. Presently two devices have been installed and are being tested on two roads in Tuscany and Umbria Regions and the first data about the effectiveness of the tools will be soon available. 2. The project has initiated a negotiation process with the relevant local interest groups in order to develop a common monitoring and management protocol, which shall be shared and actively accepted by all the involved parties. The first participatory workshops have already allowed to identify a list of critical aspects that must be further discussed and will certainly be included in the future protocol. In line with the requirements of the LIFE funding rules this LIFE Biodiversity project shall function as a demonstration of the developed tools to potentially interested users both in Italy and Europe. References: Guccione M., Gori M., Bajo N. Eds. 2008. Tutela della connettività ecologica del territorio e infrastrutture lineari – Technica IReport. With the contribution of Caputo A. (ISPRA 2008)

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## Technical mitigation measures for ungulate-vehicle-collisions in Germany - Facts vs. Guesswork

Christian Trothe

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More than 200,000 deer and wild boar are killed by traffic each year in Germany. More than 2,500 people were injured and 20 died in ungulate-vehicle-collisions (UVC) just last year. The market for technical mitigation measures is growing fast. Above all, the use of optical measures increased tremendously. Especially blue warning reflectors are bought and applied by German hunters, not knowing but hoping they will help. Comprehensive studies with a clear focus on the practical use of various mitigation devices used in Germany are still missing. Until now there are a lot of divergent experiences but no reliable evidence whether these measures have a positive impact – and if so – on which species and for which habitat conditions. Different authorities and organizations have a high demand for information so they can manage and control the usage of mitigation measures. In 2011 we started a 5-year-study to evaluate two of the available systems on selected roads in northern Germany. We chose a blue semicircular rear reflector (Beutha GmbH) and an olfactory repellent system (Hagopur AG) because those are most commonly used. 25 roads in Schleswig-Holstein with at least 8 UVC / km / year were selected and mitigation measures were applied in March 2011. Even though factors that likely influence UVC occurrences (e.g., game density, individual characteristics of animals or the awareness of the driver) cannot

be reliably measured, the large number of test roads and the duration of the study make it possible to assess the effectiveness of mitigation measures across a large variety of conditions. Another advantage of using test roads is that we are able to collect a high data volume with manageable effort. The test roads are divided in three classes, agriculture, structured landscape and forest, to take the main habitat types into consideration. For each test road framework conditions, such as involved species, land utilization, crop rotation, amount of traffic, vehicle speed or road signs, are gathered in order to get a detailed profile and identify influencing factors. UVC are reported using a standardized form and compared to the numbers in the four years before, without mitigation measures. Preliminary findings after two years show that both mitigation measures seem to be effective, with a wide heterogeneity in the results. None of the test roads showed more ungulate-vehicle-collisions than in the years before. However, there is a wide range in the percentage of the decrease of collisions. On some test roads the UVC decreased by 74 % up to 81 % on average, with  $p < 0,002$  in the Poisson distribution. On other roads the decrease only amounted to 14 % and less, with no significance in statistical analysis. Also a spatial relocation of the crash sites could be determined. Final analysis will be conducted in 2015 and give more insight on what the influencing factors are, which mitigation measures might be helpful depending on involved species, land utilization and traffic. These results should also lead to practical recommendations for using technical mitigation measures on German roads.



## Parallel session 2A

# Wildlife-Vehicle-Collision (WVC) avoidance by cooperative smart ITS-sensor/actuators

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Every year, there are several million wildlife-vehicle-collisions in the U.S. and in Europe. In the U.S., the national total damage in 2007 was estimated at USD 8.4 billion. WVS's are increasing at a rate of about 6% per year – over 50% during the past 8 years. Wildlife is a huge and widely underestimated challenge to traffic safety.

The 'DeerDeter' combines in a novel approach a cooperative sensor/actor network with the latest results of the EU-FP7 ITSSv6 project to protect wildlife and road users. Active wildlife protection devices are superior to passive optical reflectors. They utilize electronic headlights sensors to be activated and opto-acoustic warning alerts to clear the road from wildlife. The novel cooperative sensor/actor system DeerDeter is compliant with the ITS Action Plan of the European Commission and carries out the future requirements for road transport systems.

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## GPS-based real-time application to warn drivers of high risk of animal-vehicle collision

**Víctor J. Colino-Rabanal**

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A wide range of mitigation measures have been proposed and tested to reduce the number of animal-vehicle collision (AVC). These mitigation measures work at different spatial scales, from regional planning to transversal structures and other mechanisms that work at road segment scale. They have different objectives, aimed to modify driver's behavior, modify animal behavior, or both. Moreover, they also show different costs and effectiveness. The mitigation measures focused on the driver as the main responsible for avoiding AVC are commonly installed throughout the world. For example, traffic warning signs are the most widely applied measure. The warning expects to get driver's attention and to manage a reduction of the vehicle speed, considering that speed is one of the most remarkable explanatory variables involved in AVC occurrence and in the seriousness of them. Nevertheless, road signs have shown limited long-term effectiveness because, after a certain period of time, the driver's response to the warning decreases. This fact can

be explained partly because of the absence of temporal correspondence between the warning and the real risk. Effectiveness may increase focusing the warning only in those moments and locations of high risk of AVC. Thus, one of the main characteristics that we can exploit to deal with the AVC problematic is that they are not randomly distributed either the space or time. There are important temporal changes across the seasons, within the day or within other facts as moon phases. Moreover, AVC commonly concentrate in certain landscapes and habitats. Hence, it is possible to model the spatio-temporal probability of AVC occurrence with a road network. We have obtained the model for AVC in Castile and Leon region (NW Spain). The resultant spatio-temporal model can be implemented in an app for smartphones or incorporated easily to a GPS vehicle navigation system, coupling it with the positioning system, the calendar and the clock of the device. The result is an application that shows at real-time the probability of AVC considering the vehicle positioning. An alarm alerts the driver only when the risk of AVC is high, this is, when the driver passes through a road segment with high probability of AVC occurrence just in a period of time (month, hour, moon phase, etc.) given to AVC.

## Parallel session 2A

# Costs on car repairs due to wild animals accidents

**Fredrik Valgren**

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A highly increasing number of accidents between cars and wild boar in Sweden has led insurance companies to count on, and estimate overalls costs on repairs due to accidents with wildlife. More than 99 percent of police

reported accidents between cars and wild, is represented only on three species, elk, deer, and since the 90's, wild boar. Due to normal shifts of nature, populations can vary highly from one year to another. It is of certain interest for insurance companies to learn about these differences, and take part on work preventing accidents. Insurance companies' knowledge and estimations could become a contribution for scientific research on this topic.

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## Effectiveness of acoustic wildlife warning devices to reduce risk of animal-train collisions

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As Poland's railway lines are modernized, the safety of passengers must be assured as well as the impact of rail transport on the natural environment must be limited as far as possible. The subject of this study was the effectiveness of the so-called UOZ-1 device in reducing risk of animal-train collision. The device emits the natural calls of animals, i.e. warning call of the jay, the sound made by a frightened brown hare, the baying of hounds, the howl of a wolf, the squeal of wild boar, shortly before train arrives. The work was carried out in central Poland in the years 2008-2012, in two sites along the E 20 line where UOZ-1 devices were installed in 2005. Digital cameras were used to register the activity of animals 24 hours a day. Altogether 2262 cases of mammals present at or by the rail track were registered (with 2956 individuals involved). These represented 13 species in total (i.e. moose, red deer, roe deer, wild boar, red fox, raccoon-dog, badger, otter, marten, brown hare and red squirrel, as well as domestic cats and dogs. 76% of observations were concerned with situations in which there was no arrival of a

train imminent, in the remaining a train approached when animals were observed. In such case, the majority of both the wild-living and domestic animals (in 82% of cases, i.e. n=443) escaped once the acoustic signal emitted by the UOZ-1 device had switched on. In the case of the wild animals only, the escape reaction applied in some 88% of cases (n= 377). The mean time all animals took to escape before a train passed by was 52 s. In the case of the roe deer, the most numerous species, the effectiveness of the device was checked by comparing animals' reactions with it switched on or off. Roe deer significantly more often escaped if the UOZ-1 device had been operational, as opposed to switched off (in 84% of cases, as opposed to 68%) and were less likely to display a total absence of reaction when the device was in use (in 16 versus 32% of cases). When the UOZ-1 was in operation, animals of all species escaped three times as quickly as when it was switched off. In the case of roe deer, the escape reaction was 20 seconds faster. The animals did not become habituated to the warning signals emitted by the UOZ-1, their reactions in successive years being the same. Also the time of escape reaction did not change over years. The results of the research therefore make it clear that the UOZ-1 is an instrument effective in reducing the risk that trains will become involved in collisions with animals.

## Parallel session 2B

### South Africa: the road ahead

Wendy J Collinson

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Despite evidence suggesting that road traffic is a major threat to biodiversity, very little is known about its impact on wildlife populations in South Africa. Road density and traffic volumes are increasing globally, and although huge budgets are devoted to the construction and upgrading of roads, there is insufficient allocation to the implementation of mitigation measures for protecting fauna in most countries, particularly those in Africa. South Africa is the third most biologically diverse country on earth and hosts a multitude of indigenous and endemic species and habitats. South Africa has a population of 51 million and an annual economic growth rate of 4%. To continue to enable this economic development, the Department of Transport plans to “spur a major revolution” through investments in public transport, including road infrastructure, rail upgrades, freight services and intelligent transport systems, all of which will almost certainly impact wildlife. We developed a standardized protocol for the detection of vertebrate roadkill on South African roads and used it to determine baseline estimates of roadkill rates in the Greater Mapungubwe Transfrontier Conservation Area (GMTFCA), Limpopo Province. Roadkill carcasses of 1121 individuals were identified from 166 different species over 120 days in 2011 and 2012. Birds were the most commonly impacted group (52%); mammals, reptiles and amphibians comprised 26%, 20% and 2%, respectively. Incidental records for roads adjacent to the

GMTFCA indicated that five cheetahs (*Acinonyx jubatus*) were killed between January 2006 and June 2009 and nine African wild dogs (*Lycaon pictus*) in a 3-month period in 2012. With only ~450 African wild dogs left in South Africa, road collisions may seriously impact the long-term persistence of this species in the country. To date, South African road ecology studies have focused primarily on roadkill rates, with results highlighting the need not only for a greater understanding of the primary determinants of roadkill and its threat to biodiversity, but also the indirect effects of the country’s roads on wildlife. Although South Africa has a legislative framework that facilitates environmental impact assessment for the development and upgrading of roads, these tools have not been optimally applied due to the lack of capacity to ensure compliance and enforcement, and a poor understanding of the real impacts of these activities. The identification, adoption and implementation of mitigation measures is also urgently needed, and this is best achieved through integrated landscape-level land-use planning. We plan to continue to build capacity and find solutions to South Africa’s roadkill issues. While South Africa is fundamentally different to Europe and North America, application of the information and lessons learned in developed countries should be explored within the African framework. Major differences that may influence this process include faunal diversity, landscapes and geography, the density of roads and humans, socio-economic priorities, and funding and support for road ecology research and mitigation measures. The development of ‘African’ solutions may be required to solve uniquely African issues.

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## Environmental aspects in national plan on logistics and transportation plan of Brazil

**Simone Rodrigues Freitas**

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**Introduction:** The Brazilian government has been heavily investing in transportation infrastructure, including highways and railways, and conflicts between engineers and environmentalists have been increasing. According to environmental laws, businesses must do an environmental impact assessment (EIA) following norms stipulated by the federal Law of Environment ("Política Nacional do Meio Ambiente", law number 6,938 of 1981). From the engineers' point-of-view, these EIAs usually include too many modifications to the project, which increase expenses and cause delays in the original plan. From the environmentalists' point-of-view, the modifications included in EIAs mitigate the project's biological and physical impact. However, the EIA is a regulatory measure applied post project, which allows for limited project changes. For deep changes in the original project, the environmentalists must participate from the initial steps of the planning project. For the transportation sector, a National Plan on Logistics and Transportation (NPLT) developed by various sectors of the Federal government recommends aims, targets and plans for Brazil and neighboring countries for the future. We intend to evaluate the environmental aspects of the NPLT to discuss how Road Ecology and Landscape Ecology could contribute to transportation planning in the medium- and long-term. **Methods:** We evaluated three reports of the National Plan on Logistics and

Transportation (NPLT) of 2007, 2009 and 2012, available online, focusing on environmental aspects. **Results:** The 2007 report was a landmark in resuming transportation planning in Brazil, which stopped during the military dictatorship in the 1970s. The report showed concern for environmental impact of transportation projects and the necessity of respecting environmental laws. The following reports indicate the need to invest in different kinds of transportation, which until then concentrated on highways. In addition, the need for a Strategic Environmental Assessment was also mentioned. Road Ecology and Landscape Ecology were not treated in the report, thus, certain concepts, such as connectivity, were not considered. **Discussion:** We believe that a strategic approach, such as the Strategic Environmental Assessment (SEA), is the only way to evaluate a plan in Brazil, a country with size and complexity comparable to Europe. Brazil can adapt governance tools used by the European Union, particularly in the transportation sector, to improve the interface between transportation and environment. The SEA could be a basis for preventing severe environmental impact that EIAs could not properly mitigate. A new law has been discussed in the federal legislature that improves the federal Law of Environment (law number 6,938 of 1981) including SEA ("Projeto de Lei" number 2,072 of 2003). Some basic concepts of Road Ecology and Landscape Ecology must be developed and included in SEA to protect environmentally vulnerable regions, giving high priority to biodiversity conservation in Brazil. Engineers, planners and environmentalists must work together to develop Brazil from an economic, social and environment perspective.



## Parallel session 2B

# Green Belt: 25 Years in Germany – 10 Years in Europe

**Mark Hoerstermann**

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Experience made with the worlds' largest international ecological corridor system. Green infrastructure and particularly green corridors are subject of several political and scientific approaches. However, major scale implementation is still rare – in Europe and worldwide. Hence, practical information about implementation is lacking. This includes aspects of spatial planning, road/corridor conflicts, mitigation, financing, acquisition of land, public relation including stakeholder dialogues and other key factors. The Green Belt along the former inner-German border is an existing and growing national corridor system and memorial landscape celebrating

its 25th anniversary in 2014. In addition, since more than 10 years the European Green Belt Initiative is about to establish an international corridor system across Europe all along the former Iron Curtain from the Barents Sea in the north to the Black Sea in the south. The proposed presentation gives an overview on keys of success as well as backlashes, and outlines future work. It focuses also on cross-border differences in framework requirements and their influence on international corridor planning, using the data and experience made in 24 co-operating countries of the European Green Belt. Finally it will be outlined, how the experience made with the Green Belt project will be transferred to other international corridor projects to come, such as the safety net for the wild cat and the green wall (rampart) in the west.

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## The BioREGIO Carpathians project: aims, methodology and results from the “Continuity and Connectivity” analysis

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BBioREGIO Carpathians is a transnational cooperation project, co-financed under the second call of the EU South East Europe Transnational Cooperation program, priority area “Protection and Improvement of the Environment”. BioREGIO Carpathians run for three years (2011 – 2013) and is a flagship project for the Carpathian Convention (article four dealing with landscape and biological diversity), its Biodiversity Protocol and the Biodiversity Working Group. The project is built on the conservation, restoration and valorization of ecological features to enable large herbivores and carnivores to live in coexistence with modern society. The maintenance of an ecological continuum opens positive socio-economic effects for the local populations concerning the prevention of road kills, tourism, recreation, high-quality environment. These themes are effecting particularly the Carpathian countries as they are expecting a massive modernization of their road infrastructures. 1700 km of new motorways will be constructed in Czech Republic, Hungary, Romania and Slovakia within the next few years. If not considering the requirements of ecological network, this run-to-development will create fragmented natural areas, limit dispersal and genetic exchange of wildlife species. Mainly large carnivores and herbivores react sensitively to landscape fragmentation due to their habitat requirements and low densities of occurrence. Picking up that thematic issue, BioREGIO aims to explore the distribution of potential suitable habitats, core areas and of least-cost paths. Therefore two free-downloadable ArcGIS 10.0 tools are applied in a three-step approach considering the most relevant ecological character-

istics of those seven umbrella species selected for the BioREGIO Carpathians project. The results from analyzing ecological connectivity are visualized through a Web-GIS application. The combination of core areas and least-cost paths with Google Open Street Map indicates the possible physical barriers that may hinder the free movement of the considered species. Additional threats to the detected ecological connectivity may come from the foreseen motorways and from the expansion of settlements. Thus, not only physical barriers are influencing ecological connectivity but also legal aspects and socio-economic behavior are playing a major role to conserve wildlife population. The problems to maintain ecological connectivity occurs particular in a local surrounding and requires thus local solutions. For this reason, we have organized specific site visits in Slovakia, Romania, Ukraine, Serbia and Hungary at locations with a meaningful potential of conflicts between the extension of human facilities and ecological connectivity. The multi-disciplinary approach followed in BioREGIO at this site visits, allowed the identification of the most influencing barriers regarding connectivity in each location. They are ranging from illegal urban sprawl, the absence of road-kill prevention systems, the construction of new motorways regardless of ecological connectivity to the low awareness of local people concerning ecological connectivity. The investigation on the ground together with local experts and stakeholders enabled the adaptation of the GIS results and the development of feasible solutions to overcome the detected barriers from a physical, legal and social point of view. The project results will be transferred into an outlook about future actions to be implemented in the Carpathians to maintain connectivity and to sustain large carnivores, herbivores and biodiversity.

## Parallel session 2B

# A method for establishing the landscape as regional platform for cooperation between national and regional authorities (Integrated landscape character assessment ILCA)

**Lars Erik Nilsson**

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In our project "Including landscape in long-term spatial planning" (Landskap i långsiktig planering) we have developed a method for an integrated landscape character assessment which comprises aspects such as the perceived landscape, the historical landscape and landscape ecology. The analysis has been carried out in the Västra Götaland Region, covering an area of 24 000 sq. km including the second largest city in Sweden, Gothenburg. The regional and national plans for transport infrastructure (2010-2021) have been used as preconditions for assessments. The project creates a common arena where regional and national authorities can meet and discuss the impact of the plan. By understanding and explaining how the landscape is composed and function, the method presents a multi-disciplinary tool for finding the susceptibility and potential in every landscape. This has made it possible to assess what

effect new infrastructure and the plurality of management activities may have on the landscape. With the knowledge from the integrated landscape character assessment it is possible to initiate and manage activities that can enhance landscape qualities early in the planning process. These are questions that may not usually be addressed, but have a great potential in both planning and maintaining infrastructure. The method of integrated landscape character assessment has also been applied in another region, Västmanland. The precondition here has been a regional development plan. The results show that the method provides a new arena for regional planning that is useful for making landscape issues visible and that landscape qualities can become an important factor/driving force in the planning process. In 2013 a range of applied studies and demos will be carried out using ILCA. The intention is that the spatial planners at the Swedish Transport Administration, in the future, always will address landscape characters in early planning stages. And thereby contribute to a sustainable development by enhancing landscape qualities.

## Parallel session 2B

# Handbook of Road Ecology

**Rodney van der Ree**

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There are 102 million km of roads on earth – enough for 130 return trips to the moon. Brazil, India and China are adding ~10,000 km of new or upgraded highway annually over the next 10 years; India will quadruple vehicle numbers (to 450 million) by 2020; and North America, Western Europe and the UK are undergoing extensive widening and repairs to their ageing road network. Against this backdrop the issue of roads and wildlife is increasingly on the agenda; across all levels of Government, civil society, non-governmental organizations, and commercial stakeholders involved in all aspects of road design, construction and operation. For example, in the USA alone, over 80 million birds are killed each year by traffic; and the cost of collisions with wildlife (vehicle repairs, human

injury and death) in Europe and North America exceeds \$2 billion per annum. The “Handbook of Road Ecology” is a compilation of 60 chapters from 100 experts from 25 countries – with each chapter documenting world’s best practice in ecologically sustainable roads, railways and utility easements. Due for release in late 2014/ early 2015, this handbook is set to become the definitive, international guide for all professionals seeking to better understand and respond to these issues. Chapters span the project continuum – from planning, design, construction, monitoring, research to management. All new road projects, and road upgrades, require authoritative, reliable and informative advice in a timely and easily accessible format. This book is a unique and truly global collaboration that will fill the needs of planners, designers, construction teams and regulators around the world. A “pre-printers-proof” copy of the book is available during the poster session to view. To receive an email alert when the book is published, please drop your business card in the pouch provided.



## Parallel session 2C

# Workshop: Road maintenance practices to improve wildlife conservation and traffic safety

**Carme Rosell**

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The projects SAFEROAD- 'Safe Roads for Wildlife and People' and HARMONY- 'Procedures for the Design of Roads in Harmony with Wildlife' are carried out as part of the Transnational Road Research program 'Roads and Wildlife' funded by the Conference of European Directors of Roads (CEDR). Both projects will develop guidelines for Best Maintenance Practices (BMP) that help to reduce the adverse impacts of roads on wildlife, prevent animal-vehicle collisions, and take advantage of the ecological potential of infrastructure corridors in wildlife conservation. BMPs can provide opportunities for adaptive management for wildlife conservation. They are also a key factor for ensuring the effectiveness of road mitigation measures that aim at reducing barrier effects and habitat fragmentation. However, opinions on BMPs vary greatly among countries, as they depend on the organizational and geographic context. The goal of this workshop is to explore maintenance

practices as perceived by experts from different countries and to discuss how this may contribute to the development of guidelines for BMPs. An overview of BMPs will be presented and the participants will be invited to present their own insights, experiences or new ideas. In particular, we will address the following questions:

- How can we optimize the maintenance of verges and medians? Our focus is placed on the influence of verge vegetation maintenance on the occurrence of wildlife casualties and on the creation of new wildlife habitats. Both cost and benefits can be highlighted.
- Which are the key maintenance practices for ensuring long term functionality of wildlife passages?
- Which maintenance practices can be applied to bridges and drainage structures to enhance their function as safe passages for wildlife?
- How can maintenance practices help improving fencing in order to reduce road casualties and to guide the animals to the fauna passages? And how can we help reducing wildlife mortality caused by other elements such as bird collisions with screens?

Contributions from specialists on different taxonomic groups will be welcome in order to define the BMP for different target habitats and species.

## How traffic mortality affects four ungulate species in southern Finland?

**Milla Niemi**

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Ungulate-vehicle collisions (UVCs) are widely studied in many countries with focus mainly on traffic safety. Many of these ungulate species are also game animals, whose population size and structure are controlled by hunting. However, the effect of road kills on populations has been often ignored although the road-kill rates should be considered when planning the annual harvest quotas. We studied four different ungulate species (moose *Alces alces*, white-tailed deer *Odocoileus virginianus*, roe deer *Capreolus capreolus* and fallow deer *Dama dama*), purposing to get an estimate about their road mortality and how it is related to species' population. The studied species are game animals in Finland although the role of fallow deer is minute. In the Finnish collision statistics, moose-vehicle accidents are registered at the species-level but crashes with other wild ungulates are treated as deer-vehicle collisions regardless of the species. Therefore, we were not able to use the existing nation-wide database. Instead, we used a local dataset collected from Hyvinkää Game Management Association Area by voluntary hunters who work as official assistance for police. The volunteers have detailed knowledge about the road-killed animals, because they visit the collision sites and take responsibility for the aftercare of UVCs. The study was conducted

between 2001 and 2012 in a relatively densely populated area in southern Finland. Ungulate population size estimates were provided by the Finnish Game Agency and they were based on an annual snow track counting. Altogether 497 ungulates were involved in traffic accidents during the study period. A total of 378 individuals (76 %) were killed directly in collision or put down afterwards (later referred as road-killed). The rest of the animals disappeared after collision (19 %), they were found to be uninjured (4 %) or their status was marked as unknown (1 %). Over half of the road-killed individuals (52 %) were white-tailed deer, followed by moose (22 %), roe deer (19 %) and fallow deer (7 %). White-tailed deer was found to be the species suffering the highest traffic mortality (8 % of wintering population) followed by moose (6 %), fallow deer (4 %) and roe deer (3 %). Our study was based on a relatively small dataset but it gives a clue that traffic mortality rates differ between ungulate species. Also, the study was conducted in relatively dense populated area with high traffic volume so the results can't be generalized without additional research. Still, at least with white-tailed deer, the annual traffic mortality was relatively high and should be noted when planning annual harvest quotas. In addition, due to the different traffic mortality rates, the number of road-killed individuals might be used as supplementary information when estimating population sizes of different ungulate species. Thus, we recommend to improve the official UVC-registering system to contain more accurate, species-specific information.



## Road sites selection for primates crossings: factors for the black-tufted-ear marmoset (*Callithrix penicillata*)

Alex Bager

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Primates tend to stay isolated in forest fragments scratched by roads, as result of restrictive arboreal habits. Influence degree of barrier effect will be dependent of species behavior, landscape aspects, and road characteristics. The study objective was evaluate how road and your surrounding characteristics influence selection of road sections by Black-tufted-ear marmoset for crossings, and assess if some period of horary is preferential for crossings occurrence. The study was conducted in south of Minas Gerais State, Brazil (21°14'0.40"S, 44°59'28.80"W). The crossings monitoring was performed in four sections road with distinct characteristics. The choice of sampling points prioritized proximity with forest fragments that *C. penicillata* occurs. The sections were characterized in relation to forest fragments presence in contact with each side of road (One side: Pres\_frag1; Two sides: Pres\_frag2), and declivity (Left side: Decliv\_1; Right side: Decliv\_2). The width road was measured (Width), and the aerial connection presence was evaluated through canopy contact above the road (Pres\_Connec). Finally, vehicular traffic estimation was made through video cams installed in road margins (Traf). Three sampling campaigns were performed in each road section, completing 108 hours of observation. These samplings were conducted in three different time periods (Period1: 06:00am – 10:00am; Period2: 10:00am – 02:00pm; Period3: 02:00pm - 06:00pm). A crossing was recorded when an individual moved from one margin to the other. We used

Generalized Linear Models with binomial distribution from presence/absence data of marmosets' crossings in each road section as response variable. All measured variables and period of time sampled were inserted as predictive variables. We ranked models through Akaike's Information Criterion (AIC), categorized in seven groups of predictive variables influencing crossing occurrence a priori: (1)Time; (2) Road; (3) Road\_Surrounding; (4) Time+Road; (5) Time+Road\_Surrounding; (6) Road+Road\_Surrounding; (7) Time+Road+Road\_Surrounding. The multicollinearity between variables was tested by Spearman Correlation. Variables with correlation coefficient less than 0.05 were removed of the same model, keeping those with greater biological sense. Only models that showed  $\Delta AIC < 2$  were considered with sufficient inference power. Furthermore, we tested the difference of crossing number between two road sections with canopy connection in relation with other two points without canopy connection through Chi-Square with equal proportions expected over the three campaigns. We tested 65 candidates models, and a single model exhibited  $\Delta AIC < 2$ , composed by variables Traf+Width+Pres\_Connec+Pres\_frag2 ( $\Delta AIC = 0$ ). However other models showed  $\Delta AIC$  values near 2, e.g. models Traf+Width+Pres\_Connec+Pres\_frag1, and Traf+Width+Pres\_Connec (both with  $\Delta AIC = 2.6$ ). The crossing number in road sections with canopy connection was higher than sections without connection ( $\chi^2 = 46.061$ ; g.l. = 2;  $p = 0.0001$ ). Among predictive variables evaluated in our models, those that appear be attractive for road sites selection by marmosets, were: forest fragments presence in both road sides, smaller width road, smaller vehicular traffic and especially presence of canopy connection.

## The effects of roads on demography and genetic structure of expanding bobcat (*Lynx rufus*) populations in New Hampshire, USA

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We are conducting a comprehensive evaluation of the effects of roads on the distribution and genetic structure of expanding populations of bobcats in a portion of the northeastern United States. First, we compared the distribution of bobcat-vehicle collisions to the density of surrounding roads and traffic volume at the kill sites. We then estimated collision probabilities for specific landscapes using information on traffic volume and bobcat movements in combination with a moving-window analysis. Next, we captured two samples of adult bobcats and equipped them with GPS collars to monitor habitat selection and responses to roads. The resulting resource-selection function was converted to a cost-surface map that was used in combination with circuit theory models to examine the barrier effects of high-traffic volume roads on bobcat movements. Finally, we are now examining how genetic structure of bobcat populations may be affected by the distribution of major roadways. As expected, the distribution of vehicle-killed bobcats was associated with dense road networks or state and interstate highways. Collision models suggested that portions of southeastern New Hampshire may function as sink habitat because of the

abundance of major roads. Although this region contains suitable cover types (e.g., wetlands and forests), resident bobcats likely encounter roads often, substantially reducing their survival rates. Transmitter-equipped bobcats selected areas distant from roads. Simulated movements throughout New Hampshire in the context of the cost-surface map also indicated barrier effects of major roads on bobcat movements, especially in the southeastern portion of the state. These patterns were also supported by the genetic structure of bobcats within New Hampshire. A preliminary analysis using multiple microsatellite loci revealed several subpopulations in the state. The sharpest divisions among genetically-distinct demes occurred along large natural boundaries (e.g., White Mountains) and in road-dense regions with otherwise suitable habitat (southeastern New Hampshire). Populations in these regions exhibited a similar degree of inbreeding, suggesting roads have as great an effect on functional connectivity as large, natural barriers to dispersal. In conclusion, our study indicates that high-traffic volume roads have a substantial influence on the local distribution and abundance of bobcats. The barriers imposed by these roads also may limit dispersal of juvenile bobcats and thus diminish the vitality of some populations. As human populations in the region increase, it will become essential to develop approaches that lessen the effects of major roadways on bobcats and other wide-ranging species.

## Raccoon dog: relationships between roadkill numbers, traffic intensity, the hunting bag and climate change

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The raccoon dog is one of the mammals most frequently killed on the roads of Lithuania. In 2002–2013, we registered 1066 individuals killed on the roads (31.2 % of total), with the roadkill index averaging  $0.82 \pm 0.05$  ind./100 km/day. Extrapolation indicates that 3000 to 20000 raccoon dogs were road killed annually in this period (average ca. 12000 individuals). In the same period however, only 26 individuals (0.3% of registered 9712 wildlife casualties) were registered in the database of Lithuanian Police Traffic Supervision Service. This latter figure is expected to grow as increasing numbers of new cars have comprehensive insurance, resulting in the registration of even small road incidents. The roadkill index was significantly higher on main roads ( $0.91 \pm 0.06$  ind./100 km/day) than on regional roads ( $0.59 \pm 0.09$  ind./100 km/day,  $t = 3.01$ ,  $df = 1560$ ,  $p = 0.003$ ) and fencing of roads has not reduced the number of WVA with raccoon dogs. Despite ecological species plasticity, high breeding potential and climate change, no analysis of future expectations in regard to raccoon dog roadkills have previously been conducted. With increasing numbers of raccoon dogs remaining active throughout recent winters or hibernating for very short periods, we expect the number of WVA with these animals to grow. To study relationships, correlation and multivariate analysis was used, based

on averages of traffic intensity, raccoon dog bag numbers (a proxy of population size), depths of ground freeze and snow depths, annual precipitation and temperature averages (annual, July and January). The dependent variable was the average raccoon dog roadkill index. This index was positively correlated with traffic intensity ( $r = 0.89$ ,  $p < 0.001$ ), annual precipitation, bag size and annual average and winter temperature. It was negatively correlated with snow depth and average summer temperature. The main factors, explaining 78.3% of the roadkill index variance, were firstly traffic intensity and population size, and secondly several climate variables. Assessed in 2008, average raccoon dog density was  $11.71 \pm 0.81$  (95CL 10.03–13.4) ind./1000 ha and was expected to grow. Population growth has been confirmed by increases in the roadkill index in 2012 and 2013. We expect that milder winters with less snow will produce significant increases in the number of WVA involving raccoon dogs. Increasing numbers of these invasive animals also pose a threat to biological diversity: they are vectors of rabies and scabies in the country and have a negative influence on ground-breeding birds (including the threatened capercaillie) and rare and threatened herp species (such as pond tortoise, smooth snake, natterjack and fire-bellied toads). A program of raccoon dog number reduction is now being conducted at ten sites in Lithuania, using several trapping and hunting methods. Based on the results, we will prepare recommendations for most effective methods to reduce raccoon dog numbers in protected areas and near main roads.

## Wildlife road traffic accidents: a standardised protocol for counting flattened fauna

Wendy J Collinson

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Previous assessments of wildlife road mortality have not used directly comparable methods and, at present, there is no standardized protocol for the collection of such data. Consequently, there are no regionally comparative statistics documenting roadkill rates. In this study, we used a combination of experimental trials and

road transects to design a standardized protocol to assess roadkill rates on both paved and unpaved roads. Simulated roadkill were positioned over a 1 km distance, and trials were conducted at eight different speeds (20-100 km.h<sup>-1</sup>). The recommended protocol was then tested on a 100 km transect, driven daily over a 40-day period. This recorded a total of 413 vertebrate roadkill, comprising 106 species. We recommend the protocol be adopted for future road ecology studies to enable robust statistical comparisons between continental studies.



# Mortality of vertebrates caused by traffic in Niepołomice Forest, southern Poland

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Niepołomice Forest (10.8\*103ha) is a protected area included in the Natura 2000 scheme, situated 35 km east of the city of Cracow in southern Poland. Some 56 kilometers of local public roads lie adjacent to the forest area of the Niepołomice Forest (48.0 km), and cut through two forest complexes (8.0 km). The studies were carried out over 12 months from January 2013 to January 2014, driving an off-road vehicle on these roads every other week. The road journeys took place at a speed of 15-30 km/h in the early morning hours of Wednesdays, Thursdays, Fridays, Saturdays, and Sundays. The locations of dead animals were recorded using readings from the car's milometer. In all, during 144 days, 8064 km were driven, with 1152 km in forest areas. A total of 856 dead animals were found, representing 38 species. Among the collected animals, the most numerous were amphibians (71.0%), among them the Common Frog (*Rana temporaria*), (n=120), the Common Toad (*Bufo bufo*) (n=90), and the Moor Frog (*Rana arvalis*) (n=80) predominating. Mammals constituted 22.0% of the dead animals collected. These were principally hedgehogs (*Erinaceus roumanicus*) (n=56), and domestic cats (*Felis domesti-*

*cus*) (n=42). Only 6% of the dead animals were birds, chiefly house sparrows (*Passer domesticus*) (n=8). Among reptiles, which constituted only 1% of the dead animals found, the majority were grass snakes (*Natrix natrix*) (n=5). The number of animals killed was highest in spring (0.300 individuals/km\*day-1), among which 85.5% were amphibians. In summer, the aforementioned indicator was 0.089 individuals/km\*day-1, in autumn it was 0.029 individuals/km\*day-1, whereas in winter it was only 0.006 individuals/km\*day-1. No significant differences were found between summer and spring, and between winter and autumn. Between the remaining pairs of seasons there were significant differences as established by the Kruskal-Wallis test. In summer, autumn, and winter, the highest proportions of animals killed were those of mammals – 53%, 94%, and 89%, respectively. When examined by the Mann-Whitney test (U), the mortality index of animals killed on roads running through forests was significantly higher (0.01>p>0.001) than in non-forest areas (0.279 individuals/km\*day-1 vs. 0.076 individuals/km\*day-1. To sum up, motor traffic in the study area poses a significant threat to the amphibian population, particularly along a 4 km-long section going through deciduous forests. Therefore, it is highly recommended to build several culverts under the road which – in combination with low fences - might effectively redirect the migration routes of these animals.



## Deer-Vehicle Collisions Situation Identified by Questionnaire Surveys to Drivers

Misako Noro

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**Introduction:** To prevent deer-vehicle collisions, other than establishing facilities for accident prevention, various efforts to increase drivers' awareness to the accident risk have been made through providing the risk information through brochures and websites or installing warning signs. To make those efforts more effective, more specific accidents situations need to be identified. The authors conducted questionnaire surveys targeting drivers to ask the details of how they collided with deer or avoided the collision. **Methodology:** The targets of the survey were drivers who experienced collisions with deer or barely avoided the collision. The surveys were conducted for three months in 2006 and 2008, respectively. The questionnaires asked the accident type (collision or collision avoidance), details of the accident situation (season, time, deer behavior, vehicle speed, driver's behavior) and damage (damaged or no damage), damage type (physical damage, property damage, or both) and the amount of damages. **Survey Results:** In total, 483 valid responses were obtained. Among them, for the accident types, collisions numbered 160 (33.1%) and collision avoidances numbered 314 (65.0%). For monthly frequencies, the both accident types marked the highest in October followed by May. As for accident hours, the frequencies of collision avoidances peaked around 20:00, starting to increase from 15:00 throughout the year. Those accidents take 48.6% of the

total collision avoidances. The frequencies of collisions peak around 17:00 common to all collisions in a year. 74.0% of those happened in the months from October to February (17 out of 23 cases). In those months, the sunset time is around 17:00. As for the all collisions, 48.0% of those occurred from 17:00 to 20:00. Concerning driver's behavior, more than 50.0% drivers pressed the brake pedal in both collisions and collision avoidances. 10.0% of the drivers sharply turned the steering wheel to avoid collisions. In the accidents, deer mostly abruptly jumped out to the roadway. In more than 70.0% of both types of accidents, the distance to the deer was 30 m or less. In those cases, in 75.0% of collisions avoidances, the vehicle speeds were 60km or less. Contrastingly, 60.0% of the collided vehicles speeds were 60km or faster, mostly exceeding the speed limits. **Conclusion:** The survey results found that the risk of deer-vehicle collisions was significantly high at the sunset time. That's probably because of the multiple reasons such as, deer are most active in early morning and evening, which increases the chances deer encounter vehicles, and the early sunset deteriorates drivers' visibility. Another fact identified by the survey was that collision accidents occurred because the drivers could not avoid colliding with deer due to over speeds. These indicate that to prevent deer-vehicles collisions, encouraging drivers to be more alert against deer and drive slower in the evening than during daytime is necessary. This also suggests increasing lighting facilities and taking measures to physically reduce vehicles speeds may be effective for the deer-vehicle accident prevention.



## Effect of tree clearance on ungulate-train collisions

**Carin Eriksson**

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After a major storm in 2005 that caused extensive damage to rails and electric lines by felled trees, the Swedish Transport Administration began clearing railroad corridors from trees that still imposed a potential threat to rail traffic. This resulted in hundreds of kilometers of clear-cut corridors alongside the most trafficked and important railways corridors. Simultaneously however, train collisions with deer, especially moose and roe deer, became significantly more frequent and the costs of material damage and consequent delays in traffic were recognized with growing concern. There was reason to believe that tree-clearance could have contributed to the increase in collision frequencies by providing valuable forage to deer and thus attracting wildlife from the wider landscape. Likewise, it was argued that the increased visibility of both deer and train could be beneficial as animals might be more likely to detect and flee from an approaching train in time. Yet, increased snow accumulations in the opened terrain could be counteractive, as many deer

would rather use the snow-free railway track for their flight than the snowy right-of-ways. The objective of our study was to investigate whether tree clearance affected the number of accidents with moose and roe deer. We applied a BACI-approach (before-after control-impact) to compare deer-train collision frequencies before and after clearance of selected railroads with frequencies on uncleared railroads. All together, we studied 480 railway sections (total of 4137 km) cleared during 2006 to 2012 in comparison to 983 control sections (8889 km). Collision frequencies with moose increased during this period by 25% on cleared and by 39% on uncleared control railway sections, averaging 7 reported incidents per 100 km railway and year at the end of the period. Similarly, roe deer collisions increased by 25% and 24%, respectively. There were differences in collision frequencies between northern and southern Sweden; also cleared and control railways differed in average collision frequencies and traffic volume, but overall the increase in deer-train collisions could not be attributed to tree-clearance per se. We discuss possible reasons for the observed pattern and conclude that a better understanding of animal-vehicle collisions on railways is necessary to effectively mitigate the problem and produce a safer and more reliable railway traffic.

## Temporal and spatial patterns of deer-vehicle collisions in intensively managed landscapes in Denmark

Morten Elmeros

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Collisions between large wildlife species and vehicles constitute a safety and economical issue for the drivers. As deer populations increase in many parts of Europe, the need for efficient management of the wildlife-vehicle conflict also increases. We employed tracker dog handlers to collect detailed information on deer vehicle collisions (DVC) to identify spatial and temporal DVC patterns. We collected information for collision sites for 29,695 roe deer (*Capreolus capreolus*), 1,1400 red deer (*Cervus elephus*), and 1,444 fallow deer (*Dama dama*) in 2003-2012. DVC data was analyzed to identify best explanatory factors for spatial and temporal patterns by generalized linear modelling. Based in the statistical modelling the DVC frequency for all 100m road stretches in Denmark were predicted. DVC numbers pr. 100m road were highest on major roads (>6m wide) and expressways, and peaked at roads with a traffic intensity at ca. 8,000 vehicles pr. day. The most important explanatory factors for the spatial

collision patterns varied between species but included the Shannon-Weiner landscape diversity index and forest cover at the 10x10km-sq level, forest cover and area of protected nature at the 1x1km-sq level, and length of forest edge at the 100x100m-sq level. DVCs were negatively correlated with build-up area and number of buildings. The best statistical model explaining temporal DVC patterns include the variables: Month linked to day-type (weekend or working day), weekday and lunar size. The differences during the week probably reflect temporal traffic patterns. DVC risk is ca. 12% higher in periods around full moon than in periods with new moon. By predicting spatial DVC patterns the potential conflict sites can be located objectively, thus a higher effectiveness of implemented mitigating measures could be expected. If GIS-information on mitigating measures is available, the analytical method may also be applied to evaluate the efficiency of mitigating measures on a larger scale compared to studies at selected sites where the measures are located. Furthermore, the predicted spatial and temporal variations in collision risk could be disseminated to drivers by an application for smart phones or GPS's that warns the drivers if they are approaching high-risk road stretches.

## The influence of spatial units to identify factors explaining wildlife vehicle collisions

Alex Bager

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One of the goals of wildlife-vehicle collisions (WVC) studies is to identify the factors that affect the incidence of mortality in order to minimize them. In the majority of studies spatial units, namely the shape and size, are arbitrary which may influence results and placement of mitigation measures. In this study, we evaluate the role of size and shape of spatial units in determining the factors that explain WVC according to species' spatial requirements. More specifically, we used spatial units with different shapes (buffers and segments) and sizes (daily movement length, standard size (1000m) and dispersal distance) in five vertebrate species. We used road-kill records of two reptilians, water

snake (*Helicops infrataeniatus*) and D'Orbigny's slider (*Trachemys dorbignii*), and three mammals, white-eared opossum (*Didelphi salbiventris*), nutria (*Myocastor coypus*) and skunk (*Co-nepatus chinga*). Hierarchical partitioning was used to evaluate the independent influence of different land use classes on road-kills varying shape and size of spatial units. Our results show that the variables related to road-kills vary little among shape and size of spatial units and the most important variable explaining road-kills was, in general, consistent over the different spatial unit types. However, we found some differences regarding the contribution to explain the road-kills occurrence. Standard size seems to be a reasonable solution as it worked well for species with home-range sizes until 165ha. Our study highlights the importance of prior analysis with several sizes and shapes to identify the appropriate spatial unit to model road-kill occurrence.

## A new method for identification of clusters of animal-vehicle collisions on road networks

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An analysis of traffic accidents caused by animals (animal-vehicle collisions, AVC) on Czech roads was performed using the new two-stepped KDE+ method, which is a statistical approach based on kernel density estimation (KDE) followed by Monte Carlo simulations. This approach is capable of determining whether the accidents on a road section are distributed randomly or not. In the latter case, only statistically significant clusters of AVCs are identified and their strengths are enumerated. This enumeration process allows for sorting the clusters according to their strengths and comparing the results across the entire road network. We took advantage of the fact that all traffic accidents recorded by the police in the Czech Republic have been localized by GPS as of 2006. The resulting clusters are therefore precise in their locations within the road segments. The entire Czech road network is approximately 39,000 km long including primary and secondary rural

roads and excluding the urban networks. The analyzed database covered the years 2009 – 2013 and included 17,032 AVC. After the application of the standard KDE, numerous clusters naturally emerged. We therefore applied the KDE+ method and received 1730 statistically significant clusters in which 4991 (29.3 %) were AVC. The remaining AVC (70.7 %) did not form significant clusters. The KDE+ process narrowed the results to only 0.4 % of the entire Czech road network. Moreover, the KDE+ process allows for sorting the clusters according to their strengths. For the illustration we selected 100 of the most significant clusters which were then depicted on the enclosed map. This set contained only 0.034 % (13.2 km) of the Czech road network. Traffic accident databases in numerous countries do not contain, however, the GPS locations of AVC. To make our method universally applicable for the less precise data, we adjusted this approach to cover data rounded to those relative stationing systems. The entire KDE+ process will be transferred into stand-alone software which will be provided by the CDV to support the efforts of road administrators and scientists from various countries in locating these AVC hot-spots.

## Differences in the variables related to animal-vehicle collisions between livestock and wildlife

**Víctor J. Colino-Rabanal**

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Animal-vehicle collisions have showed a remarkable increase during the last decades. To minimize the magnitude of the problem, the main explanatory variables involved in the spatial distribution of the collisions have been modeled. The aim of these models is to focus the mitigation measures in the main hotspots. Nevertheless, not many studies have compared the variables involved in the collisions with different large species at regional scale. Moreover, collisions with livestock are not usually included. In this study we modeled 13,721 collision sites in Castile and Leon region (NW Spain) during the period 2002-2008 including both wildlife and livestock data. The explanatory variables varied between wildlife and live-

stock. Collisions with wildlife were related to the surrounding habitat and were located mainly at mosaic landscapes, close to or in the interior of forested areas and shrubs, with certain slope and near to water sources. On the contrary, collisions with livestock were more related to roads with high traffic volumes and near to human settlements. There were also differences within each group. Collisions with roe and red deer were related to forestal and mosaic landscapes and water closeness. Badgers and wild boars with forested areas. Red foxes in roads with high traffic volume and speed. Within the livestock group, collisions with cattle and goats were located at pastures in mountainous areas. Collisions with sheep occurred at dry croplands, mainly cereals, used for feeding after the harvest season. Dog roadkills were concentrated near the large cities. The livestock management system is a key factor to explain livestock-vehicle collision occurrence.

## Island biogeography and ungulate-vehicle collisions. Planning considerations for roads.

**Víctor J. Colino-Rabanal**

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Much effort research has been focused on the study of the variables involved in roadkill occurrence at local scale. However, less knowledge has been gained about the spatial distribution of roadkills at regional scales. Road planning and strategic environmental assessment require of this knowledge. Many parts of Europe are strongly fragmented and the detrimental effects of habitat fragmentation are well documented for those species that require forest. For this reason, it would be interesting to study

how forest fragmentation affects roadkill spatial distribution. This study assesses the pattern of ungulate-vehicle collision (UVC) occurrence of three species, the wild boar *Sus scrofa*, the roe deer *Capreolus capreolus* and the red deer *Cervus elaphus* in forest fragments located in agricultural landscapes of central Spain with a coarse-grained pattern of fragmentation (< 20% forest cover in the landscape). Forest remnants are separated by an inhospitable matrix of cereal crops which dominates the landscape. UVC occurrence in forest fragments was studied in relation to: forest size, isolation and vegetation structure. Results indicated a significant effect of fragment size on UVC occurrence and an effect of isolation.





## Inventory of connectivity structures in the road network in Catalonia

**Jordi Solina**

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There is no any exhaustive listing about the number and location of these connectivity structures existing in Catalonia (specific fauna passages or others). The information about them is in different documents disperse and it is necessary to consult the informative studies and the constructive projects or others to obtain the concrete information about their location, dimensions and use. The Inventory of connectivity structures allows integrate all this information and it's a tool of support for the management by the Administration and other organisms implicated in:

- Environmental impact assessment process of near new roads
- Management and maintenance of the roads
- The planning of measures to preserve and to restore the ecological connectivity, in the strategies of defragmentation or build up the green infrastructure
- Resolve the conflicts between fauna and traffic as accidents caused by animals

The Inventory integrates at the end of 2013 a total of 630 existing structures of connectivity

into the roads of the Government of Catalonia and other administrations, integrated into 70 projects. The structures distribute in 8 types: from landscape bridges to specific overpasses for the fauna and multi-functional underpasses. The Inventory has allowed to put the work that has been carried out from the Administration to improve the permeability of the road infrastructures in value. The information about the structures has been integrated into the following interrelated tools, which have been designed and programmed for the management and consultation of the data set:

- Data base is linked with a Geographical Information System (GIS), which integrates the basic information of each structure.
- Digital cartographic layers that constitute the GIS linked to the data base. An application that allows the consultation of the information of the Inventory in environment has been programmed Google Earth / Google Maps.
- Descriptive cards with the information that characterizes each structure.
- Protocol for the standardized update and the maintenance of the information contained in the data base and in the GIS.
- Web portal with information about the Inventory and other related documents.

The Inventory constitutes a tool programmed so that it can periodically be updated with the information of the new structures of connectivity that they keep on being constructed in a future.

## Large scale defragmentation plan for ungulates and large carnivores along E20 in southwestern Sweden

Mattias Olsson

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Highway E20 in southwestern Sweden is being upgraded to a higher standard, involving a widening of the road, increased vehicle speed and wildlife fencing for human safety. The study provides a method to describe the ecological flow at the landscape scale and the effect of fauna passages to increase the connectivity for ungulates and large carnivores. The aim was to identify geographical boundaries along highway E20 where it may be desirable and effective to implement mitigation measures for the fauna. The analysis was done using ArcGIS in conjunction with Circuitscape which is a program that measures the electrical current (described as the theoretical ecological flow in the landscape) in an ecologically designed resistance map for ungulates and large carnivores as model species groups. In this study we focus on the area between lake Vänern and Vättern which is a regionally critical corridor for

large mammal migrations between middle and southern Sweden. The present highway acts as a strong barrier to movements due to fencing and high traffic volumes. Existing bridges and tunnels are too small to support movements of moose, but several passages may support large carnivore movements. However, the ecological effect of the present crossing structures is limited, since all of them are conventional bridges or tunnels without any adaption to wildlife. Thus, new passages should be included to meet the conservation goal of connectivity between middle and southern Sweden. The addition of ecoducts at strategic locations is redirecting the currents to these locations and the overall resistance decrease in this landscape. It is desirable to include several wildlife crossings or ecoducts at strategic locations, providing a more robust green infrastructure. The use of Circuitscape may be an effective tool to visualize landscape patterns and ecological flow for a variety of different species groups. However, the method needs further evaluation and testing before it can be used as a standard tool for mitigation planning.

# Escape rates and times of carabid beetles from various types of precast concrete roadside ditch blocks

**Yoshiki Yamada**

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Road construction and traffic affect wildlife in a number of ways. Roads have been reported to cause alterations in original habitats, individual deaths, photoperiodism disturbance from road lighting, chemical pollution from vehicles, road-kills, habitat fragmentation, physical barriers. In Japan, another problem associated with roads is the death of small animals from falling into roadside ditches. Because Japan has rainy season (Tsuyu) from early June to mid-July, U-shaped ditches of 30-cm deeps are often built along roadsides to protect roads from excessive precipitation. However, ditches can trap small mammals, amphibians, and reptiles and invertebrates. Precast concrete roadside ditch blocks with escapable slopes have been produced to address this problem. Although the efficacy of these sloped blocks has been reported for amphibian escapes, for insect escapes their effectiveness is unclear. We examined the Escape rates and times of carabid beetles from various types ditch blocks. Four flightless carabid beetle species (*Cychrus morawitzii*, *Carabus granulatus*, *Damaster blaptoides*, and *Leptocarabus arboreus*) were examined. The following precast concrete roadside ditch blocks were used: (1) U-shaped blocks generally used along road-

sides in Japan, (2) Haidasel® type I blocks with wide escape slopes, (3) Haidasel® type II blocks connected to existing U-shaped blocks to provide a narrow escape slope, and (4) modified U-shaped blocks with patterned indented surfaces made of mortar. We examined escape ability and time to escape for each of the four carabid beetle species. Experiments were repeated 30 times for each species and type of block. For all beetle species examined except *D. blaptoides*, escape rates from the U-shaped blocks were significantly lower than those from the other three block types. *C. morawitzii* was completely unable to escape from the U-shaped block. The escape times for all carabid beetles from the U-shaped blocks were significantly longer than those from the other three types of block. The escape times of *C. morawitzii* and *L. arboreus* from the modified U-shaped blocks were significantly longer than those from the Haidasel® type I and II blocks. Our study demonstrates that many Carabid beetles are not able to escape from 30-cm deeps U-shaped roadside ditch blocks. These U-shaped roadside ditch blocks obstruct the survival of carabid beetles. By contrast, commercial sloped ditch blocks and modified U-shaped ditch blocks have a positive effect on the escape of carabid beetles from roadside ditches. Thus, these blocks should be used to prevent carabid beetles from becoming trapped in roadside ditches.

## Youth Education for Sustainable Transport – increasing the public awareness of landscape fragmentation due to transport infrastructure : the Czech experience

Ivo Dostal

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Landscape fragmentation and long-term landscape changes due to the construction and operation of transport infrastructure is one of the serious environmental problems. But in comparison to air or noise pollution are often underestimated (with some exceptions) by decision-makers in the public administration and the general public as well. Therefore, it is desirable to increase the general awareness of these issues to give a fair attention to them. Highly effective approach is the integration of the issue in the educational process at secondary level schools (age 15 – 19), where students already have the necessary basics knowledge in biology, ecology and geography. That was the main motivation to prepare separate work package focused on landscape fragmentation in the context of a comprehensive youth education (age 11 – 19) project solved by the Transport Research Centre. As part of the project (running from 2014 to 2015) are implemented activities that stimulate interest of students and

their teachers in the issue of fragmentation and in science in general and to found the direct cooperation between research institution and chosen secondary schools. The key activity 1 is focused on researchers to gain skills in the popularization of science, in work with Youth and to effectively disseminate the results of research and development projects. Another key activity will be implementation of methodological worksheets in cooperation with researchers and chosen secondary school teachers. The emphasis is on practicality and applied forms of teaching. The third and fourth activity is focused on further education teachers from the secondary schools by researchers, allowing efficient knowledge transfer of newest research results to the education process of students and to work with academicians from both - professionally and pedagogically oriented universities. An important part of the project will be also direct work with talented students - long-term courses for students led directly by researchers, as well as contact seminars and workshops to enable the target audience to get new knowledge from scientific sphere by an attractive and interesting way. This activity contains also field trips with students and their teachers visiting interesting locations from the perspective of fragmentation and land-use.







# Abstracts: Thursday, September 18

## Plenary session

## Parallel sessions

- 3A - Wildlife accidents, traffic safety and mitigation 3 (chair: Mattias Olsson)
- 3B - Roadless areas (chair: Nuria Selva)
- 3C - Road kill observation and reporting (chair: Fraser Shilling)
- 4A - Workshop: animal reporting system (chair: Fraser Shilling)
- 4B - Infrastructure habitats (chair: Jörgen Wissman)
- 4C - Biodiversity offsetting (chair: Anders Enetjärn)
- 5A - Workshop: NVR - Swedish National Council for WVC (chair: Fredrik Bergh)
- 5B - Impact and mitigation (chair: Eric Guinard)
- 5C - Road mortality and population effects (chair: J-O Helldin)

## Poster session

- Wildlife accidents, traffic safety and mitigation
- Infrastructure habitats
- Planning for better infrastructure
- Wildlife passages

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## Plenary session 2

### Jesse R. Barber



Assistant Professor, Dept. of Biological Sciences, Boise State University, USA

Jesse R. Barber received his PhD in Biology in 2007 at Wake Forest University, Wyoming, and conducted 3 years of postdoctoral work at Colorado State University in the Department of Fish, Wildlife and Conservation Biology in collaboration with the Natural Sounds and Night Skies Division of the National Park Service. In his Sensory Ecology Lab, Jesse addresses behavioural, evolutionary and conservation-related questions related to how animals process sensory input and act on the resulting information. Understanding how anthropogenic changes to the sensory environment alter animal behaviour is a key focus of his work.

## An experimental investigation into the effects of traffic noise on birds: The Phantom Road project

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Many authors have suggested that the negative effects of roads on animals are largely owing to traffic noise. Although suggestive, most past studies of the effects of road noise on wildlife were conducted in the presence of the other confounding effects of roads, such as visual disturbance, collisions and chemical pollution among others. I will discuss experimental work where we applied traffic noise to a roadless area at a landscape scale - thus avoiding these confounds. We replicated the sound of a roadway at intervals - alternating 4 days of noise on with 4 days of - during the fall migratory period for songbirds using a 0.5 km array of speakers within an established stopover site in southern

Idaho, USA. We conducted daily bird surveys and mistnetting along our 'Phantom Road' and in a nearby control site. We document over a one-quarter decline in bird abundance and almost complete avoidance by some species between noise-on and noise-off periods along the phantom road and no such effects at control sites - suggesting that traffic noise is a major driver of effects of roads on populations of animals. Furthermore, songbirds exposed to road noise during migratory stopover showed reduced body condition and stopover efficiency compared to birds at the control site. Laboratory investigations demonstrate that this effect is likely due to interference with birds' foraging-vigilance behavior. Our results show that traffic noise alone can decrease the value of habitat that would be otherwise suitable, and that organisms might not leave to avoid these negative impacts.

## Plenary session 2

### Nuria Selva



Associate Professor, Institute of Nature Conservation, Polish Academy of Sciences, Poland

Nuria Selva is an Associate Professor at the Institute of Nature Conservation in Krakow, Polish Academy of Sciences. She received her PhD in Biology in 2004 at the University of Seville, Spain. Her research interests cover a wide range of topics within animal ecology – particularly the ecology of large carnivores, carrion and scavengers- and conservation biology. Her current projects deal with habitat requirements and management of brown bears in the Carpathians under global environmental changes. Nuria has served in the Society for Conservation Biology-Europe section as member of the Board

of Directors and Chair of the Policy Committee. Together with SCB colleges, she has been leading the Roadless Areas Initiative, launched in 2007 by the Policy Committee, which aims at promoting the protection of road-free areas. She has also focused on conservation policies at European and international level, with special interest on non-intervention practices, protection of ecological processes and wilderness. She lives in Bialowieza Forest, at the Polish-Belarusian border, the last primeval temperate forest in Europe.

## Why keep areas road-free? Roadless and low-traffic areas as conservation targets

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With more than 100 million km of roads worldwide, the road network plays a main role in shaping the environment. Road impacts on the environment are numerous, very complex, time-lagged and extend far beyond the edge of the road itself. Probably the most important road effect is what we have termed “contagious development”: roads provide access to previously remote areas, thus opening them up for more roads and developments, and triggering land-use changes, resource extraction and human disturbance. In this context, keeping road-free the remaining large unfragmented patches of natural habitats is of crucial importance for their conservation. Roadless and low-traffic areas represent relatively undisturbed natural habitats and functioning ecosystems. They increase landscape connectivity, act as barrier against pests and invasions, and render many ecosystem services. Roadless areas largely contribute to the preservation of native biodiversity and contain more species and individuals, species with large spatial requirements and species sensitive to human disturbance. They get special relevance in the context of climate change because their higher resilience and buffering capacity. With a few exceptions, roadless and low-traffic areas are not considered in national or international legislation. For example, in Germany, although the Natura 2000 network covers an important proportion of the country (16%), most low-traffic and roadless areas (75%) lie

outside this network. We propose that planning of new transport routes should identify existing roadless areas and avoid dissecting them. It is important to systematically evaluate whether a road is REALLY needed, and if so, explore alternative route options before dissecting and eliminating roadless areas or increasing traffic volumes in low-traffic areas. Road-free areas of natural and semi-natural habitats should be maintained by concentrating traffic on existing highly travelled roads and bundling infrastructure close together. When this is not possible, it is crucial to protect the remaining area by avoiding contagious development through implementing sustainable development schemes at large spatial scales, as well as to apply compensation policies of NO NET LOSS of unfragmented lands. Measures like promotion of railroads or speed and traffic limitation should be considered. Unnecessary and ecologically damaging roads may also be reclaimed to enlarge roadless areas and restore landscape-level processes. By keeping areas road-free, we help to protect them de facto, at practically no financial cost. The maintenance of roadless areas is more cost-effective than measures to mitigate or minimize road impacts, or even road reclamation. In this context, a vital task is to identify, map and describe the remaining roadless and low-traffic areas, and to promote their maintenance and protection. Roadless and low-traffic areas are a timely tool to preserve intact functioning ecosystems at local and global scales in the face of climate change. Their rarity and the services they provide to society calls for systematically considering them in modern land-use and road planning, while supporting the need for rewilding in a human-dominated planet.

## Two spatial scales of moose-vehicle collisions

Milla Niemi

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Moose-vehicle collisions (MVCs) result in a serious traffic safety problem in Europe and North America. In Finland, the majority of animal-vehicle accidents causing human injuries and economic losses have been collisions with moose. Therefore, there is an urgent need to better understand the reasons affecting to the MVCs. We studied the effects of the various environmental variables to the spatial distribution of MVCs in central Finland. The MVC data was collected using an electronic survey for voluntary hunters working as executive assistance for police. Those volunteers visit every collision site, put the animal down if needed and transport the carcass away from a road area. Thus, they have the knowledge about the placements of MVCs. Our data included placements of 218 MVCs occurred in the years 2009–2011. For every collision point, we created two buffer zones: one with the radius of 500 meters (landscape level) and one with 100 meters (habitat level). We randomized two individual non-collision reference points to each collision point, one for each level. References were, however, chosen within two kilometers from the collision points and buffers were not allowed to overlap. For landscape level analyzes, we calculated the proportions of land use and forest structure within the 500-m buffer areas. At habitat level (100-m buffers), we used

distance to river, inhabitant area, and forest edge as well as elevation, slope and nine forest structure variables. The differences in means of these variables between collision and reference sites were tested and only variables differing statistically significantly ( $p < 0.05$ ) were taken for the further analyzes. The effect of these variables on the collision risk was characterized using odds ratios (ORs), separately on landscape and habitat level. OR-values below one indicate decreasing MVC-risk while values above one indicate the opposite. At the landscape level, the proportion of agriculture has a major diminishing effect on the risk of MVCs ( $OR=0.1$ ). The most important forest structural variables were the proportions of old forest ( $OR=30.1$ ) and Norway spruce ( $OR=13.2$ ) which both increased the risk of MVCs. At the habitat level, the most important factors were the distance to the forest edge ( $OR=0.9$ ), elevation ( $OR=1.5$ ), stand volume ( $OR=2.6$ ) and proportion of birch ( $OR=253$ ). Although some of the ORs were rather large, our results indicated that it is useful to combine different spatial scales when evaluating the effect of environmental variables on MVCs. Based on our landscape level analysis, it was possible to conclude that MVCs in our study area are more likely to happen in road sections framed with old-growth spruce-dominated forests. However, additional information is required when allocating on the single measures, such as wildlife warning signs. For these cases, supplementary information provided by the habitat scale analysis helps to identify the most probable local collision hot spots such as forest edges.

## Parallel session 3A

# Locations of the registered moose-vehicle collisions and their spatial relations with green network in Estonia

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The effects of roads on wildlife have become an important issue. In the case of large mammals, wildlife-vehicle collisions also pose a risk to the drivers` and passengers` safety. Moose *Alces alces* is the largest wild animal in Estonia. About 200 to 250 moose-vehicle collisions occur on Estonian roads each year, which is about 10% of all road collisions. In 2013, 234 moose related traffic accidents were registered, 1 person was killed and 14 were injured. Estimated property damage is about 1 million euros annually. It is assumed that most of these collisions take place in sections where roads cut green network. Estonian green network (also referred as ecological network) is part of the Pan-European Ecological Network (PEEN) for the protection of ecosystems, habitats, species and their genetic diversity and landscapes of European impor-

tance. While specifying green network during the legal planning process, habitat preferences and migration corridors of several species were taken into account. So it can be assumed that in the places where roads cut the structures of the green network, wild animals` encounters are more frequent than in other areas. These are potential conflict spots, where extra attention should be paid to mitigation or compensation measures while planning or designing any infrastructure objects. The aim of the study is to verify how many moose related traffic accidents occur in areas where the green corridors or core areas are cut by the roads. For this, the locations of 1800 registered moose-vehicle collisions (from period 2004-2013) are detected. A thematic spatial data layer is created and compared to the green network layer and related natural landscape diversity indicators. The hypothesis that most of the collisions take place in the green network areas is checked. Other potential collision places include river bridges, power line crossings etc.

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## Clusters of traffic accidents caused by ungulates: identification and evaluation of their significance in the Catalonia road network

**Carme Rosell**

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Animal Vehicle Collisions (AVC) often show a pattern of aggregation, with clusters along conflictive road stretches. Road traffic safety is diminished in these hotspots, due to the risk of accidents involving animals. Therefore, the identification of these stretches is essential to apply effective mitigation measures. Data from 2,110 accidents involving ungulates were registered in the 12,124 km of the Catalan (NE Spain) road network during a five-year period (2007-2011). The data were collected by traffic police and completed with data provided by road management teams, the traffic management agency and the wildlife management department. Two different methods were used to determine the location of the clusters of accidents caused by ungulates. First the kernel density estimation

(KDE) was applied to the 1-km stretches of road that had previously been identified as the most conflictive by comparing the data with a random situation in which the probability of occurrence along each stretch followed a Poisson distribution. However, this method could not be used to determine the statistical significance of the clusters that were identified. The second method (KDE+) consisted of a procedure based on standard KDE that identify the most hazardous road stretches by testing the statistical significance of the resulting clusters. The clusters were identified where the kernel density function exceeded the significance level corresponding to the 95th percentile, and the application of cluster strength evaluation provided a sorted list of hazardous locations. Traffic accidents caused by ungulates (mainly wild boar and deer) have a strong tendency to cluster, with about one third of accidents located at around 1% of the road network length. The results provided by this method allow efforts to apply mitigation measures to be focused on the most hazardous road stretches, where the best benefit-cost ratio can be expected.



## Parallel session 3A

# The effect of the moon in wildlife-vehicle collisions

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The phase of the moon is well known to affect activity patterns of animals at night, and may also affect visibility for motorists. However, surprisingly little is known about whether moon phase is correlated with frequency of wild-life-vehicle collisions (WVC). We investigated the relationship between frequency of WVC at night and lunar phase for four common large ungulate species that account for significant numbers of serious WVC along roads in agri-

cultural and forested landscapes: wild boar *Sus scrofa*, roe deer *Capreolus capreolus*, and red deer *Cervus elaphus* in Castile and Leon, Spain, and white-tailed deer *Odocoileus virginianus* along roads in New York State, USA. Three of the four species were more frequently involved in WVC around the full moon phase of the lunar cycle; this pattern was evident throughout the year but strongest in winter. Roe deer, the species with WVCs that were mostly closely associated with the lunar cycle, had a frequency of WVC involvement that was 71.3% higher during the full moon than new moon period. Our results indicate that rates of nocturnal ungulate WVC cycle on a period of a lunar month, which has implications for traffic safety planning and for preparing emergency responses for WVC.

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## Quantification of railroad-related barrier effects on the movements of ungulates and medium-sized mammals in southern Sweden

Mattias Olsson

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Roads and railroads can act as movement barriers to many terrestrial wildlife species. The barrier effect can be attributed to several factors among which fencing and traffic volume are thought to most affect wildlife. However, systematic studies designed to identify barrier effects are uncommon and only few have attempted to quantify the dose-response relationship between traffic and barrier effect on wildlife. We used snow tracking along unfenced sections of railroad in southern Sweden (170 km of railroad at 94 study sites) to distinguish between patterns caused by disturbance/avoidance behavior and movement barriers, and to quantify the dose-response relationship between traffic volumes, snow depth, and wildlife movements. Specifically, we used snow tracking surveys to monitor animal movement across three parallel transects: 1)

railroad tracks (R-railroad); 2) the forest edge approximately 10 meters from the railroad (E-edge); and 3) the control transect 200 m from the railroad (C-control). We found significantly more moose and roe deer tracks along control transects (C) compared to E and R, transects, indicating that busy railroad corridors repelled many of the species we monitored. Hare and red fox exhibited lower response to railroad traffic. Traffic volume contributed most to the barrier effect on ungulates, with an interplay of other variables such as the number of railroad tracks. Roe deer and moose movements across railroad tracks were significantly reduced with increasing railroad traffic volume, indicating a strong dose-response relationship. Our results indicate that increased traffic volume effects ungulate movement across railroads. Railroads with traffic volumes >140 trains/day had lower permeability and should be considered barriers to ungulate movements. We recommend that connectivity plans for wildlife be developed for existing and new railroads that support high traffic volumes.

## Parallel session 3B

# Indices for the spatial assessment of road and traffic impacts on ecosystems

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The increase in roads and traffic through the last century has caused extensive fragmentation of the landscape affecting biodiversity and ecosystem function. Subsequent changes to the natural heterogeneity of landscapes have impaired movement and persistence of populations for many species and altered ecosystem structure and processes. Science lacks a full understanding of the effects of road disturbance on ecosystem health because methods for assessing the immediate and lasting influences they have on biodiversity and ecological processes are in early stages of development. Recently, two indices have been developed for the assessment of road and traffic impacts on ecosystems. First, a spatial road disturbance index (SPROADI) was developed and applied to the Federal State of Brandenburg in north-eastern Germany as a case study. The index is calculated from three sub-indices: (1) traffic intensity as a measure of traffic volume per time and space;

(2) vicinity impact, which is the assessment of edge effect of roads on adjacent habitats (the road-effect zone); and (3) fragmentation grade, which provides an indication of the degree to which the landscape is intersected by roads. Second, SPROADI was integrated into a novel, ecosystem-specific index designed for assessing the functionality of forests. Again, three sub-indices are devised: (1) tree-related forest structure; (2) connectivity and size of functional forest patches; and (2) non-forest matrix characteristics (including SPROADI). When applied to land cover data for Brandenburg the integrated index clearly identified forest patches of potentially high conservation value. It also provided a more sophisticated picture of the relationship between forest functional status and disturbance by roads. An important message to forest managers refers to areas under low road and traffic impact that were assessed as of low functionality. These may have a particularly high potential to be developed into highly valuable forests. As a central message to traffic infrastructure planners, the index indicates the existence of, sometimes relatively large, forest areas of high ecosystem functionality that have not yet been dissected by roads. Road construction through these valuable areas should be avoided or at least be reduced to the minimum extent possible. These novel methods thus have important implications for proactive planning and sustainable management of landscapes.

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## Identifying roadless areas in Europe

**Maria Psaralexi**

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A considerable number of studies has revealed that transportation networks and the consequential secondary development are determinant factors of habitat fragmentation and biodiversity loss. Thus roadless areas' preservation (RAs) should be promoted in Europe, offering at the same time biodiversity conservation, ecosystem services and economic profit. Our goal was to identify RAs and assess their potential role in broadening the existing protected

area network at the European level. Based on a literature review, we concluded that areas should have a distance of at least 1km from the nearest road and a surface of at least 100 km<sup>2</sup> to be considered as roadless. Next we examined the landscape characteristics of the European RAs, along with their spatial relationship with the Natura 2000 network. The identification of RAs as well as their overlaps with Natura 2000 network could form an innovative means to conserve biodiversity but also a forefront to protect these important areas in a cost and time-efficient way at a coarse scale. The outcomes of our research highlight the important contribution of roadless areas in a more environment-friendly Europe.



## Parallel session 3B

# A global assessment of roadless areas

**Monika Hoffmann**

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We present a detailed and comprehensive global assessment of roadless areas based on open-access road information (OpenStreetMap). For the purpose of this study, we review the

size of the road-effect zone reported in the literature for a wide range of road ecological effects. Roadless areas are identified by establishing 1-km buffers along all existing roads and mapping the resulting polygons. These polygons representing the remaining roadless areas on Earth are evaluated according to their size and the quality of their territories. Protected area coverage and degree of strict protection are analysed, as well as attributes such as ecosystem functionality, species richness or biomes/anthromes. Accuracy of data is discussed taking into account different data sources. The results will be used for a global interactive assessment and a campaign for roadless area conservation.

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## A Spatial Assessment of Fragmentation and Disturbance Effects of the Swedish Road Network

Mårten Karlson

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Transportation infrastructure has a wide range of effects on aquatic and terrestrial environments, and its effect on ecological processes have been increasingly studied the last decade. The aim of this study was to assess the impacts of the Swedish road network by spatial modeling of transport infrastructure effects identified in the literature. Further, this study aimed to analyze and compare the potential impacts of fragmentation and disturbance, and to discuss the utility of the method employed for environmental assessment purposes. Six ecological profiles representing disturbance and fragmentation sensitive species were created from datasets on land-cover and valuable nature types.

Fragmentation and disturbance effects were analyzed using overlay operations in a GIS, and FRAGSTATS was used to calculate two ecologically important landscape metrics. The results showed that natural grasslands and southern broadleaved forest were more exposed to road effects in Sweden, compared to other habitat types. The results further suggested that 1) qualitative degradation of habitat could potentially reduce habitat amount dramatically 2) that forest species with high resource demands are more adversely impacted by roads, and 3) that fragmentation effects are a concern primarily for mammals with low resource demands. The potential utility of the study methodology for environmental assessment was concluded to be high. The metrics calculated could be useful for generating baseline environmental information as well as coarse predictions on likely consequence, and for the development of mitigation and management strategies.





## Parallel session 3B

# An approach to road networks and soundscapes

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Roads and traffic are the most important source of noise in the environment. Moreover, much research effort has been aimed to identify and to quantify road impacts on animal populations. Species composition, richness and abundance are modified by road presence. Thus, roads not only alter natural soundscapes by traffic noise but also by changes in the animal communities which are involved in the creation of that soundscape. Furthermore, other indirect impacts caused by roads as greater accessibility or land-use changes may become main factors of natural soundscape modification. For all these reasons, the spatial configuration of the soundscapes in a region is related to the road net-

work. Roads, especially main highways, are not distributed at random but tend to follow certain landscape units. Road network is also known to have fractal features and its patterns are closely related to the urban system. This research explores the influence of these factors in the spatial alteration of natural soundscapes caused by traffic noise. Calm areas with low road densities have been proposed as target areas for conservation. The initial purpose was the preservation of relatively unaltered communities far away from road impacts but these zones could be also used to protect natural soundscapes. These calm zones partially overlap with protected areas but there are also important calm areas that remain unprotected. The approach here showed could serve as theoretical framework to study the spatial interactions between road networks and soundscapes and, therefore, be used to locate these calm areas.

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## Wildlife-Vehicle Collision Observation Collection and Hotspot Identification at Large Scales

Fraser Shilling

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Highways provide commuter traffic and goods movement among regions and cities through wild, protected areas. Wildlife-vehicle collisions (WVC) can occur frequently when wildlife are present, impacting drivers and animals. Because collisions are often avoidable with constructed mitigation and reduced speeds, agencies want to know where they can act most effectively and what kinds of mitigation are cost-effective. Collecting observations of WVC is often either carried out by specialists, but narrow in time and space, or is carried out widely by highway maintenance staff, but is narrow in taxonomic breadth. To understand the significance of WVC locations for both conservation and driver-safety concerns, it has become necessary to develop WVC observation systems that are both extensive (e.g., US state-scale) and intensive (i.e. detailed and accurate observation data). We describe and test this type of system here. For this study, WVC occurrences were obtained from two sources: 1) highway agencies that monitor carcass retrieval and disposal by agency maintenance staff and 2) opportunistic observations of carcasses by participants in the California Roadkill Observation System (CROS; <http://wildlifecrossing.net/california>) and the Maine Audubon Wildlife Road Watch (MAWRW; <http://wildlifecrossing.net/maine>). Since September, 2009, >30,000 independent observations of >450 vertebrate species have been recorded in these online, form-based informatics systems by >1,480 observers. We asked whether or not WVC observations collected by

these two existing large-scale volunteer-science networks could be used to inform transportation-mitigation planning. Cluster analyses of volunteer-observed WVC were performed using spatial autocorrelation tests for 16 state highways and interstates. These clusters were compared to similar findings from agency-collected WVC data. Statistically-significant WVC hotspots were modeled using the Getis-Ord  $G_i^*$  statistic, with Moran's  $I$  being used to estimate distance bands. High density locations of WVC that were not necessarily hotspots were also visualized. Statistically-significant hotspots were identified along >1,900 km of highways, primarily in areas near urban or agricultural development. In more natural areas, hotspots were less evident or lacking, except if observations for single species were used. For highways with frequent deer-vehicle collisions, we calculated annual costs from collisions to range from (US) \$0 to > (US) \$30,000/km. We also compared the occurrence of statistically-significant WVC, based on volunteer observations, with similar clusters of deer-vehicle collisions, based on agency observations. Although there was no overlap of clusters between these data sources identified by analysis of spatial autocorrelation, there were a few locations that were both hotspots identified by volunteer observations and a location of high estimated cost and risk from deer-vehicle collisions, based on agency observations. We show that volunteer-collection of WVC observations at US state-scales could be useful in prioritizing mitigation action by state transportation agencies to protect biodiversity and driver safety. Because of the extent and taxonomic accuracy at which volunteer observations can be collected, these may be the most important source of data for transportation agencies to protect drivers and wildlife.

## Motorways and vertebrates traffic casualties: comparative methodology study in obtaining unbiased number of roadkills

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**Objectives:** Obtaining unbiased estimates of animals killed by infrastructures is an important conservation issue and implies that researchers take into account key-factors which influence carcasses counts. Studies estimating animal roadkills are numerous but few took into account carcass persistence and detection rates. Capture-Recapture (CR) models can be used to estimate unbiased numbers of carcasses using open capture-recapture approach (Schwartz & Arnason 1996). This approach allows estimating both an entry rate (p-ent rate) into the carcasses available to detection and a « survival » rate (hereafter persistence rate) of the carcasses. Using these two parameters the total number of carcasses can be inferred. This study aim at testing two CR approaches to estimate unbiased carcasses numbers, the usual super-population approach and a more recent alternative based on "stop-over duration" models (Schaub et al. 2001) to compare their accuracy of the number of carcasses estimations, in order to obtain more accurate vertebrates taxa's traffic casualties estimation. Studied areas: 4 motorways sections have been studied in South-West of France for a total of 150 km (2006-2008). Method: Each motorway section was studied every season during a 3 days survey period. During these 3 days, 5 successive vertebrate carcasses

counts were performed to obtain Capture-Recapture histories of carcasses. Surveys were made by car, driving at 40-50 km.h<sup>-1</sup> on the safe lane, each carcass being identified and positioned. Super-population models were fitted with POPAN (available in the software Mark Program) while the Stop-Over Duration models were fitted with SODA and population size was thus derived using matlab routines. Results and discussion: Results obtained from POPAN indicate that parameter estimates vary significantly among the number of sessions analyzed, especially concerning p-ent rate. Persistence rate was significantly higher for hedgehogs than other mammal orders, being lower for Passerines than other bird orders. Persistence rate was higher for Anoures than Urodels. Persistence rates of bird carcasses varied between seasons, those of mammal carcasses depended on position on the motorway and those of amphibian seemed constant. Detection rate was constant for all taxa except for birds. The reptile carcass sample size was too small to be analyzed. We compare these results with those obtained with SODA. Such comparison should be useful for researchers and practitioners to obtain unbiased estimates from different softwares and their limit of use. Normalization of this methodology could permit to collect a big set of comparable data. References: Schaub, M., Pradel, R., Jenni, L., & Lebreton, J. D., 2001. Migrating birds stop over longer than usually thought: an improved capture-recapture analysis. *Ecology*, 82(3), 852-859. Schwarz, C. J. & A. N. Arnason. 1996. A general methodology for the analysis of open-model capture recapture experiments. *Biometrics* 52: 860-873.

## Citizen science and smartphones take roadkill monitoring to the next level

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Road networks, even in industrialized countries, become denser year after year and traffic volumes also increase at a steady pace. It is imperative that we monitor the impact of this trend on wildlife, but monitoring roads for flattened fauna is a time consuming effort and roadkill monitoring projects conducted up till now are relatively small scale both in terms of time and space. This hampers the progress of road ecology towards the higher level of analysis on landscape and population scale. We argue that citizen science projects not only take roadkill monitoring to this higher level, but simultaneously offer data for safer transportation and for mitigation of roadkill hotspots. It is also very effective in raising public awareness. In 2008 such a project started in Flanders (Belgium), the region with the most dense road network of Europe (more than 5 km of road per square km) and one of the highest population densities (359 inhabitants per square km). This makes Flanders the ideal location for a citizen science project about roadkill monitoring. The objectives of this project were to (1) identify roadkill hotspots, (2) collect data to measure the impact of roads and traffic on fauna and (3) raise public awareness for the effects of habitat fragmentation by roads. Incidental observations of roadkills by volunteers were gathered through

a website and a smartphone app. In 2013 the website was updated with a new module to allow the systematic monitoring by volunteers of routes for the presence of roadkills. During the project period (2008/05/15 – 2014/04/30) 42.076 roadkills of vertebrates were registered on the website. Therefore the project resulted in what may be the largest and most dense dataset on roadkills in the world. This data has already been applied to identify hotspots and mitigate them. Five months after the start of the systematic monitoring of routes 69 volunteers are monitoring 94 routes for a total of 852 km. Already 1.064 route counts have been registered and more than 8.156 km were surveyed by car, bike or on foot. The gathered data is spatially explicit: roadkill and route positions are registered on the website and can be extracted as digital maps for analysis in GIS software. From this ongoing project we conclude that citizen science indeed delivers big data and takes roadkill monitoring to the next level. The applications are infinite. The data are used for hotspot analysis and mitigation. Possible applications of this data include a warning system for wildlife-vehicle collision hotspots on gps-systems for cars. The module for systematic monitoring can be used to monitor the success of mitigation measures or for measuring the impact of traffic on wildlife populations. The tools (website, app) of this roadkill monitoring project are available and can be deployed anywhere in the world.

## Intelligent systems for mapping amphibian mortality on Portuguese roads

**Neftalí Sillero**

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Roads have multiple effects on wildlife, from animal mortality, habitat and population fragmentation, to modification of animal reproductive behavior. Amphibians in particular, due to their activity patterns, population structure, and preferred habitats, are strongly affected by traffic intensity and road density. On the other hand, road-kills studies and conservation measures have been extensively applied on highways, although amphibians die massively on country roads, where conservation measures are not applied. Many countries (e.g. Portugal) have not any national program for monitoring road-kills, a common practice in other European countries (e.g. UK; The Netherlands). This is necessary to identify hotspots of road-kills in order to implement conservation measures correctly. However, monitoring road-kills is expensive and time consuming, and depend mainly on volunteers. Therefore, cheap, easy to implement, and automatic methods for detecting road-kills over larger areas (broad monitoring) and along time (continuous monitoring) are necessary. We present here the preliminary results from a research project which aims to build a cheap and efficient system for detecting amphibians road-kills using computer-vision techniques from robotics. We propose two different solutions: 1) a Mobile Mapping System to detect automat-

ically amphibians' road-kills in roads, and 2) a Fixed Detection System to monitor automatically road-kills in a particular road place during a long time. The first methodology will detect and locate road-kills through the automatic classification of road surface images taken from a car with a digital camera, linked to a GPS. Road kill casualties will be detected automatically in the image through a classification algorithm developed specifically for this purpose. The second methodology will detect amphibians crossing a particular road point, and determine if they survive or not. Both Fixed and Mobile system will use similar programs. The algorithm is trained with existing data. For now, we can only present some results about the Mobile Mapping System. We are performing different tests with different cameras, namely a lineal camera, used in different industrial solutions of control quality, and an outdoor Go-pro camera, very famous on different sports like biking. Our results prove that we can detect different road-killed and live animals to an acceptable car speed and at a high spatial resolution. Both Mapping Systems will provide the capacity to detect automatically the casualties of road-kills. With these data, it will be possible to analyze the distribution of road-kills and hotspots, to identify the main migration routes, to count the total number of amphibians crossing a road, to determine how many of that individuals are effectively road-killed, and to define where conservation measures should be implemented. All these objectives will be achieved more easily at with a lower cost in funds, time, and personal resources.



## Parallel session 4A

# Workshop: Systematically reporting live and dead wildlife on and near roads

**Fraser Shilling**

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Many planning, environmental assessment and mitigation actions rely on good information about the occurrence of wildlife on or near roads. Very few government agencies around the world have created systematic approaches for collecting these data. Notable examples are Sweden's reporting system for wildlife-vehicle collisions (<http://www.viltolycka.se/hem/>) and Idaho's (US) system for reporting carcasses on roads (<https://fishandgame.idaho.gov/ifwis/portal/>). Large independent systems that rely on volunteer contributions of observations have also been developed by Universities for US state (Maine and California; <http://wildlifecrossing.net>) and country scales (<http://projectsplatter.wordpress.com/>). Motion-triggered wildlife cameras are increasingly used at roadways to

understand the need for, or effectiveness of wildlife under and over-crossings. There are similarly very few systematic informatics approaches for wildlife camera data. Notable examples are the user-oriented, project and data management system at Wildlife Observer Network (<http://wildlifeobserver.net>) and the more passive picture visualization system Smithsonian Wild (<http://siwild.si.edu>). These existing systems and many potential systems have common elements that should be discussed during the early stages of development of this field, in particular in an IENE workshop. This workshop at the 2014 conference is focused on the requirements, functions, and desirable outputs of large-scale, wildlife reporting systems for observations of both dead (wildlife-vehicle collisions) and live (photographs, direct observations, tracks/scat) animals on or near roads. The architectural and programming requirements of these two types of observations and corresponding informatics systems are very similar.





## Parallel session 4B

# High environmental values in biotopes on railway stations. A method to identify and rank nature conservation values.

**Magnus Stenmark**

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Infrastructure habitats are receiving increasing attention as important habitats for endangered species. In Sweden there are about 200,000 ha managed grasslands along infrastructure such as power lines, national road network, airports and railways. The Swedish Transport Administration has documented, through a series of years, the diversity of insects and plants in railway environments in different regions. Therefore, we know that over 2,000 species of insects and vascular plants live in the railway environment and among these, about 100 are red-listed. In this work we present a method to assess and classify railway environments. The method consists of three steps: remote assessment, field visits and nature conservation action plans. The remote assessment is done on screen and picks out the railway environments that needs to be visited in the field based on a set of parameters such as visible structures and soil characteristics. Habitats for vascular plants and insects are the focus during the field visits. A set of selected habitats, species of vascular plants, structures with high nature conservation values, earth composition and management regimes are the main parameters to be recorded during the field visits. The selected habitats consist of 13 different environments that represent specific nature conservation values for railway environments. These selected habitats are each

represented by a unique combination of flora and fauna and contain one or more protected species. By focusing conservation efforts to the selected habitats, the most valuable railway environment will be preserved and developed. An example of a selected biotope is sunny sandy areas with dense patches of the herb *Herniaria glabra*. This herb species is common in sandy and gravelly ground, but sun-exposed patches are unusual. Much of the railway environment with *Herniaria glabra* is indeed sun-exposed. As a consequence, the red-listed moth *Coleophora scabrida* is frequently appearing in railway station areas in some regions. Outside the railway environment this moth species is very rare. The field visits lead to an overall classification (1-4). The class 3 (low capacity) and 4 (lack capacity) will not be considered for management plans. The railway station areas classified to 1 (very high conservation values) or 2 (high conservation values) are proposed to be the subject of a specific management plan. This plan should be developed to take advantage of the station area's conditions to further develop high conservation values. We hope that this methodology will trigger a comparable long-term valuation of the natural assets of railway environments. The methodology can eventually be developed to provide an objective view of nature value status in railway environment. We believe that the methodology will spread because it is compatible with standardized methods for assessing biodiversity values, it is simple and resource efficient to perform, comparable over time and have been developed specifically for railway environments.

## The Ecology of Large Infrastructure Embankments: From Heritage to Diversity The Example of the Likoto Eurometropoli

Denis Delbaere

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This presentation focuses on epistemological considerations for landscape ecology as applied to the embankments, verges and abandoned sites created by transport infrastructure. These embankments pose major problems for nature surveys because they are large, difficult to access and located in highly artificial environments. This presentation will discuss the results of cross-disciplinary and cross-border research carried out as part of the "En marge..." program. This project examines the quality of landscapes and biology in major transport infrastructure verges in the Lille-Kortrijk-Tournai Eurometropolis area between France and Belgium. After attempting to apply traditional inventory methods to 650 km of embankments, our team decided to develop a specific inventory method that, if valid, could change the premises of landscape ecology. Historically, landscape ecology has focused on the idea of ecological heritage; however, in the case of infrastructure, this could evolve towards the concept of specific and taxonomic diversity. Three main types of problem were encountered. Firstly, the highly artificial nature of landscapes affected by infrastructural projects led to the near absence of any relevant ecological matrix to which the biodiversity of verges could be compared. The biodiversity therefore had to be considered as an ecosystem that was more or less disconnected from its physical environment, as has been observed for dry railway embankments. This appeared to be confirmed by our sampling. Secondly, even if a large number of typological plots were

sampled, the size and diversity of verges meant that sampling only provided an overview of the situation. Any modelling based on these results was an uncertain extrapolation. Consequently, the biodiversity of embankments could not be described or even modelled in a reliable manner. Each new investigation would have led to a wider range of species, facies and environments being observed. The only thing that could be said with any certainty was that the ecological value of embankments lay first and foremost in their specific diversity. Thirdly, these areas were difficult to access. Paradoxically, this encouraged a wide variety of unobtrusive uses (walking, running, camping, prostitution, the dumping of waste, the construction of sheds, land management practices, mowing, clearing, etc.). These uses had a considerable trophic impact on the areas analyzed. The optimum biological diversity attainable in embankments was therefore largely dependent on these practices, which led to line-side vegetation in railway zones, linear afforestation in urban areas, and shrub belts elsewhere. Consequently, the ecology of embankments must take into account these optimums rather than aim for an overriding objective. We therefore developed an overview and extrapolation method, which highlighted specific and taxonomic diversity rather than ecological heritage. Verges are refuges and play a conservation role, and these functions take precedence over their connective purpose. It is their status as emerging public spaces that determines how they are managed from an ecological point of view. These results lead to questions as to the purposes of landscape ecology, in particular blue and green belt projects, which are the most visible application of the theory.

## Parallel session 4B

# Evaluation of faunistic richness of Hungarian highway verges

**Balázs Kiss**

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Plant covered highway verges and rest areas provide suitable habitats for a number of invertebrate species as well as for some small vertebrates. In spite of its importance, for example in intensive agricultural areas, this aspect of road ecology is poorly understood. In this study, 33 sampling sites were surveyed along Hungarian highways by pitfall trapping, suction sampling, branch beating and sweep netting three times a year between 2011 and 2013. In case of the invertebrate target taxa, we have found 20-36 % of the species of the Hungarian fauna in the first two years (Orthoptera: 36 %, Araneae: 35 %, Auchenorrhyncha: 34%, terrestrial Isopoda: 27 %, Curculionidae: 22 %, Carabidae: 22 % Coccinellidae: 20 %), while in vertebrates it varied

around 30%(Amphibia: 29 %, Reptilia: 31%). A relatively high number of endangered and protected species was also proved to occur in the studied sites, and 13 arthropod species was detected for the first time in Hungary. Among the new species, there are faunistic rarities and newly introduced invasive species, too. A comparative analysis of the flying ability of captured carabid beetles was realized for the estimation of the disturbance level at the collecting sites. The relatively high proportion of species of low dispersive ability suggests that grassy areas along highways can often be considered as relatively stable habitats. Our results also proved that highway verges may have a real nature conservation value in certain regions. A continental scale survey of arthropod assemblages in highway verges would also be a useful tool for monitoring the procedure of biological invasions in case of several taxa. The study was supported by OTKA grant (No. 83829) and Hungary-Greece Joint Research And Technology programs (TÉT\_10\_1-2011-0472).

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## The importance of infrastructure for biologically important trees

Jörgen Wissman

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Forestry has been intensified over the last 150 years in Sweden and the refuge for old trees in forests has more or less disappeared. At the same time, the major part of the open or semi-open grasslands has been transformed to forest or arable fields. Hence, in the modern landscape old solitary trees are scarce. By looking at the red-list of Sweden it is obvious that tree trunks and branches as well as the cavities in sun-exposed old trees are one of the richest and most threatened substrates in the country. By improving the abundance of solitary trees in Sweden, it is expected that the future survival probabilities of about 400 red-listed species will

be enhanced. In four censused areas in Sweden, more than 10 % of all old and, for conservation, important solitary trees was found along roads and railroads. However, only about half of these had suitable successors that potentially could take over after the tree dies. Appropriate actions to improve the situation for biodiversity on and inside trees differ dependent on e.g. tree species, the abundance of threatened species and landscape parameters. Studies of age structures and measures for ensuring successors nearby valuable trees is of importance. In some cases other, more controversial, measures may be necessary, e.g. large nesting boxes that mimic the interior of old trees, fauna depots of dead wood and tree trunks, or active measures for the creation of holes or dead wood on young trees to simulate old structures.



## Parallel session 4B

# Minor rural road networks: values, challenges, and opportunities for biodiversity conservation.

**Peter Spooner**

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Roads corridors are a conspicuous part of most landscapes, which can have significant impacts on local ecosystems. Roads cause wildlife mortality, alter water and nutrient flows, change local microclimatic conditions, act as vectors for weeds and pest animals, and have other far-reaching effects. Not surprisingly, there is much attention from both road and conservation managers to lessen these impacts, with an emphasis on developing solutions to mitigate the barrier effects of major roads to wildlife movements. However in many anthropogenic landscapes, road corridors can also provide key habitat and connectivity for local biodiversity. In particular, where traffic volumes are low, minor rural roads often provide critical habitat and refuge for many native species in otherwise heavily modified landscapes. Knowledge of the ecology and biodiversity conservation values of minor rural road verges has been underpinned by studies in various contexts, such as sunken roads, field margin and hedgerow networks in much of Europe, to stock routes in Spain and eastern Australia. Despite their different histories and management constructs, important commonalities have been highlighted in terms of their biodiversity values, and the factors which influence these values. As such, minor rural road networks can be vital in providing connected, functioning ecosystems within rural landscapes. The importance of vegetated minor rural road networks will only become more pressing with future climate change. Minor rural roads networks are under

continual pressure from a number of internal (e.g. road development) and external (e.g. adjacent farm inputs) threats. These include grazing by stock, invasive species and pollution from adjacent areas - which require constant vigilance. As human constructions, the key to success in managing roadside environments is in addressing ongoing human impacts. In Australia, a vast network of vegetated road reserves exist, which are corridors of public land set aside in the 19th century for future road transportation needs. In conjunction, Travelling Stock Routes (TSRs) were developed, which are larger vegetated corridors that often form the 'backbone' of these vegetated road networks. Rather fortuitously, the survey of roads and TSRs has resulted in the conservation of extensive tracts of remnant vegetation throughout much of Australia. As such, this infrastructure is one of the most extensive green networks of its kind in the world, possessing important social, aesthetic and cultural heritage values. Road management authorities in Australia are tasked with the dual roles of maintaining road transport needs (i.e. priorities for road maintenance and safety concerns), whilst maintaining the environmental values of roads. In this paper, I will discuss present day challenges and constraints, and the usefulness of the Australian 'model' for developing green infrastructure elsewhere which integrates both transport and biodiversity conservation concerns. Recently, various conservation agencies have developed collaborative partnerships with road managers to better conserve biodiversity in road reserves. Case studies will be presented in conjunction with results of a systematic literature review, to highlight the biodiversity values of minor rural roads.

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## Parallel session 4C

# Biodiversity offsetting in context of the mitigation hierarchy

**Anders Enetjärn**

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Biodiversity offsetting has become a more utilized tool in development projects around the world. Developers are today more often required by authorities to offset residual loss on biodiversity. Biodiversity offsets can be defined as "measurable conservation outcomes of actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken" [1]. There have however been concerns that

biodiversity offsetting will become 'a license to trash nature' and a way for companies to buy themselves free from the damage caused by a development project. Thus, it is crucial that offset is not used before all appropriate prevention and mitigation measures have been taken, that is following all steps in the 'mitigation hierarchy'. The aim of session 4C is to highlight the four different steps of the mitigation hierarchy by using practical examples from different development projects. The main focus during the session will be on road and infrastructure projects, and on methods and metrics used for determination if an offsets is adequate to what is being lost. [1] Source: [http://bbop.forest-trends.org/pages/biodiversity\\_offsets](http://bbop.forest-trends.org/pages/biodiversity_offsets)





## Parallel session 4C

# Mitigation by avoidance in infrastructure planning

**Anders Enetjärn**

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Biodiversity offsetting has become a more utilized tool in development projects around the world and it can be defined as “measurable conservation outcomes of actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken”. There have however been concerns that biodiversity offsetting will become ‘a license to trash nature’ and a way for companies to buy themselves free from the damage caused by a development project. Thus, it is crucial that offset is not used before

all appropriate prevention and mitigation measures have been taken, that is following all four steps in the ‘mitigation hierarchy’, i.e. avoidance, minimization, restoration and offset. The presenters will focus the first step in the mitigation hierarchy, which is “Avoidance”. During the presentation Anders Enetjärn will explain how avoidance has been used in infrastructure planning in northern Sweden. He will share two practical case examples; the first from planning of new infrastructure in Swedish arctic environment and the second from the planning of the large-scale railroad project Botniabanan (Umeå, Västerbotten county). These different examples are both in line with what the EU- commission would call “No Go Areas” and in IENE-context would be so called “roadless areas”.

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## Mitigating large-scale infrastructure impact on reindeers in northern Sweden and on plant diversity along roadsides

**Maria Bergstén**

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Minimization can be defined as “measures taken to reduce the duration, intensity and/or extent of impacts (including direct, indirect and cumulative impacts, as appropriate) that cannot be completely avoided, as far as is practically feasible”[1]. During this part of the workshop we will share two examples of how The Swedish Transport Administration (Trafikverket) have worked with mitigation measures from two infrastructure projects. Maria Bergstén will present experience from a project where Enetjärn Natur has monitored and evaluated the function of overpasses in relation to reindeer husbandry in northern Sweden. The purpose of that project was also to investigate how these overpasses function for other mammals. The Swedish Transport Administration has recently constructed four overpasses to mitigate large-scale impacts that infrastructure can have on reindeers. One of the overpasses is located at Råtsi (Kiruna municipality), two at Sangis (by Haparandabanan and the E4 road) and one at Aitik (Gällivare municipality). To evaluate the function of these, Enetjärn Natur has, on be-

half of The Swedish Transport Administration, performed a field survey during the 2013 winter season. Interviews with reindeer herders have also been conducted as a part of the work. The study is currently being conducted but the report is to be completed in early summer. Maria will during her presentation present the results from the project and share her recommendations for future overpasses in reindeer herding areas. During the presentation we will also share an example of how impacts from road projects can be mitigated by designing roadsides that promote biodiversity. We will share our experience from another project for The Swedish Transport Administration. The purpose of the project was to develop functional requirements for roadsides of a new 20 km long road between Stingtorpet and Tärnsjö in Uppsala County. Roadsides were planned with inspiration from surrounding nature and habitats that are important for many organisms will be created on roadsides. For example the rare plant *Pulsatilla vernalis* grows along the planned road and to mitigate impact from the new road on the plant a habitat that remains of pine heathland will be created along a section. [1] Source: [http://bbop.forest-trends.org/pages/mitigation\\_hierarchy](http://bbop.forest-trends.org/pages/mitigation_hierarchy)

## Parallel session 4C

# Ecological restoration as a part of a road building process

**Astrid Skrindo**

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Worldwide, technical interventions are considered as the greatest threat towards biodiversity. Heavy technical intervention may also, when it involves replanting or reseeding, be a source of genetic contamination. The objective of this presentation is to address that the ecological disadvantages of new roads can be counteracted through ecological restoration. To address the objective, Astrid will during her presentation describe how ecological restoration has been implemented in the road building process of a new road, a part of E10 in Northern Norway (called Lofast II). This is a project that faces considerable environmental and technical challenges since the new road borders a national park, a landscape preservation area and a permanently preserved watercourse. Landscape adjustment of a road construction site involves both landscape shaping and limiting the intervention's adverse ecological effects. One of the tools used, was re-vegetation by germination and sprouting from indigenous topsoil only. No introduction of foreign seeds, fertilizer or plants was made. Natural re-vegetation from

indigenous topsoil is a simple method, which should be the first choice for re-vegetation of road construction sites through rural areas. Methods are however needed to be adjusted to the site-specific conditions. For example, where the ecological factors differ from before the intervention, i.e. close to the road, the area should not be restored to the same ecosystem as the origin but to a new that can cope with the new ecological factors. In areas where the ecological impact has been limited, i.e. for undisturbed ecosystems, the goal of the restoration should be to restore it back to the original ecosystem. Both situations reduce the potential destruction of biodiversity! Astrid will during the presentation describe how the results from the restoration in the Lofast II project show that ecological restoration can help to reduce the impact of large interventions on biodiversity. As an example, this project shows that even if the composition of species will change as a part of the natural succession, just after a couple of seasons the demarcation line between the affected and non-affected areas will be indistinct in several areas. Thus, restoration is an important step of the mitigation hierarchy and this project is a good example of why it should be included in infrastructure projects.

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## Offset - how to balance losses and gains of biodiversity

**Josefin Blanck**

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During the presentation Josefin Blanck will share our experience on developing methods and metrics to determine adequacy of an offset project [1]. We want to engage the audience in a discussion on harmonization and standardization of methods by addressing a number of challenges e.g. related to measuring biodiversity. One of the core principles set by the Business and Biodiversity program (BBOP) is 'No net loss'. The principles states that "an offset should be designed and implemented to achieve measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity[2]. Thus, different quantitative methods are being developed in projects around the world and Enetjärn Natur has during 2013/2014

been involved in a first Swedish pilot project where quantitative methods for calculating losses and gains have been tested and applying an international standard on biodiversity offsetting. In our presentation we will also share our practical experience from various Swedish offset projects, e.g. lessons learned from offsetting impact on biodiversity when building the Botnia railroad through a Natura 2000-area. We will also give a brief outlook on what is happening on biodiversity offsetting internationally both regarding application of offset in specific projects and integration of offset regulations in national laws and international guidelines. [1] An offset can be characterized by management measures, such as restoration of degraded habitat. It can also be in the form of averted risk that is protection of areas where there is imminent or projected loss of biodiversity. [2] [http://bbop.forest-trends.org/documents/files/bbop\\_principles.pdf](http://bbop.forest-trends.org/documents/files/bbop_principles.pdf)



## Parallel session 4C

# A national survey of environmental compensation in infrastructure projects and its implications for policy development

**Jesper Persson**

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Environmental compensation is a series of activities aimed at balancing negative impacts of development projects that remain in the environment after all preventive and corrective measures have been fully implemented. Where compensation measures focus on ecological aspects such as biodiversity, they can be referred to as 'ecological compensation'. Sweden, being a member state of the European Union (EU), must implement compensation under EU directives such as the Habitat Directive. However, like in other countries, implementation is not yet widespread in Sweden, and new practices and guidelines remain to be developed both nationally and at European level. This need is all the more urgent considering that the European Commission estimates that, within the EU, about 100,000 hectares of land is converted from its natural state each year. The aim of this paper is to describe current environmental compensation practices in Swedish road and railway projects and to discuss issues of vital importance to the development of compensation policy, such as what to compensate for, how much, and how. A national survey was performed, for the first time in Sweden, to identify compensation measures in road and railway projects. Data were collected through a national mailing list including 141 officials at county administrative boards (CABs), internal e-mail correspondence within the Swedish Transport Administration and databases of court decisions. The survey focused on formal

compensation measures, i.e. such compensation as is required under the Swedish Environmental Code. In addition, two case studies were carried out to investigate the planning of compensation measures. The results showed that CABs and courts rarely order compensation in infrastructure projects, even though this is possible under Swedish law. Between 2004 and 2012, 37 cases (i.e. permits issued) were found for which compensation was required. Of these, 76% concerned habitat protection (such as small ponds and stone fences) whereas the rest concerned damage to national reserves or Nature 2000 areas. No CAB made use of the possibility to order compensation for non-protected areas. Compensation ratios were never explicitly mentioned in permits, but in practice a ratio of 1:1 was usually applied. The compensation measures typically consisted in recreating the same kind of natural asset that was affected, in a location close to the damaged area. In the two cases studied, the road and railway planning processes were not properly adjusted to integrate compensatory issues, resulting in unnecessary bureaucracy and insufficient co-ordination between different projects, such as between the EIA process and the compensation process, or between closely related sub-projects in the same region. To meet the EU's goal of no net loss of biodiversity, we suggest stricter policy requirements and incentives for voluntary compensation. In line with the goals of Swedish national transport policy and the European Landscape Convention, social and cultural aspects ought to be included, and there should be a shift from a focus on individual projects to a broader planning approach, since this would allow compensatory measures to be taken where they can deliver the greatest environmental benefits.

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## Workshop: Managing Wildlife-Vehicle Accidents in Sweden

**Fredrik Bergh**

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This workshop presents and discusses the work of the Swedish National Council for Wildlife-Vehicle Accidents (Nationella Viltolycksrådet, NVR). The NVR was founded in 2003 in response to the seizure of the road authority to register accidents with wildlife that did not entail human injuries and a growing need to organize the caretaking of wounded animals. However, the first challenge was to establish an organization that, despite being split into 21 county administrations and involves both governmental as private organizations, would operate united and use the same procedures for registering and managing wildlife-vehicle collisions (WVC). The NVR consists today of 16 member organizations, each with special responsibilities for the prevention, registration and management of WVC. The establishment of a hunters' organization that would efficiently and safely take care of the wounded or killed animals proved to be an important obstacles the council had to solve. Through the commitment of the Police and national hunting associations, an effective organization was developed that quickly responds to SOS-emergency calls and provides an important quality control of driver reports, as hunters are obliged to report the exact time and location of the accident, as well as the involved species, sex and age-class. Through this, a reliable and very comprehensive database is developing that shall help in the development of efficient mitigation measures. Today, the NVR faces new challenges, especially related to the prevention of accidents. Further research is needed, but the NVR has yet to establish means to fund relevant projects. In addition, more efforts seem to be necessary to increase awareness among stakeholders and produce a political agenda for the prevention of WVC. With this workshop, we intend to discuss these challenges and learn from experiences in other countries, as well as we want to encourage others to develop similar collaboration for a better management of wildlife-vehicle collisions.

The workshop includes:

- Background of the NVR or why it needed a multi-organisational network to deal with wildlife-vehicle collisions - short presentation by Håkan Karlsson, chairperson of NVR and Chief Constable of Norrbotten county police
- Presentation of the Swedish National Council for Wildlife-Vehicle Accidents – a unique organisation - short presentation by Lars-Erik Nilsson, operative Director of the NVR
- Data management of accident reports and usage in research and prevention approaches - short presentation by Marcus Alsér, CEO Mindbite AB
- Practical experiences with taking care of and hunting of animals wounded in traffic - short presentation by Torkel Norling, Hunters' association of NVR
- Panel discussion

General discussions about:

- Awareness: How do we most efficiently increase awareness and knowledge among car drivers and the general public? Do we need to redesign information campaigns? What are the experiences with civil participation and the role of social media in accident reporting?
- Valuation: How do we convince decision makers and politicians to take WVC more seriously?
- Data: How reliable are police reports? How can we handle uncertainties and knowledge gaps? What are alternative sources on WVC?
- Development: How can we better support and promote the development of cost-efficient mitigation measures?
- Cooperation: What can we learn from other countries – and how can we work together across borders?



## Parallel session 5B

# Understanding roadside salt exposure

**Göran Blomqvist**

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Infrastructure habitats in northern countries, where the roads are chemically anti- or de-iced during winter time, are exposed to salt to different degree during the season, which impose a strain to roadside biota. Knowledge of the ecological vulnerability to salt exposure of different biota is usually based on controlled or semi-controlled laboratory or field experiments. Up to date, knowledge of the roadside exposure patterns is, however, most often based on long term deposition patterns, which show the accumulated exposure, but gives no or little understanding of the temporal variation of the exposure during the season. This is

addressed in this paper by studying the processes responsible for the loss of salt from the road surface (run-off and traffic induced splash and spray) in a high temporal resolution under semi-controlled conditions in a road size scaled field study. A former air-strip in Denmark was prepared with a proper asphalt surface, different salt and weather sensors, and trafficked by different types of cars at different speeds under different weather conditions at the same time as the residual salt on the road surface and the roadside deposition in transects across the road was monitored in a high temporal resolution. The finding is that both run-off and roadside deposition vary greatly with the meteorological conditions which imply that a better understanding of the true salt exposure of infrastructure habitats is possible if using weather, traffic and salting data rather than just accumulated salt deposition profiles.

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## Mitigation measures to enhance the ecological value of strongly human influenced navigable waterways in Flanders (Belgium)

Andy Van Kerckvoorde

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Flanders (northern part of Belgium) has a dense and coherent network of navigable waterways (artificially created canals or canalized rivers). These waterways are mostly strongly human influenced. To facilitate navigation hydromorphological alterations are undertaken. These include (1) channel alteration due to straightening, widening and deepening, (2) artificial bank reinforcement, (3) in channel structures like locks and weirs and (4) water regulation. In addition, moving vessels generate physical waves and currents which increase bank erosion, sediment suspension, turbidity and cause water level fluctuations. As a result, severe impacts on biodiversity along navigable waterways occur originating from habitat losses, fragmentation or unsuitable abiotic condition. On the other hand, especially in highly fragmented landscapes with few or very small semi-natural habitats left, navigable waterway can function as corridor and may serve as habitat or refuge for different species. Through integrated water management, a harmony between the different users and the functions of the waterway is to be found. The presentation offers some examples of ecological mitigation measures concerning aquatic, riparian and embankment habitats associated with navigable waterways realized in Flanders. Mitigation of the aquatic habitat of navigable waterways is considered by promoting hydrological connectivity allowing longi-

tudinal and lateral free migration of aquatic species. Measures may include the construction of a fish bypass to mitigate for negative effects of locks and weirs or free connections with tributaries, historical meanders or constructed side channels. The marginal riparian habitat and its biological functions may be restored or enhanced by ecologically friendly bank stabilization techniques. These techniques use vegetation for bank stabilization and favor a gradual change between aquatic and terrestrial environment. The application of coconut fiber rolls, biodegradable geotextiles, willow spilling, live plantings and the construction of wave- and current-protected shallow water zones are examples of ecologically friendly bank stabilizations. Embankments associated with waterways have an ecological value for semi-natural grassland species. This emphasizes the importance to apply an appropriate ecological management by means of mowing or extensive grazing. In general, ecological management changes the competitive relationships in a vegetation by suppressing productive plant species and favoring small-statured species. Moreover, through repeated mowing with disposal of cutting material, soil nutrient availability is gradually lowered. As a result, ecological management of embankments results in a species rich bank vegetation. Ecological mitigation measures play a role in maintaining and enhancing ecosystem services of navigable waterways. As a consequence, these measures may be necessary to achieve the ecological goals of the European Water Framework Directive and help for an appropriate functioning of navigable waterways in the EU Green Infrastructure.

## Parallel session 5B

# Movement behavior of Montane Akodont near roads: pavement or edge effect?

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Road networks are increasingly expanding worldwide, spreading the subsequent changes to the surrounding landscape and increasing the accessibility and pressure of human activity to undisturbed remote areas. This expansion is being more accelerated in emerging economies where a great part of biodiversity richness is concentrated, such as the Brazilian Atlantic Forest, in Brazil. Roads break apart the habitat and represent an important source of mortality through wildlife–vehicle collisions, while also being responsible for restricting individual movements. Both mortality and movement barrier effects can affect the occupancy, reproduction and survival of species and lead to genetic structuring. Hence, there is an urgent need for studying behavioral responses of individuals to roads, requiring the observation of fine scale movement patterns. Nevertheless, few studies addressed how different individuals respond to road presence, precluding an inference of the road barrier effect at individual and population level. Here we study the movement behavior responses of Montane Akodont (*Akodon montensis*) toward roads. The Akodon is a nocturnal rodent inhabiting semi-deciduous wooded areas with dense vegetation cover nearer the ground. It is thus expected to avoid

open areas, as those resulting from road clear cuttings. The purpose of this study was to test the hypothesis that this small mammal avoids roads independently of type of pavement. We captured individuals in the interior of forest patches and translocated them to the edge, and tracked their movements using spool-and-line techniques. Surveyed patches were bordered with roads with dissimilar design (dirt or paved) but with virtually no traffic disturbance during animal activity. No translocation of individuals was made between roadsides as we didn't know the barrier level and the genetic structure of the populations. Movement behavior was assessed by measuring the path tortuosity, response angles and space use, using individual, population-based and null model analytical approaches. We tracked 50 individuals in a total length of 1892 m, with tracks ranging between 3.8 and 55.8 m (mean  $43.0 \pm 22.9$  m). Overall we recorded no crossings in any of the roads surveyed, or any sign of crossing attempts. Movement behavior analyzes suggest a strong avoidance behavior by the majority of individuals of both sexes. Nevertheless we found no clear patterns distinguishing movement behavior between sites bounded by dirt or paved roads. Our results have a profound implication for road mitigation plans and conservation biology, given the strong barrier effect detected. Moreover, we expect that the impact of the barrier effect in habitat specialists is more exacerbated, calling for urgent measures to restore landscape connectivity across the Brazilian Atlantic Forest. Mitigation measures, including road planning, under passages and traffic volume control are discussed.

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## An artificial canal limits movements and causes a greater genetic divergence than a major road for the threatened western ringtail possum (*Pseudocheirus occidentalis*) in Western Australia: a need for mitigation measures

Kaori Yokochi

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Artificial linear structures can limit movements of wildlife, resulting in reduced genetic diversity within the population and greater genetic divergence between fragmented populations. Detecting these effects is important but our knowledge of impacts of linear structures other than roads, such as artificial canals, is still limited. We aimed to assess the short-term and long-term effects of a major road sealed 50 years ago and an artificial canal built 80 years ago on a threatened arboreal marsupial, the western ringtail possum (*Pseudocheirus occidentalis*) in Western Australia. We radio-tracked 37 possums near the road and canal for three years to monitor their movements. We used twelve microsatellite markers to assess the genetic divergence of possums across the road and canal, using population-level approaches such as FST, and individual-level approaches such as Bayesian cluster analysis, spatial autocorrelation analyzes and pairwise relatedness analysis. No collared possum crossed the road successfully in three years, while two attempted and were killed by cars. One crossed the canal but it was thought to be a rare accident due to severe weather. At the population level, significant genetic divergences were observed on the same and opposite sides of the road, as well as

the same and opposite sides of the canal. Pairwise FST value was the highest between groups that were separated by both the road and canal. At the individual level, three clusters were observed among sampled possums, and individuals on different sides of the canal showed different cluster structures. Results from spatial autocorrelation analyzes showed an evidence of a positive genetic structure among possums for up to 600 m in a continuous habitat; however, results from pairwise relatedness analyzes suggested that individuals separated by the 30 m wide canal was less related compared to those on the same side (Wilcoxon rank-sum test,  $P = 0.002$ ). The relatedness of possums separated by the road was not different from those on the same side ( $P = 0.219$ ). The canal is a physical barrier restricting the movements of possums and driving genetic divergence. Radio-tracking data indicated that the road is also a barrier for possums but it has not had apparent genetic effects on possums possibly because it is newer than the canal. A rope bridge was built over the road in July 2013 to encourage safe crossings by possums, and motion sensor cameras and microchip readers were installed to monitor its use by fauna. Possums are using the bridge regularly at the rate of  $7.2 \pm 0.29$  complete crossings per night. Artificial linear structures other than roads tend to be forgotten or ignored when we assess the barrier effects on wildlife. This study has shown that they can cause greater barrier effects than major roads, and mitigation measures, such as rope bridges, should also be implemented on these structures.

## Parallel session 5B

# Mitigating the impact of noise barriers on reptile populations on rail and road verges

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Hundreds of kilometres of noise screens are being built along the Swiss railway and highway network, impacting important reptile populations that have found refuge on the transportation network verges. In Canton Zürich road and railway verges make for 50 % of the sand lizard populations, so that this problem is of high nature protection relevance. Different mitigation measures have been implemented so as to permit reptiles to cross the barriers and adjust to them. This study examines the success of these measures. The sand lizard (*Lacerta*

*agilis agilis*) was used as a model species to understand the spatial use pattern of verges by reptiles, the barrier effect of noise screens and the impact of construction sites on populations. The success of diverse mitigation measures was examined. Telemetry was used to follow individuals in different situations and understand the spatial patterns. It was shown that the use of gabions to support noise screens, permits the lizards to get through. The potential mobility of the species appeared smaller as expected, putting them to high risk of mortality in the construction phase. The results of the study will provide recommendations on how to improve mitigation. These measures will be integrated in the road and railway standards (noise and green areas). The research also develops efficient methodology for the study of the spatial patterns of reptile populations.

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## Roadkill influence on mammal diversity and sustainable use

**Linas Balčiauskas**

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The aim of this study is to evaluate species composition of mammal roadkills (using Lithuania as a case study), their numbers and roadkill influence on populations. We used long-term official data, as registered by the Lithuanian Police Traffic Supervision Service for 2002–2013, and data collected while driving over 135000 km on the roads in 2002–2014. The number of killed mammals was extrapolated from the roadkill index. The list of roadkilled mammal species totaled 28, two of which were registered exclusively by the police, whilst 12 were species not included in the official police database. Game animals form three groups. In the first group, the influence of roadkills on the population is equal or greater to that of hunting. Within this group, species include raccoon dog (roadkills equal ca. 50–400% of the hunted number), pine and stone martens (roadkills up to 14 times higher than the hunting bag), American mink (up to 4 times), red fox (ca. 15–220%) and badger (roadkills up to 23 times higher than the hunting bag). In the second group, where roadkills are 5 to 50% of the bag size, species include elk (roadkills 16.5–53.6% of the hunting bag in 2004–2012), roe deer (1.2–11.3%) and European hare (insignificant roadkill in 2002–2005 and 2010, but 5.9–66.2%

of the hunting bag in 2005–2012). In the third group, where the roadkill number is less than 5% of the numbers hunted, species include beaver (roadkills 0–0.3%), red deer (0.4–1.2%) and wild boar (0.2–1.4% of the hunting bag in 2002–2012). The numbers of wild boar roadkills are unexpectedly low in comparison to the population size. In 2014, as a preventive measure to reduce the spread of the African swine fever, the government plans to reduce the wild boar population by 90% through intensive hunting. It will be interesting to check the corresponding changes in roadkill numbers. In small game species, such as red squirrel, losses on the roads amounted to several hundred per year and in non-game species, the roadkill influence even higher, for example the number of Eastern European hedgehogs killed on the roads exceeded 100,000 some years. Discussing protected species, the roadkill index indicated that there are 20 to 90 individuals of Eurasian otter killed annually, i.e. 0.7–3.0% of the population. Meanwhile, one Eurasian lynx is known to have been killed on the road in the 10 last years, while three European bison have been killed in the last 10 years. In such examples, the roadkills represent an insignificant portion of the population and do not pose a threat to species conservation. Further investigations into the extent of the otter roadkills are however required, as this species may go unregistered or misidentified. All known otter roadkills occurred on just two roads, and thus the possibility exists that roadkills do actually pose a greater threat.



## Parallel session 5C

# Traffic mortality – a growing threat to wildlife conservation

**Jan Olof Helldin**

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Traffic kills an immense number of animals. Road killed vertebrates sum up to at least half a billion annually in Europe. In Sweden, a country relatively sparse in traffic but rich in wildlife, the corresponding figure may be 20 million. Road kill statistics are generally dominated by the more common species, but at the same time it is well known that some species are more vulnerable due to their behavior or life history. It is therefore important to identify any impact that traffic mortality may have on the population level, and hence on wildlife conservation. However, such studies are surprisingly few. We present recent species-wise figures on traffic killed large and medium-sized mammals in Sweden, and relate these to national population estimates. The comparison reveals that for a handful of species, annual traffic mortality at

national level may presently be a round 10%, and could potentially have population effects. With traffic concentrated in more urbanized areas, the traffic mortality may locally be vastly higher. Moreover, with the steady rise in traffic, the related mortality is expected to increase. We argue that, contrary to general belief in Sweden, traffic mortality is a present and growing threat to mammal conservation, and the field needs to be better acknowledged in wildlife research and management. A fundamental question is whether road mortality is additive or compensatory. With specific examples, we illustrate how this question can be approached by more detailed studies of road killed specimens, such as sex and age distribution, condition, and spatial and seasonal patterns. The results of such studies must be related to a solid understanding of the species' demography and spatial ecology, and hence be included in basic population ecology research, which is currently rarely the case, at least in Sweden.

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## Global impact of roads on carnivores: which species and where?

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Carnivores have life histories that can render them susceptible to roads, such as low population growth rates and great mobility. However, little is known about the effect of roads on population viability. In this study we determined which carnivore species are more affected by roads at the global level, and the spatial match between the number of species affected and road density. We used a reaction-diffusion model describing population dynamics to predict the impact of a road network on a population including the following parameters: dispersal distance, growth rate in favorable natural habitat patches, and growth rate in unfavorable habitats (roads). We applied this approach to 230 carnivore species at a global level. To rank the species most affected by roads we used maximum road density, and the minimum size of the patches between roads, above or below which populations cannot persist. We addressed the following tasks: 1) for each species we computed the maximum road density and the minimum patch size between roads that allow species to occur, using species-specific life histories and road mortality

data; 2) we obtained the road density, and the number and size of the patches between roads that are observed within each species range, by intersecting each species IUCN range map with roads (density) map from openstreetmap; 3) we computed for each species the ratio of maximum to observed road density and the number and area of patches that are bigger than the minimum patch size; 4) we selected the species within the 5% percentile for these quantities as the most affected species. We found that family Ursidae has the highest percentage (43%) of species within the 5% most affected species, followed by family Felidae and family Canidae. We also found that 54% of the most affected species are not threatened by roads according to the IUCN, including 10 species that currently have an IUCN "Least Concern" status. The highest numbers of species affected by roads are found in Europe, North and Central America, South of Asia and China, and central-east Africa. However, while in Europe this high number of species is matched by high road density, this is not necessarily the case in the other regions, indicating that species can be affected even at low road densities. Our approach can be extended to any species for which the necessary life history data can be obtained, and can assist in developing conservation and mitigation measures. Furthermore, it can be applied at different spatial or temporal scales, such as projecting the impact of future road network development.

## Parallel session 5C

# The mortality rate of amphibians killed by motor traffic during their spring migration across the E22 express road between Elbląg and Kaliningrad

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The opening of the Polish-Russian (Kaliningrad Oblast) border to local car traffic in 2013 has caused a rapid increase in traffic volume on the express road E 22 between Elbląg (northern Poland) and Kaliningrad. This was the reason for attempting a preliminary determination of the mortality rate of amphibians on the Polish section of the express road between the town of Elbląg and the border crossing point in Grzechotki (52.5 km). The studies were carried out from April 1-28, 2014. In the early morning hours of each day, road journeys were made first on the southern, and later on the northern side of the studied section of the road. On these trips, dead amphibians were removed from the road and roadside, and their species identified (whenever possible) while the locations of dead animals were recorded by a GPS device. The air temperature and humidity data was also recorded on the roadside. A total of 910 individuals representing various amphibian species were collected in 28 days. On particular days, the amphibian mortality rate fluctuated from

2 – 111 individuals, and was positively correlated with air humidity ( $r=0.87$ ). The average daily rate was 32.5 animals per day. It was not possible to identify the species of more than half of the specimens collected (53.2%; 484 individuals). Among the identified species of amphibians ( $n=426$ ), the Common Toad *Bufo bufo* ( $n=215$ ) predominated, constituting 50.4%. There was also a sizeable number of Common Frogs *Rana temporaria* ( $n=125$ ); 29.3% of the individuals identified. Other species collected were the Green Toad *Bufo viridis* ( $n=25$ ), the Moor Frog *Rana arvalis* ( $n=20$ ), the European Frog *Rana esculenta* ( $n=15$ ), the Marsh Frog *Rana ridibunda* ( $n=15$ ), and the Tree Frog *Hyla arborea* ( $n=11$ ). High concentrations of amphibians killed by cars were found at road locations 30, 41, and 47 kilometers from Elbląg. As many as 61% of all amphibians fell victims to passing cars there. In the studies to be carried out over the next years, the percentage of population numbers of amphibians killed by cars on the studied section of the road during spring and autumn migrations will be calculated. The results of studies conducted in the Niepołomice Forest (southern Poland) indicate that vehicular traffic could be a reason for the decreasing numbers of amphibians in the areas adjacent to roads with high traffic volumes.

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## The effect of major roads on bat activity and diversity, and the effectiveness of current mitigation practice

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It is well known that roads have a significant impact, usually negative, on species and ecosystems. However, despite their protected status in many countries, research into the effects of roads on bats has begun relatively recently. We investigated the effects of major roads on bat activity and diversity using broadband acoustic surveys on walked transects perpendicular to two rural motorways in the UK. Bat activity was recorded at different distances up to 1.6 km from the road. Climatic and habitat variables were also recorded, and the relationships between bat activity and these variables were investigated. Total bat activity, the activity of *Pipistrellus pipistrellus*, (the most abundant species) and the number of species were all positively correlated with distance from the road. Total activity increased more than three-fold between 0-1600 m from the M6 in Cumbria. These effects were found to be consistent over two years, and supported by a second study on the M5 motorway in Somerset. Our results show evidence of a large scale negative impact of roads on bats, with the scale of the impact indicating a barrier effect. To mitigate against these effects and comply with environmental law, many countries install bridges, gantries or underpasses to make roads safe to cross.

However, although bats had been shown to use some of these structures their effectiveness at protecting populations had not been assessed. Three underpasses and four wire bat gantries were investigated in northern England. Echo-location call recordings and observations were used to determine the number of bats using underpasses in preference to crossing the road above, and the height at which bats crossed. At gantries, proximity to the gantry and height of crossing bats were measured. Data were compared to those from adjacent, severed commuting routes that had no crossing structure. At one underpass 96% of bats flew through it in preference to crossing the road. This underpass was located on a pre-construction commuting route that allowed bats to pass without changing flight height or direction. At two underpasses attempts to divert bats from their original commuting routes were unsuccessful and the majority of bats crossed the road at traffic height. Underpasses have the potential to allow bats to cross roads safely if built on pre-construction commuting routes. Bat gantries were ineffective and used by a very small proportion of bats, even up to nine years after construction. Ongoing work will also be discussed, with reference to the species-specific effects of roads on bats, the potential of habitat improvements as a mitigation measure and the use of habitat suitability modelling for decision making in road construction.

## Potholes on the way to effective mitigation measures for bats

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Many bat populations are still fragile and endangered and therefore need special consideration if changes are planned in their habitat. In the European Union these species are legally strictly protected and hence are regularly considered in building projects of linear infrastructure. However, being nocturnal and elusive mammals, bats are quite difficult to investigate and thus research is labor-intensive and expensive as compared to research in other groups. This results in bats often being studied inadequately – e.g. only acoustical methods were used although numerous bat species cannot be measured and identified sufficiently by these measures alone. Also, wrong species identifications occur regularly which easily leads to an under- or overestimation of the extent of required mitigation strategies based on such data. Over the last decades a variety of mitigation strategies have been designed and in careful revisions some of these have been proven to be highly effective. However, the current state of knowledge is often poorly considered when mitigation projects for bats are planned, thus leading to ineffective measures. Given that mitigation measures for transportation infrastructure are usually linked to high costs it is of major importance to implement cost-effective measures. Even a careful conceptual design can lead to difficulties in implementation. Especially if construction consultancy is realized without expert knowledge problems are inevitable. By means of specific examples we show that expert supervision is essential for an effective

implementation. Extensive investigations have shown that the bat species clearly differ in their requirements for effective mitigation strategies. In some of the species we still lack knowledge on their behavior at linear infrastructure and crossing structures. Therefore even a good implementation can lead to problems. We recommend that following a constructive conceptual design and implementation there is a need for rigorous function control and efficiency assessments of the mitigation strategies to be carried out for several years allowing for subsequent corrections, addition of strategies, and their optimization. In addition, changes in the surroundings made by a third party may lead to serious detraction of the measures' functionality. In conclusion, there exist proven solutions to many different functional problems. However, there is a high potential for improvements on all levels. A regular and interdisciplinary exchange between bat experts, planning institutions, construction consultants, and the operators of the respective infrastructure is highly important to include the current state of knowledge and to find common solutions. One essential point is, that the planning authorities confer right to use all relevant data and findings. Collaboration in this context has to happen on the same level based on mutual respect and a common language to foster understanding across disciplines. It is also highly important to make the extensively gathered knowledge promptly accessible for implementation. Especially data for projects paid for by public funds should be readily accessible and preferably published for everyone to benefit from this know-how. We present case studies of potential conflicts between bat conservation and transportation infrastructure with approaches to solve single problems and to minimize impacts of transportation infrastructure on bat populations.



## Costs and effects of deer-train collisions in Sweden

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Train collisions with wildlife, especially moose, rein deer, roe deer and wild boar, have become an increasingly frequent and a well-recognized traffic issue on Swedish railways. Train drivers report several thousand incidents per year and species, yet the actual number is probably substantially larger. Although collisions with wildlife usually impose very little risk for human injuries, new data from the Swedish Railway company (SJ) on train damages and repair costs indicate astonishing corporative expenses, especially with the newer train and engine models for passenger transport. In addition, costs for repairs appear relatively small in comparison to

the consequential costs of train delays and rail traffic disruptions that occur at a much larger scale. Given the strong political incentive in Sweden to promote and extend railway traffic and increase speed and train densities, collisions with wildlife can thus become a significant economic issue that requires expensive mitigation, especially along high-speed railways. We present statistics on the spatial and temporal distribution of deer-train collisions and their immediate economic costs to SJ; and produce case studies to illustrate the consequences to rail traffic at large. We further identify hotspots in collisions and discuss where and whether mitigation may be needed. With these data, we intend to initiate a discussion on animal-safer railways and effective mitigation approaches. We also hope to encourage other train operators elsewhere to follow up more closely on collision reports with wildlife, assuming that the problem might be underestimated as it has been in Sweden before.



## Brown bear (*Ursus arctos*) road mortality data in the Region of West Macedonia, Greece in the framework of development of Hellenic Roadkill Observatory

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The expansion of well-developed and extensive road networks evaluated as basic importance of the modern world and requirement for the economic development of human societies. While the development of these transport infrastructures intersect natural habitats and landscapes, these networks poses a serious threat to wildlife and their natural ecosystems through increased mortality, habitat fragmentation and reduced gene flow between fragmented populations of wildlife. In Greece, habitat fragmentation and wildlife – vehicle collisions first emerged as a conservation threat to local wildlife during the design and construction of the “Egnatia” highway in the middle of the 1990ies. Since then, the Hellenic, environmental, non-governmental organization ARCTUROS, has been taking decisive actions in order to promote an environmentally friendly strategy in the construction and operation of the national road network, while initiating at the same time the first public discussion concerning the impacts of large infrastructure works on natural habitats. Although the final alignment of the Egnatia Highway included important and vital improvements on the mitigation measures of the highway as tunnels, viaducts, underpasses and one green bridge, which finally covered almost 50% of the length of a road section in the main bear habitat in the Regional Unit of Grevena at the Region of West Macedonia, the initial weak

fence lead to a serious bear-vehicle collisions. According the Hellenic Roadkill Observatory designed and established by ARCTUROS (epatap.arcturos.gr), similar problems in the vertical axis of Egnatia Highway in the Regional Unit of Kastoria in the same Region increased the bear road mortality cases to a total number of 36 during the last 5 years (2009-2013). Most of the accidents (n: 22, 61%) were accident on the highways of Egnatia (n: 11) and its vertical axis (n: 11) while the rest (16) were in secondary regional road network. Since 2013 the construction of the new stronger and higher fence by Egnatia Odos S.A. gave positive perspectives as in the sections with the new fence no accidents recorded. The determination of the technical characteristics was a result of a productive cooperation between ARCTUROS, Egnatia Odos S.A and Kallisto NGO based on two parameters: The evaluation of the fence as a basic tool which leads the animals -and especially the bears with their unique morphological characteristics- to the mitigation constructions as tunnels and viaducts, in combination with the experience on the hospitality and management of bears in captivity –ex dancing bears and bears from circuses and zoos- in the Bear Sanctuary of ARCTUROS’ Environmental Centre in Nymfeo of Florina in the Region of West Macedonia. The basic final technical characteristics of the fence include a high of 3 m including an overhang of 0.8 m after the high of 2,2 m with negative angle to stop climbing of the bears and a horizontal mess 1,5 m wide on the ground connected with the vertical one to deter bear digging. The completion of the construction in 2014 will give a more comprehensive and hopefully more effective overview.

## Results from a drivers' questionnaire about wildlife-vehicle accidents in Sweden

**Andreas Seiler**

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Ungulate-vehicle-collisions (UVC) are a well-recognized traffic safety problem in Sweden. Accident reports have been registered by the Police and the Swedish Road Administration since the late 1970-ies, and in 2003, a National Council for Wildlife accidents has been installed to administer accident statistics, manage the tracking of injured animals, and initiate new prevention methods. Since 2010, car drivers are legally obliged to report any traffic incident with ungulates and several other large wildlife species listed in §40 of the Swedish Hunting law. Thousands of kilometers of highways have been fenced by now and much effort is put into information campaigns. Nevertheless, accident reports continue to increase and the societal costs of UVC are rising, estimated to exceed 3 billion SEK per year. There are still significant gaps in knowledge and deficiencies in quality and reliability of official statistics impede the development of more efficient mitigation. One major drawback is that not all accidents are reported to the police and not all reports are filed appropriately. Official data responds thus for an unknown proportion of the true number of accidents that occur. In addition, police reports lack accuracy in crucial information such

as time and place of the accidents. Our study aims at obtaining first-hand complementary data directly from car drivers. Since October 2013, we entertain a wildlife-vehicle accident questionnaire online (<http://www.viltolycksenkaten.se>) that is open to the general public and disseminated via public and social media, information campaigns and through personal invitations. At present, a total of 3670 responses have been collected. The questionnaire will be open until December 2014, and new campaigns are planned for the summer and autumn 2014 to further increase response rates. As for now, most respondents are middle-aged men, driving an average of 20,000 km per year. Most believe to have good or very good knowledge about wildlife and more than 80% consider UVC to impose a significant traffic safety risk in Sweden. Every second respondent has been involved in UVC since 2005 and about one in five respondents did not report the incident to the police. Luckily, most accidents did not produce human injury. The estimated cost for car repairs averaged 15,000 SEK. Most accidents occur on larger country roads, few on motorways, but over 23% are reported to occur on minor roads with only very little traffic. Overall, the present responses are well in concurrence with other data on wildlife-vehicle accidents in Sweden, but they suggest that the proportion of unreported incidents may be at about 20% for all species combined. This figure is essential for the cost-benefit estimation of mitigation measures. We present preliminary findings and discuss their implications for a better accident reporting system and database management.

## Help, where are my trees and shrubs? The 'Green inventory'!

**Sandra Vandewiele**

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**Objectives:** Due to the growing urbanization in Flanders, the importance of public green elements is increasing. A lot of municipalities have a broad network of public green elements such as trees or hedges along roads, small parks, public squares, ... Generally the municipality is also responsible for the management of these green elements. However, a municipality often has no clear overview of which specific green elements are present on their territory. The 'green inventory' is a very useful GIS based online application/database which allows them to develop an overview of their public green elements. The tool also allows to perform queries. This information forms the basis for the management of the municipal green infrastructure and allows to take measures to increase the biodiversity. For example: choosing for plants that are adapted to the abiotic conditions of the region will allow to reduce the use of pesticides. **Methods:** The 'green inventory' allows to mark planted green elements such as tree rows, hedges, solitary trees, herbaceous borders, shrubs, ... on a map. Elements as ponds, benches and litter bins can also be added. Additionally, information regarding the green elements is noted in a database: species, amount, age, condition, tree height, who is taking care of maintenance, how long ago was the last maintenance,

... Through queries, the municipality can get information linked to their management and policy, for example: how many trees are present on the territory, where are the trees that are in an unhealthy condition or that are old and need to be checked for safety, where are trees that have been infected by the oak processionary moth, how many m<sup>2</sup> hedges need to be cut? This can be used to make a work planning or green management plan. By embedding the tool in an online environment, permanent usage is ensured. The province of Antwerp, who has developed the tool, also ensures technical support. By providing a central tool, on a server of the province of Antwerp, problems with individual updates are avoided. Moreover, the tool gives the possibility to the 70 municipalities in the province of Antwerp to all use the same program, which will avoid future problems with compatibility. **Results:** The 'green inventory' GIS-based online tool has been developed. Every municipality in the province of Antwerp can receive free access to the tool. Municipalities now have two options. Either they enter the green elements on their territory in the tool themselves or they ask the province of Antwerp to do the inventory for them. **Conclusions:** The 'green inventory' tool is a very useful instrument for municipalities to get an overview of which planted green elements are present on their territory. It forms a good basis for developing a green management plan for existing and new green elements. This plan allows to create green infrastructure which is 'functional for biodiversity'.

## Abundance of red-listed species in infrastructure habitats – “responsibility species” as a priority-setting tool for transportation agencies’ conservation action

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Road and railroad verges may contribute to nature conservation by providing habitat for many species, but due to limited resources, there is a need to select the most important roads and railroads stretches for adapted management. We explore the “responsibility species” concept as a tool for the Swedish Transport Administration to make this selection. We propose lists of candidate responsibility species based on relative abundance of conservation priority species in the vicinity of roads and railroads, respectively. Abundance data were derived from crowd-sourced species observations. Species with  $\geq 20$  % of observations in infrastructure habitats were included as candidate responsibility species. For roads, 35 species were included in the list, for railroads seven species, with an overlap

of three species between the lists. We analyzed habitat and management requirements of the listed species to try identifying functional groups. Most of the species require open or semi-open habitats, mainly dry grassland or heathland on sandy or limy soil, un-sprayed crop fields, or solitary trees. Host plants or substrates include broom (genus *Genista*), patches of bare soil, and sun exposed wood. Conservation actions prescribed for the species include, i.a. late or irregular mowing, removal of the field layer, planting of host species, protecting and providing particular substrates, and special protection of certain sites. We argue that road and railroad managers are particularly well fitted to conduct most of these actions. We consider the responsibility species concept to be a useful tool for transportation agencies to set priorities for adapted verge management, and discuss the possibility to also identify responsibility habitats or general management measures based on the results.

## Conclusions of new strategies for improved inventories of species-rich roadsides in Southwest Sweden

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In 1995 a project called "species-rich roadsides" was initiated. The aim was to find roadsides with the typical flora found in meadows or pastures and adapt maintenance to benefit them. Some roads were surveyed and appointed as species-rich. However, the surveys were in many cases lacking in both methodology and a deeper knowledge of species. Furthermore, during the following years the project stagnated, with no more than a few re-visits to existing objects. In the western region of Sweden, however, the project was brought to life again in 2007. The condition of existing objects was evaluated and new objects were soon being appointed. By 2010 the ambition was set to inventory all state-owned roads in the region, a goal that will be achieved in 2014. An important part of planning the field work includes collecting suggested areas from NGO:s or private persons, as well as official data of reported red-listed or rare species in the area. This collection of data prior to the field work give a good overview of the valuable areas and the survey can then be directed towards these roads. The field surveys involves examination of roadsides by car, with further inventory by foot if an interesting stretch is found. A list of plant species indicating a specifically valuable habitat is used, all indicator species are also noted. However, the surveys are general and valuable habitats may

be missed or it may be difficult to fully evaluate the value of the road. Therefore, some roads get a more detailed inventory each year, often focusing on insects like butterflies (*Lepidoptera*), wild bees and their relatives (*Aculeata*), since the general surveys are more focused on plants. By 2013 the appointed species-rich roadsides in the western region of Sweden had grown to almost 3.49 % of the total network of state-owned roads in the region, a total of 1880 km roadsides. This compares to 0.6 % in 1995, or 261 km roadsides. The number of species-rich roadsides in the 22 surveyed maintenance areas have generally increased by 10-100 times compared to the original inventories and now numbers 551 objects in total, compared to 178 objects in 1995. This shows how much valuable habitats there are along the road infrastructure in Sweden, contributing to the overall biodiversity in the landscape. To contribute to the national data of red-listed species, all those found in the field surveys and in the detailed inventories, are reported to the Swedish Species Information Centre, Artdatabanken. A detailed inventory in Atradalen, found that 70% of all observations of a mining bee, *Andrena hattorfiana* (NT on the Swedish Red List) in the area was connected to roadsides. This number may well be influenced by the fact that this study was responsible for 50% of all known findings in the area, however this also shows how much surveys of these infrastructural habitats may contribute to the acquisition of species-related data on the whole.



## Potential of linear infrastructures verges for conservation and dispersal of wild pollinators

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Context: There is growing evidence that wild pollinators are declining worldwide, leading several authors to question whether a global pollination crisis is underway. The consequences of such a crisis would be severe due to the importance of animal pollination for many crops and wild plants. Habitat loss and fragmentation due to agriculture intensification and urbanization have been showed to be the major causes of pollinator decline. The areas adjacent to roads, railways or power lines (hereafter "LTI (linear terrestrial infrastructures) verges") are, a priori, subject to less human pressures than urban and intensively cultivated areas. Hence, LTI verges could be « conservative islands » for biodiversity. However their patrimonial benefit for wild pollinators and the potential pollination service offered to the surrounding landscape mosaic by wild pollinators present in verges have not been assessed yet. Main objectives and expected results: The central objective of the project is to improve the knowledge about the role of LTI verges as habitat, source, and support for movement and dispersal towards wild pollinators. In order to study the habitat function of LTI verges, we will sample wild bees and butterflies. Moreover, we will sample flora and seek for nesting sites, to evaluate if feeding and nesting requirement are met for the two pollinator groups in our sites. Then capture-mark-recapture experiments will be performed to better understand the movement

of pollinators within the verges and in the surrounding landscapes (agricultural mosaic). Analyzes will be carried out regarding internal (intrinsic quality of LTI verges) and external (at landscape scale) factors influencing abundance, species richness and composition of species assemblages. The functional relationship between LTI verges and the surrounding landscapes will be analyzed. The project aims at providing, information dealing with operational advises in order to favor pollinators within LTI verges, and recommendations to enhance the source function of verges towards these insects. The feasibility to consider the whole approach in the field, according to the ecological engineering concept will be regarded too. Method and study areas: The study methodology is based first on the identification and selection of a range of study areas corresponding to both so-called favorable and unfavorable verges toward wild pollinators, such verges being located in various landscape mosaic characterized by different agriculture contexts (grassland used as a reference context, oilseed rape production area, fruit tree production area). On such sites the habitat function of verges will be assessed (influence of present and past management practices). The identification of functional relationships between verges and landscape mosaic will let analyzing the source function and its influencing factors. Investigations are scheduled from Brittany to Midi-Pyrénées regions, including diverse biogeographical zones and various LTI types. To achieve this program, the project team is composed of researchers experienced in multi-disciplinary projects and specialized in ecology of wild pollinators, landscape ecology, botany, agronomy, restoration ecology, ecological engineering and conservation applied to land planning, technical and scientific communication.



## Work group for infrastructure grassland management – a cross-disciplinary forum promoting efficient biodiversity conservation in “new” grasslands

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Due to changed land use, grasslands rich in biodiversity are becoming increasingly rare. The present, highly modified landscapes contain many “new” types of grasslands – roadside verges, power line corridors, railway banks and switchyards, airfields, gravel pits, golf courses, public parks, private gardens, and marginal surfaces in industrial areas. Even if many of these strongly anthropogenic grasslands have rather low biodiversity in terms of species, some are habitat for species of conservation concern, and many more could be managed to better promote biodiversity and ecosystem services like pollination. These areas often provide a variety of substrates, soils and structures on a small scale, and moreover, they are distributed over the landscape with a potential to connect remnant patches of agricultural grasslands. Whereas our knowledge of grassland management for

biodiversity derives mainly from studies conducted in grasslands for forage, the new grasslands may require un-conventional forms of management to deliver the desired outcomes. In lack of knowledge, innovative solutions and new research is needed. In order to exchange knowledge and experiences in this field, we established a cross-disciplinary work group, with members from, inter alia, road- and rail-road agencies, the national agricultural board, nature conservation agencies, managers of airports and power lines, the golf sector and academia. The group is regarded by its members as an invaluable forum for discussing practical management issues, monitoring, research, and project cooperation. Our goal is to break down the disciplinary boundaries that are often considered an obstacle for efficient land management, and to highlight how these infrastructure habitats can be a part of a green infrastructure and biodiversity conservation. In this poster, we describe how the collaboration in the group has come so far and what our goals are.

## Infrastructures in arid environments: water cisterns as death traps for amphibians and reptiles in south-western Morocco

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Arid regions are increasingly being anthropogenically altered. In the north-western Sahara, a growing road network facilitates the use of habitats adjacent to roads. In regions where livestock is the traditional and main economic resource, local people are currently building numerous water cisterns for watering livestock, leading to an increase in the extent of pasturing of domestic livestock. Modern cisterns built thanks to the easier transport of materials

through these former roadless areas may attract desert vertebrates and act as death traps for species with already sparse populations in these arid areas. This paper is the first to examine the impact of cisterns as lethal traps for amphibians and reptiles in the Sahara, using a survey of 823 cisterns in south-western Morocco (covering 114 672 km<sup>2</sup>) to identify and quantify species affected. Four amphibians and 35 reptiles were trapped in cisterns, some of which were listed as threatened. At least 459 017 individual amphibians and reptiles were trapped annually within the study area. The low productivity and low population densities of terrestrial vertebrates in this arid region suggest cisterns have a substantial impact upon amphibian and reptile species. As road network and cistern construction are increasing, management actions are required to mitigate this impact on the herpetological community.



## A new highway in Brazilian central west: aspects of Environmental impact assessment to support best project's choice for BR-080/MT construction.

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According to the Brazilian environmental regulations, the Brazilian Institute of Environment and Renewable Natural Resources (Ibama) is responsible for the environmental permits procedures regarding the projects that involves regional or national impact's activities. In 2007, Brazilian Govern initiated the Growth Acceleration program (PAC) which aims to execute major infrastructure projects, like new highways and railways, for instance. Despite the legal assumption, the environmental aspects are not relevant in the decision making process, when it comes to the projects execution. This study aims to evaluate the peculiarities of the environmental permits procedures for construction of federal highway BR-080/MT, to be implanted in a roadless biome's transition area in Brazil's Central West region. The highway section to be built is in a region of Amazonia's, Cerrado's an Pantanal's transition that stands out for having, in the same reminiscent area, forests, savannah and seasonally flooded grassland, which put together particulars rivers, lagoons, and lakes ecosystems. In influence area of the highway to be built, there is a diversity of relevant social-environmental areas, such as Meandros do Araguaia Environmental Protected Area, Quelonios do Araguaia Wildlife Refuge and Pimentel Barbosa Indian Land. This will be a unique case

in which an environmental study is going to support the best choice for an alternative route of a highway project. Due to its magnitude and to the social-environmental aspects involved, this project is featured as a significant environmental impact one, according to the Brazilian laws, which requires the drafting of an Environmental Impact Assessment (EIA) study. To elect the most viable route alternative, environmentally speaking, and to allow the issuance of the permits that follows, the EIA must show the evaluation of environmental impacts and the mitigating or compensatory measurements to be taken, according to the influence area for each alternative. With that objective, Ibama elaborated a reference term which defines the minimal standards to be complied, regarding the physical, biotical and social-economics aspects, including the data collection through all seasons of the year. The best alternative for highway route must be based on the environmental, economical, and technical criteria, for each option pre-defined options, and must overcome the normal analysis made exclusively on cost and extension basis of the highway, which, in this case, may vary from 150 to 800 km. Others criteria should be considered, as the intervention on native vegetation and forest fragments, the social impacts to traditional population and the imminent interference on hydrologic sensibility zone, extremely relevant to the local biota. The EIA must be finished by the end of 2014 and IBAMA expects that this study brings all the socio-environmental variables, which are expected to impact the Project, with a highlight to the protected or sensitive areas, for its best analysis of impacts and mitigation's measures.

## Biodiversity taken into account by a road network manager: a global approach, from diagnosis to continuing education

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The french West Interdepartmental Road Department (DIRO) manages a 1500 km road network, of which 1200 km are dual two-lanes. Mainly located in Brittany, these infrastructures are relatively old and require an upgrade to address today's environmental concerns, especially to integrate the concept of ecological continuums. Aware of the cut-off effect of its network, DIRO has been implementing since 2012 a global approach to rehabilitation of its infrastructures concerning biodiversity and ecological transparency. Actions within this context take various complementary forms that are either raising awareness of the DIRO's personnel or improving the infrastructure by implementing on-site fauna pathways. This approach is based on:

- an agreement with 3 environmental non-profit organizations (Groupe Mammalogique Breton, Mayenne Nature Environnement, Ligue de Protection des Oiseaux) to carry out a diagnosis of the network regarding the cut-off effect for the otter, to provide technical advice while implementing otter pathways and setting up continuing education programs;
- the carrying out, by CEREMA public establishment (Center of study and expertise on risks, environment, mobility and town and country planning) of a study on the environmental redevelopment over the 1500 km long road

network. This work is aiming to define a survey program (278 areas and structures have been diagnosed), and thus a redevelopment program;

- the national and regional stakes concerning the french green and blue infrastructure locally transcribed in the regional plan of ecological coherence (SRCE) are also taken into account;
- the redevelopment of 8 waterway structures in the same catchment area in order to restore the otter continuums. The project intends to test new methods of implementing fauna pathways, like floating benches, and aims to assess their efficiency by a 5 year monitoring;
- implementing a collision survey protocol over the entire network, in order to locate major conflict spots and to improve local and national knowledge of species distribution;
- implementing continuing education programs for DIRO's personnel, involving 4 courses (Biodiversity, Why preserve it?, Fauna recognition, Flora recognition, Biodiversity and natural environments during construction works)

Finally, DIRO's network is also the source of a research project (IFSTTAR – Cerema) on the role of roadside green verges in hosting wild pollinating insects and their contribution to neighboring cultivated fields. Cerema is guaranteeing the coherence of all implemented actions by a permanent consulting assistance to DIRO, on both technical and operational issues. During the french 2012 INTERROUTE convention, the ID-DRIM (Institute of roads, streets and infrastructures for mobility) has awarded to DIRO and its partners, the first prize in the competition « Infrastructures for mobility and biodiversity », for its global approach in favor of biodiversity recovery.

## Institutional framework for integrated research on infrastructures, landscapes and biodiversity

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Policy makers, researchers and practitioners alike seek substantive scientific responses to professional questions, as well as methods to transfer research from lab to land. ITTECOP is a multi-disciplinary research program on infrastructures, landscapes and biodiversity which seeks to attain this goal. The French Ministry for Ecology, Sustainable Development and Energy (MEDDE) created ITTECOP in 2008. ITTECOP is a multi-disciplinary research program that explores infrastructure issues (affecting river, rail, energy and road transport, as well as regional interfaces such as train stations, ports and airports) with respect to landscapes in the regions concerned. This may include spatial and temporal dimensions, regional governance issues or ecological factors. ITTECOP hopes to help develop a lasting research community that evaluates the impacts of land-transport infrastructure (LTI). ITTECOP anticipates public decision-making needs in the fields of infrastructure, landscapes and biodiversity. A community of practice (made up of researchers, professionals and members of NGOs) can contribute to original thinking and support public decision-makers when evaluating LTI impacts. This is being explored in cases involving landscapes and biodiversity. For example, a project named GRAPHAB has developed landscape graphs to evaluate and mitigate the impacts of major transport infrastructure on species. As a decision-making tool, GRAPHAB can be used for decisions involving train lines or the optimization of wildlife localization. Another project, developed in partnership with a local council, helps adapt a road project to

local constraints (landscape, biodiversity and traffic issues). The research answers questions on developing bypasses and motorways in city fringe areas, identifying the requirements for bringing about changes in road manufacturing for fast point-to-point connections, and acquiring knowledge on ecosystems and corridors allowing the movement of plants and animals. ITTECOP is producing a unique research framework focused on founding infrastructures, landscapes and biodiversity projects and building a research community. The ITTECOP program is managed by two authorities: a scientific board and a steering committee. The multidisciplinary scientific board sets scientific guidelines, prepares calls for research proposals, evaluates reports, and carries out program facilitation and promotion actions. The steering committee is in charge of defining the programs' directions and identifying priority research proposals, in addition to taking part in program facilitation, evaluation and optimization actions. It is made up of representatives of the Ministry's decentralized departments and services, and representatives of public and private agencies. Special attention is paid to the scientific facilitation of the program and to optimizing research projects in order to ensure knowledge is transferred to public-policy actors, researchers and practitioners. For this purpose, ITTECOP's first scientific results were published in 2013 and a web documentary released. The programs' challenge is to develop a research production framework in the field of infrastructures, biodiversity and landscape from initial studies to the transfer of knowledge. To better test this experimental structure and develop an international network of researchers and practitioners, the ITTECOP program seeks to amplify international research connectivity.

## Methodology for identifying and assess geo-related ecological and cultural values

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The importance of geology and geomorphology for ecological and cultural values are often overseen in planning, why methodologies for identifying and assessing their value is needed. Therefore, in this study, a methodology is suggested to tackle this problem and to facili-

tate the inclusion and handling of these values in infrastructure planning. The methodology is based on available studies of current and historic maps and surveys in a specific area in Östergötland, Sweden, combined with field studies and basic GIS analysis. The resulting synthesis and analysis highlight a number of different aspects of the interaction between the physical landscape (geology and geomorphology) and infrastructure where conflicts as well as possible benefits are identified.





## On the scales of ecological and environmental impacts on islands

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The scale of disturbances is critical to the prospects of species and humans inhabiting small islands. Smaller islands, due in part to their smaller areas and insularity, can tolerate smaller disturbances than larger islands or continental areas. Likewise, disturbances of a similar scale or magnitude are likely to have different impacts on different sizes of islands. We can predict that the same scale of disturbance is likely to affect more species on small islands than on large islands. This paper addresses how development or disturbance of a scale found on islands may be applied to the impact scale of roads on watersheds. The nature and scale of disturbances (e.g., human development) on islands determines how many people will be affected by the disturbance, which is considered an environmental issue, and how many non-human species will be affected, which is considered an ecological issue. For purposes of this analysis, events affecting the same numbers of human residents or species on different sizes of islands are defined to be the same scale, regardless of the absolute magnitude of the disturbances. The concepts of fractal geometry and species-area relationships are employed to quantify and predict the differences in the scale of impacts of similar disturbances on two different-sized islands. We derived: 1. Differences between islands in the spatial scale of ecological effects. 2. Differences between islands in the temporal scale of ecological effects.

3. Extinction rate on islands. 4. Recolonization rates of an empty habitat on islands. 5. Differences between islands in the scale of environmental effects. The results show substantial differentiation in the scale of impacts of similar disturbances between the two islands and provide a theoretical basis for the difference, or "scale differential". The derivation results are as followings: 1. Since smaller islands have higher species densities, the same size of a disturbance may affect more species on a small island than a large one. 2. In terms of temporal scale, i.e., the speed of recolonization of specific species, the location of an empty habitat is more important than its size. 3. From this research, it is clear that disturbances of the same size on islands of different sizes have different environmental impacts on the islands. The scale differentials should be considered in order to avoid disproportional impacts on island environments. This research has implications for the conservation of ecosystems not just on islands but also in segments of large islands or watersheds. Watersheds that are surrounded by mountains, for example, where there is infrequent movement by animals or plants into or out of the area, can be treated like island ecosystems. It is imperative that pragmatic development scales be developed for small watersheds in order to develop sound EIA or development guidelines and ensure sustainable environments and ecosystems. This research may help residents of watersheds more accurately identify the appropriate scale of development and disturbances such as roads, and plan accordingly, and ensure sustainable environments and ecosystems.

## Genetic Database of Selected Species of Mammals of the Czech Republic

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The aim of project is evaluation of road impact on genetic variability of selected mammals' species population (deer, roe deer, wild boar, fox, badger, hare and moose). During the projects were chosen places, where the population isolation is expected due to high traffic volumes and the absence of wildlife crossing. At these locations we are collecting tissues of hunted animals from local gamekeepers. After collection of a sufficient number of samples the microsatellite DNA analysis will be performed for evaluation of genetic variability and degree of popula-

tion fragmentation. Another goal of the project is to create a genetic database of mammals for keeping records of samples that were collected during this project for further evaluation. At the end of the project the database will be accessible through internet to professional public as a resource for research in the field of road ecology and landscape fragmentation, nature conservation, land use planning and other. The database will be available at [www.genedbase.cz](http://www.genedbase.cz) and [www.genedbase.eu](http://www.genedbase.eu), currently the information about the project is available there. We would like to present the preliminary results of the project – results of microsatellite DNA analysis and draft database design. Research project No.TA02031259 "Creating a genetic database of selected species of mammals in the Czech Republic to be used for sustainable transport development" is supported by the Technology Agency of the Czech Republic.



## Greenbridges as crossovers for bats

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In Baden-Württemberg (southern Germany) we studied 15 crossovers (9 green bridges, 3 tunnels and 3 road bridges). All sites have been investigated four times between May and September 2005. The bats were detected by personal counting on the greenbridges and with automated registration systems at all constructions. We found a higher bat activity on greenbridges than on ordinary road bridges within the same area. Tunnels showed the highest bat activity. Forestry roads don't seem to have had a negative effect on bat activity on the greenbridges as opposed to the activity of many other mammals. Bat activity was not significantly different between the narrow/wide bridges, connectivity/non-connectivity or dense/scat-

tered structures on the bridge. There are broad bridges with dense bushes and a good connection to the surroundings but also a middle sized bridge with scattered distributed bushes and a single line hedgerow and only a one side connection to the surroundings. However, bridges, which were wide, well connected and had a high density of structures on the bridge had the highest bat activity. On the other hand, a wide bridge with scattered bushes and a suboptimal connection to the surroundings showed a much lower bat activity. In contrast to that, a narrow bridge with a good amount of structures on the bridge and well-designed connections had a higher bat activity. The most important factors for a well-built greenbridge seem to be good guiding structures on the bridge and a good connection to the surroundings. An optimal greenbridge should contain at least a double row of hedges and good connections on both sides if an established flight path should be preserved.

## Monitoring the infrastructure transparency for Bats using 3 dimensional Flight Path Tracking

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Due to their position as threatened species, being predators at the top of their food chain and their being an indicator of the efficiency of the green corridors, bats have become increasingly studied within environmental assessments of infrastructure projects. The available ultrasonic call identification solutions are: still expensive; include limited assistance for species identification; and provide basic information of presence / absence. The development of a toolkit designed to redraw in 3D the flight path of any bats encountered is a serious improvement and allows our ecologists to understand both the behaviour of bats, and the efficiency of mitigation measures intended to maintain bat habitat connectivity for road and rail. Egis Environment in association with Cyberio has developed a non-intrusive monitoring toolkit which is essentially a 3D microphone network with a bat call analysis algorithm designed in-house to enable both: species identification and accurate location of each individual echolocation call during flight. The output signals are visualised via a 3D Geographic Information System, within which the infrastructure design can be loaded thus showing bat flight behaviour in relation to built structures. Several sites have been successfully tested including: 1) A ring road underpass bridge in Mâcon (East of France) because of its particular position in a road and rail crossing, near an active green corridor. Several bat flight paths had been recorded under the highway and near the railway, for at least 3 species (*Pipistrellus pipistrellus*, *Eptesicus serotinus*, *Rhi-*

*nolophus ferrumequinum*). These records have shown existing bat flightlines pass through the underpass using a linear line of trees on approach along the railway, up to the bridge piers and under the highway. 2) A bat-bridge located on the top of a motorway cutting in France was recently investigated because it is one of the first ever overpasses of its type designed specifically for bats in Europe. The 3D records have shown numerous flight paths near the bridge entrance, which suggest that the bat-bridge is well positioned within the natural corridor. Flights have been recorded through the smooth and metallic bridge. A second survey is already scheduled for 2014 to investigate further. 3) Logging road in the Forest of Citeaux (East of France) was monitored to improve understanding of the behavior of different bat species. In this 15m corridor of the forest, the system recorded Flight paths of 5 species (*Pipistrellus pipistrellus*, *Eptesicus serotinus*, *Nyctalus leisleri*, *Myotis myotis* et *Myotis nattereri*). These records have demonstrated different patterns of flight, depending on the species: very near the woodland edge or in the open flight, within a 20m range or at the same level as the tree canopy. This system, called Bat 3 Data, is considered by Egis as a landmark in bat species identification and behavior analysis, with ready-to-use applications for infrastructure development projects. We believe that this toolkit will promote better suited eco-design transparency mitigation measures for infrastructure projects, enabling more intelligent positioning of bat-bridges, accurate and easy monitoring of bat flight paths over them, and predictive impact modeling of mitigation structures for numerous designs.

## Monitoring the use of existing crossing structures by mammals along a fenced motorway section in the Swiss lowlands

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In Switzerland, motorways must be fenced for safety reasons to prevent wildlife-vehicle collisions. Wildlife fencing however, worsens the barrier effect and impacts the viability of wildlife populations through fragmentation. The only possibility for mammals to cross fenced motorways is by using various types of existing transversal crossing structures (e.g. culverts, over- and underpasses), including specific wildlife passages. Information on the effectiveness of the costly wildlife-specific passages is widely available as success monitoring is mandatory in Switzerland. There is, however, only little information available for other crossing structures, such as culverts, over- and underpasses for traffic use. Along a 37 kilometer section of the A7 motorway in the Swiss lowland (Canton of Thurgau, North-eastern Switzerland) camera traps were used (automatic cameras triggered by passing animals) to monitor all existing crossing structures. This included 16 culverts, 25 overpasses, 13 underpasses and 3 specific wildlife overpasses. Camera traps were installed on each side of the structure to ensure that a complete crossing of the motorway by individ-

uals was verifiable. Each crossing structure was monitored for 14 days between May 2012 and June 2013. We compared wildlife-vehicle collision locations of the motorway section with our monitoring data to identify points of conflicts. The study showed that 85 % of the 57 monitored crossing structures were used by fox (*Vulpes vulpes*), 30 % by marten (*Martes*), European badger (*Meles meles*) and by roe deer (*Capreolus capreolus*), 20 % by European hare (*Lepus europaeus*), and only three structures were used by wild boar (*Sus scrofa*). Wildlife-specific overpasses had the highest number of species and individuals crossing. Although the motorway is fenced, one badger and two foxes were killed per kilometer and year. Roadkill locations did not allow the identification of points of conflicts as accidents were more or less regularly distributed. Wild boar only used wildlife specific passages. For other species ecological connectivity was a more important criterion than structure type. Structure width, height and use were also identified as the important factors in the crossing structure selection. This study confirms that specifically designed wildlife crossing structures are the most effective measure to overcome the barrier effect of fenced motorways. Additionally, we show that transverse structures are integral in enhancing the permeability of fenced infrastructures.

## New developments in wildlife crossings. Monitoring of an animal-activated electronic wildlife-crossing-system.

**Christian Trothe**

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Landscape dissection, habitat fragmentation and the isolation of populations are well recognized issues in wildlife management, nature conservation and even by road authorities. For decades wildlife crossings such as viaducts or tunnels were the only ones available to restore habitat connectivity. The benefit of those crossings, if build in the right spot, is uncontroversial. However, they are extremely expensive. Also legal requirements often get in the way. If at all possible, wildlife viaducts are erected in the course of the construction of new roads. Animal-activated electronic wildlife-crossing-systems are a relatively new development. These systems detect animals in a defined area at the roadside and will then warn the drivers by lightening up warning signs. There are six of these systems in Germany by now. The first electronic wildlife-crossing-system in northern Germany, located at the federal road B202, was set into operation in September 2011. Existing fences interrupted local and supra-regional game passes and also led to a relocation of the crash

sites to the ends of the fences. To restore habitat connectivity and enhance traffic safety the fences were lengthened and a wildlife-crossing-system with two transition areas was build. Since the initial start-up of the system, both transition areas are monitored permanently using surveillance cameras activated by photoelectric barriers. Also the sensor detections of the system are recorded and can be analyzed. Based on the recordings we are able to determine the species, amount and behavior of the crossing animals, date and time of the crossing and traffic density and speed at the time of the crossing. During the first year of operation (09/2011 - 09/2012) more than 1,700 crossing were recorded. Mainly fallow deer, but also roe deer, fox, hare, badger and wild boar were sighted in video analysis. Only five ungulate-vehicle-collisions occurred during this period within the crossing areas. This is the first wildlife-crossing-system in Germany monitored permanently and for which reliable information about the effectiveness can be provided. For large mammal species electronic wildlife-crossing-systems are a good compromise between habitat connectivity and traffic safety. They are relatively inexpensive, can easily be integrated in existing deer fences and will only warn drivers if there is a real risk that wild animals might be on the road.



## Road ecology in a Neotropical biodiversity hotspot: monitoring effectiveness of wildlife crossings in the Atlantic Forest, Argentina

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In the last decades the increase of transport infrastructure in Latin America represents a serious threat to habitats and species in biodiversity hotspots. Nowadays, new roads break through protected areas and biological corridors, and old dirt roads are being paved, thus decreasing ecological connectivity and increasing wildlife road-kills. Road ecology is an emerging discipline in Latin America and there are only few known cases of mitigation measures designed to minimize the impact of roads on Neotropical wildlife. The subtropical forests of north-eastern Argentina (Misiones Province) are considered one of the major and best connected remnants of the whole Atlantic Forest eco-region, still maintaining viable populations of large mammals. However, paved roads are affecting threatened species as jaguars and tapirs. During the last years, the Road Administration of the Misiones Province showed an increasing commitment about wildlife issues undertaking the construction of the first wildlife passages (underpasses) of Argentina and the first wildlife overpass (ecoduct) of Latin America. The aim of this study was to evaluate how large- and medium-sized mammals use seven wildlife passages on two roads (RP-19 and RN-101) within and around Urugua-í Provincial Park (84,000 ha). The RP-19 cross through the park and have four small underpasses built 20 years ago, whereas RN-101 border the park and have two medium-sized underpasses and one wildlife overpass (40 m width) built in 2008. Wildlife passages were monitored by infrared camera

traps (Reconyx RC600H). One camera was placed inside each underpass while two camera traps were deployed in the overpass due to its larger surface. All cameras operated 24h per day. The overpass was monitored for three years (2011-2013) and underpasses for two years (2012-2013). The mean sampling effort dedicated to each passage was 168 days/year (range: 121-219 days/year). To ensure independence, consecutive photographs of the same species within one hour were excluded. Wildlife Crossing Use Index (WCUI) was defined as the ratio between independent crossing events and sampling effort (camera-days). Until now, 24 species of large- and medium-sized mammals were recorded in the seven wildlife crossings. This represents 83% of all species potentially present in the region. Tapirs, dwarf brockets, red brockets, collared peccaries, pacas, tayras, ocelots, and oncillas were recorded among others. The WCUI in the oldest underpasses of RP-19 were more than sevenfold greater than in RN-101. However, only the wildlife crossings of RN-101 showed an increase in WCUI and in the number of species recorded across years, revealing a process of progressive species adaptation to the structures after its construction. During 2013, some underpasses of RP-19 showed a decrease in WCUI possibly due to management problems, such as excessive water accumulation or anthropogenic disturbances (road maintenance works). These results indicate that wildlife crossings provide safe passage for Neotropical mammals on roads of Misiones. Nonetheless, species like jaguars, pumas, and white-lipped peccaries were not recorded using wildlife crossings yet. Long-term monitoring will allow a better understanding of species adaptation to these structures and will lead to better planning of mitigation measures for Latin American roads.

## Structures to mitigate the habitat fragmentation of the Siberian flying squirrel in Japan

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In Japan, the habitat of the Siberian flying squirrel (*Pteromys volans*) covers multiple land types, including mountainous, residential, and agricultural. However, the flying squirrel's habitat is at risk because of size reduction and isolation through road construction. Habitat fragmentation may lead to the extinction of local populations, because the flying squirrel glides, rather than runs, from tree to tree. The problem of forest fragmentation especially affects the movement of flying squirrels among habitats. Two types of structure were installed at Obihiro in Hokkaido, Japan, in an effort to preserve the corridors used by flying squirrels. Here, we assessed the use of these structures by the squirrels. The two structures were monitored from May 2003 to April 2005. One consisted of two poles erected on opposite sides of a road to allow crossing by gliding. The other was a Japanese larch log installed along a reinforced wall within a road culvert. Use of the poles was monitored by observation with a night-vision camera, and use of the log was monitored by a sensor camera. Use of the poles

was not observed at night. A flying squirrel that was caught in the adjacent forest was released at the pole. It climbed the pole and then glided over the road and reached the other side of the forest in the daytime. A total of 156 photographs were taken of squirrels using the log: 38 in the first year and 118 in the second. The log was used most frequently between March and May and August and November; it was used less often in February, June, and July. The flying squirrels moved with gallop locomotion along the log. The testing of these structures is an important early step in efforts to conserve the corridors used by flying squirrels. The field experiment showed that *Pteromys volans* was able to climb and glide by using poles placed along the roadside, although further studies are required to confirm its use at night. The increase in the number of photographic records of squirrels using the log in the second year suggested that the squirrels became increasingly habituated to log use with time. The seasonal changes in the use of the log suggested that pole use was associated with changes in the activity and reproduction of the flying squirrels. The log was also effective for movement of *P. volans*, but it needed to be monitored at least two years owing to the wide seasonal changes in its use.





# Abstracts: Friday, September 19

## Plenary session

## Parallel sessions

**6A - Communication and public involvement (chair: Tom Langton)**

**6B - De-fragmentation (chair: Marguerite Trocmé)**

**6C - Wildlife movement and connectivity (chair: Daniel Smith)**

**7A - Workshop: Railways and Wildlife (chair: Andreas Seiler)**

**7B - Wildlife passages (chair: Miklós Puky)**

**7C - Planning for better infrastructure (chair: Lennart Folkeson)**

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## Plenary session 3

### Marco Fritz



DG Environment's biodiversity unit, European Commission

Mr. Fritz is bio-geographer working in the European Commission as policy officer within DG Environment's biodiversity unit. He is responsible for shaping the EU strategy on Green Infrastructure. He is also working on the knowledge base data on land use changes, for elaborating policy recommendations on how to secure the sustainable land use within future European policies from the biodiversity and ecosystem point of view.

## Implementation of Green Infrastructure in the EU

Author(s): Marco Fritz

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Marco Fritz will inform on the progress made in developing and applying the Green Infrastructure concept in policies and financing since the adoption of an EU Green Infrastructure strategy

in 2013. More and more Member state authorities, regions and local governments are using Green Infrastructure as a tool to reach multiple targets in economic, social and environmental fields. He will present examples of Green Infrastructure can be financed through the new Multi-Annual Financial Framework of the EU 2014-2020. He will furthermore suggest new ways of implementing the tool in transport and nature policies, inside and outside protected areas.



### Dmitry Kavtaradze



Professor, Head of Management Simulation Laboratory, School of Public Administration, Lomonosov Moscow State University, Russia

Professor Dmitry Kavtaradze participated in IENE from its beginning and was the official IENE delegate in PIARC. He co-authored the "IENE ABC" poster and is now involved in multidisciplinary research on urban ecology (the Ecopolis project) and works also with ecological consulting for animal passages and EcoNet planning. He teaches at several faculties of the MSU and abroad, published several books on environmental issues and interactive methods in modeling and teaching.

## Reducing Decision Making Risks of Highways Projects Design and Implementation in Ecosystems on the base of IT adaptive model and Friendly Interface

Author(s): Dmitry Kavtaradze, Larissa Gagarina, Alexey Mordovin, Yana Teplova, Victoria Kukht-jaeva

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The problems of minimizing different risks (to environment, regional economy, public health, landscapes and infrastructure) all have great importance, but they cannot be solved separately without backside negative effects. For example, minimizing one risk may cause uncontrolled growth in some other ones, and it often is difficult to predict. The second significant problem is that professional groups that are responsible for environment protection, construction, funding and other usually are in competition rather than compromising their business interests. A Cross sectional adaptive management model and friendly user interface for simulations and project testing in dynamics in order to support decision-making in the design of transport infrastructure will be presented. The complex of landscape, infrastructure and biosphere is represented as a dynamic system and the system dynamics approach was chosen for modeling. The aim of decision-making is not only to clarify and evaluate common ecological risks, connected to different types of pollution (including noise and vibration impact), but also to help the maintenance of fauna, flora, biodiversity, ecosystem sustainability, taking into account the nature of animals migration and their specific ecological and ethological characteristics. The main goals of IT adaptive model for project design simulations are the following:

- to reduce integrated ecological risks in the design of transport infrastructure and formalize the problem;
- to find reasonable places for environmental important and eco-engineering objects (passages for animals), environmental monitoring stations for evaluating impact on the environ-

ment (air pollution, infrasound, accidents, etc.) and objects of transport infrastructure.

The following parameters of the system are considered:

1) biological characteristics of two animal species:

- population dynamics;
- population size;
- existing types of natural and artificial landscape;
- preferred habitats;
- migration areas;
- average speed/duration of road-crossing;
- characteristics of the nodal points of pathways crossings;

2) Characteristics of designed highways:

- construction of 1 sq.km of the road cost;
- number of lanes;
- lane width;
- calculated traffic load.

Habitats, migration paths and intersection nodes of migration paths are created randomly, but taking into account already occupied areas, and characteristics of animals. To make next step toward sustainable highways planning special adaptive interface was designed on the "AnyLogic" software platform. Nowadays, it is necessary to refine and extend the model, including factors and landscapes. The use of adaptive models and interfaces can solve the task of integration of different organizations efforts and different economic, environmental and managerial interests of road administration, managers, planners, economists, engineers, insurance companies, local authorities, environmentalists and so on. Demo version of the model will be demonstrated. Authors believe that Green IT technology will be a positive tool in fostering IENE philosophy approach in ecologically based sustainable development of transport communication and ecopolis mode of urbanization.

## Parkways and Landscapes – Critical assessment of the ecological impact of the cultural rhetoric of parkways in North America

Aisling Marie O'Carroll

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The parkway is a well-established road typology in North American culture whose primary purpose is to provide a particular visual experience for the recreational traveler. Intended for sightseeing, parkways are a managed landscape experience - curated to present views of nature, history, geology, and man's use of land. The management strategies for these roads extend beyond the parkway corridor to maintain the desired visual effect along the road and throughout its vistas. By prioritizing a prescribed visual aesthetic, these management strategies consider a limited range of ecological factors and fail to address the extent of complexity inherent in the landscape. Although indicator studies such as debris flow occurrence and shifts in vegetative communities are often executed along parkways, they tend to focus on isolated aspects that consider neither the global context, nor the cultural origin of the landscape conditions. By doing so, large scale ecological processes are not taken into account, hence the flexibility of preservation concepts is restricted. The Blue Ridge Parkway (BRP), which runs 469 miles through the ridges of the Appalachian Mountains, is embedded in a regional rhetoric of heritage tourism and has been idolized as a landmark in American culture since its construction in the mid-20th century. This road, with its surrounding landscape, is well suited for exploring the role that parkways play in formalizing cultural perceptions, and their subsequent impact on short and long-term landscape pro-

cesses. Through the use of archival correspondence, BRP records, written histories, and historic and contemporary photographs and maps, (NC State Archives, BRP Archives, DOT Archives, and others), this study reconstructs a narrative of landscape history. The decision-making outlined by this narrative reveals the economic and strategic motivations behind the foundational and present concept of the parkway and its design, and consequently exposes the artifice behind the parkway's perceived pastoral aesthetic. Furthermore, by analyzing changes in the landscape from Native American prehistory to the contemporary condition, this narrative reveals the role that the cultural rhetoric has played in the physical destabilization of landscape systems and natural processes in the Blue Ridge Mountains. To support this analysis, quantitative indicators of changes in landscape condition are interpreted, with particular attention to the upslope spread of the *Rhododendron maximum* beyond its natural range and its effective impact on average root mass, which has led to decreased slope stability and increased occurrences of surface slumping and debris flows, (NC Geologic Survey, University of North Carolina, and others). These effects are indicative of the imbalance in altered forest composition, in part caused by limited maintenance regimes in parkway landscapes. This study identifies the underestimated effects of cultural heritage on the sustainability of parkways and landscapes, and proposes an alternative conceptual view of the parkway, allowing for greater adaptability of preservation concepts and a new perspective on deeply embedded cultural ideas not yet linked to sustainability.

## Parallel session 6A

# Integrated Landscape Character Assessment ILCA – a methodology for including landscape in long term spatial planning

**Emily Wade**

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Sweden's transport policy targets and Sweden's signing of the European Landscape Convention are important starting points for the research and innovation project Landscape in long term planning that Trafikverket - the Swedish Transport Administration has conducted. These starting points serve as a framework in order to contribute to the furthering of Sweden's environmental quality targets, to the maintenance of attractive landscapes and the facilitation of their development. The authorities have a common responsibility for sustainable development. This presupposes that the landscape can be viewed and treated as a whole. It suggests a shift in the way of thinking, from focusing on protecting designated areas to developing a holistic reasoning. Within the project, Trafikverket has developed a method for LCA on regional scale, drawing partly on experiences from both Norway, Denmark and UK. The ambition is not only to assess landscape for infrastructure planning, but also to merge with strategic resource innovation, environmental management and regional development. The methodology has been developed by a multidisciplinary team of landscape ecologists, historians, landscape architects and planners, working in close contact with regional and local administrations and stakeholders. It has been tested in two regions: Västra Götaland and Västmanland. The method – Integrated Landscape Character Assessment (ILCA) – aims to provide an overall picture of the main features of the landscape, its character, idiosyncrasies and assets. It allows for the analysis

of functional, visual and meaningful elements along with ecological, historical and cultural descriptions of the area. ILCA calls on many individuals of various professional backgrounds collating their information into a collective description of the landscape. How is it experienced today? Why does it look and function as it does today? What character areas can be defined and what distinguishes them? This is done in practice through a series of workshops and field trips, called group landscape observations (befaring), where the planners, project leaders, specialists in nature and heritage conservation, landscape architects, geotechnicians, etc. work together, developing a common understanding of the landscape. Landscapes are not static. Knowledge of the ongoing transformation processes in a landscape, its sensitivity to change and potential in how it could be developed is crucial. Equally important is an understanding of the impact of infrastructures on, and their interaction with, the landscape wherein they lie. And of course the ability to translate that understanding into action when planning, maintaining and developing new infrastructure. The method is transparent and repeatable in that it separates the different aspects of the landscape: character, development trends, sensitivity and potential. Through a system of checklists, anyone with a specific interest can trace the underlying basis for the various definitions, descriptions and evaluations. The identification of character areas has proved to be a useful platform for describing the landscape from different sectors. A properly collated integrated landscape character assessment also allows for the early involvement of those who live and work in the district, which is especially important since the assessment is not limited to merely assessing damage but also entails improving specific environments.

## Perceived landscape values and public participation in a road-planning process in Sweden

**Marianne Henningsson**

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The European Landscape Convention (ELC) underlines the crucial role of people in both the creation and evaluation of landscapes, and indicates that in any assessment of landscapes, not only ecological, but also social dimensions should be taken into account. Road construction usually means changes in the landscape, which affects people's daily life and their well-being. In this study we investigated perceived natural, cultural and social values connected to a highway construction process in a rural area in the South-Central Sweden. A questionnaire was distributed to property owners within an area of 10 km surrounding the road construction. We also analyzed public involvement in the participatory process of the road planning and the relation between the perceived landscape

values and participation. The Theory of Planned Behavior (TPB) was used for analyzing the correlations between attitudes, norms and behavior. The result showed that ecological and cultural values, such as cultivated land, meadows, forest land, paths, old houses, were presumed to be negatively affected due to the road construction, while social values (e.g. a place where I can enjoy, feel good, calm, safe and secure) would be unaffected, according to the respondents. People living within 300 m from the road were more engaged in the participatory process compared to those living further away. Only among those living close, perceived landscape values influenced participation, which suggests that they were more concerned on protecting ecological, cultural and social values in their close neighborhood. To increase public participation, small dialogue meetings with stakeholder groups at the beginning of the planning process are suggested. Large meetings were perceived as ineffective, as usually only a few persons speak at such meetings. It is also suggested that people living within a few hundred meters from the road construction should be treated as key stakeholders in the planning process, as they are most sensitive, aware and prone to be involved in the planning process.



## Parallel session 6A

# Fauna bridges, public emotions and Road Agency communication – lessons learned

**Marianne Lund-Ujvári**

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The objective of this presentation is to present a descriptive case study of the public awareness of two similar road projects in Denmark each with a 50 m wide fauna bridge and to discuss the possible reasons why the two bridges have had very different publicity. Fauna bridge A is situated on the highway no. 9 between Odense and Svendborg on Fynen and have had very negative publicity. Fauna bridge B is situated in central Jutland (highway no. 18) between Vejle and Herning and have had no negative publicity. The fauna bridges were constructed in 2007 and 2006 respectively. The result of the analysis is that the communication approach performed by the road agency might have led to a public misunderstanding reflected in the press. The way the road agency spoke about the fauna bridge seems to be important. The analysis includes questions like: When should a road agency refer to a fauna bridge as a bridge with a multiple target (many species) versus a single target (one species)? Which details about the design and the time scale is important or an advantage to tell the public in order to avoid unrealistic expectations about the efficiency of

the fauna bridge? Which issues are important to take into consideration by the road agency when designing the communication strategy? How does communication needs differ among projects? Which effects did the ongoing discussions among biologists about the suitability for dormouse of the planted vegetation (species, density and maintenance) have on the public opinion? How could the ongoing discussions among biologists about the suitability for dormouse of the planted vegetation have been turned into an advantage for the project not leading to a negative public opinion? How might this negative publicity have been avoided by using an area-oriented approach inviting all parties interested in dormouse to participate in the design of the vegetation from the very beginning? The presentation contributes to infrastructure construction practice as lessons learned in Denmark helps avoiding similar misunderstandings in public awareness leading to bad publicity on similar projects in the future. Communication needs and approaches as well as cooperation between multiple parties interested in the function of the fauna bridge (area-oriented approach) should be taken into serious consideration by Road Agencies at all time when planning and constructing expensive fauna passages.

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## Addressing biodiversity conservation on roads in South Africa

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The Wildlife & Transport program (WTP) been active within southern Africa addressing biodiversity conservation in the rapidly growing, but potentially impactful transport industry. The National Biodiversity Assessment indicated that 34% of South African's 440 terrestrial ecosystems were threatened and of South Africa's 120 rivers, 82% were threatened with 44% being critically endangered and 65% of South Africa's ocean biozones were also threatened. The South African transport sector employs 584 000 people in the formal and informal sectors, representing 4.3% of the active population. In addition, South Africa is estimated to have the world's fifth-largest mining sector in terms of GDP value (accounting for 18%) and accounts for 50% of transportation volume in South Africa, while tourism accounts for 7.9% of GDP and supports one in every 12 jobs in South Africa. These two thriving industries have the potential to place the country's transport network under increasing pressure as well as impacting

biodiversity. The WTP has facilitated the establishment of relevant forums and networks of stakeholders within the transport industry to ensure their effective engagement and involvement in the solutions to possible harmful impacts. This has been in the form of designing a road mitigation handbook for planners and environmental practitioners, and improving existing Environment Impact Assessments (EIAs). The development of a smartphone app (Road Watch) for recording roadkill sightings nationally has contributed towards an understanding of the severity of this threat to our wildlife and will further assist us in developing road sensitivity maps that can be used by road agencies and environmental planners, motivating for mitigation measures where appropriate and, ultimately, reducing the impacts of transport on our wildlife. Our current projects have focused primarily on wildlife outside of protected areas, since traffic volume is higher and impacts are often more visible. Recent reports, in South Africa, from various social media platforms have indicated huge public concern for wildlife being killed on roads in protected areas. Consequently, we are now undertaking an assessment of roadkill rates within selected key protected areas through using social media platforms, citizen science data as well as expert data collection.



## Parallel session 6A

# Progress with Green Infrastructure across the Council of Europe area.

**Tom E.S. Langton**

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The Council of Europe (CoE) based in Strasbourg, France acts as the secretariat of the Bern Convention on the Conservation of European Wildlife and Natural Habitats. It has covered for over 30 years, countries now within the European Union administrative area and with recent expansions, many Eastern European countries. The Bern Convention has a nature reserve recognition system outside the EU territory known as the Emerald Network and through an expert working group, it considers both sites of primary importance and networks for additional activities that are outside formal nature reserves and that relate more to general quality of the environment. Green Infrastructure initiatives across the entire area are required in order to create meaningful wider countryside zones for wildlife community persistence and species dispersal. It is recognized that these are

needed in order to satisfy biodiversity protection, climate change adaptation and water management objectives and other integrated objectives aimed at a more sustainable, cleaner and safer future environment. This will increasingly demand trans-boundary agreements so that countries shared objectives can be met in a holistic pan-European context. Presented here are the experiences from an initial year of investigation into the possibilities and potential for IENE's awareness and education role, across the overlapping EU/CoE area and particularly as a part of the EU Green Infrastructure (GI) strategy, approved in May 2013. Transport Ecology is arguably the most developed sector in GI initiatives and IENE has an important potential function to assist with better integration of policies from other sectors such as agriculture, forestry and water management. An effective over-arching approach to GI is essential so that transport infrastructure measures do not become isolated and neutralized due to land use change patterns on land adjoining transport corridors.

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## Defragmentation of the Belgian Sonian Forest

Anouschka Kuijsters

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The LIFE+ project OZON (= Defragmentation of Sonian Forest) tackles the far-reaching fragmentation of the Sonian Forest. The Ring Road, railway between Brussels and Luxembourg, E411 and secondary roads fragment the forest into isolated patches. About fifty animals are killed each year by the busy traffic in the forest. This was revealed by 4-year monitoring during a previous project 'Dood doet Leven'. Moreover, the construction of a wildlife bridge over the railway and recent studies on the presence of bat species provided a solid and scientific basis for the OZON project. Above, under and along all roads, more than ten wildlife crossings will be constructed between October 2013 and June 2017. These are designed to reconnect parts of the forest, so as to create a larger habitat again for numerous animals. This is good news for endangered species, such as the Daubenton's bat, European pine marten, ground beetle and palmate newt. Objectives: 1) Defragmentation of the Sonian forest: The LIFE+ project OZON aims to reconnect ecological hotspots. Therefore, more than ten wildlife crossings are constructed such as a wildlife bridge, four tree bridges and three wildlife tunnels. Moreover, wildlife fences and warning reflectors will be installed. 2) Safe passage for animals: In addition, the project tackles the existing culverts which date back to the sixties. Most of them are obstructed and need to be cleaned up. By improving the existing construction, small mammals will be able to pass safely. 3) Nature-friendly forest edges: Apart from infrastructural interventions, forest edges and pond complexes are made nature-friendly with additional open areas and

edge vegetation. Moreover, the project examines how recreation can be steered so that animals use the wildlife crossings in all tranquility. Methods: Concrete protection measures:

- Restoring existing culverts and constructing a nature-friendly environment;
- Constructing a wildlife bridge, 3 wildlife tunnels and 4 tree bridges;
- Defragmentation measures under and above secondary roads;
- Installing wildlife fences and warning reflectors;
- Creating additional open areas in forest edges with protective vegetation;
- Steering and clearly demarcating recreational flows.

Monitoring and communication:

- Monitoring the use of all passages;
- Mapping animal species and their evolution;
- Monitoring socio-economic effects;
- Communication through website, information panels, etc.;
- Laymans report and technical publications.

Results: A) Putting an end to fragmentation: The OZON wildlife crossings or habitat corridors are to counter the fragmentation of the Sonian Forest. This will allow isolated animal populations to migrate across the whole forest again. B) A boost for protected animal species: By defragmenting and restoring the habitats in the Sonian Forest, the existing animal species are given every chance to survive. C) Roadkills reduced by 90%: the number of roadkills among migrating forest animals declines by 90%. The idea is to protect existing populations, as well as to reduce the material and human damage. D) Long term investment: Closely involving the public at large in the Sonian Forest and subsequently increasing the respect for this city forest with its European valuable habitats and species.

## The results and lessons after 10 years Long Term De-Fragmentation Program in the Netherlands

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The program: In 2004 the Long Term De-Fragmentation program (MJPO) has been launched by three ministers of the Dutch government and accepted by Parliament. The aim of the program is to solve the problem points in the Dutch National Ecological Network (NEN) caused by existing national infrastructure (roads, railroads and canals). In the program 215 problem points are identified in which 605 provisions have to be realized before 2018. Directly involved are the National Road Administration (Rijkswaterstaat) and the National Rail Administration (ProRail). These organizations are responsible for the work around the infrastructure itself. The program runs with many involved organizations and people. All the 12 provinces are part of the decision making because the realization of the NEN is their task. Area-oriented approach is obligatory in the program. It makes the involvement of the province even more necessary. The NEN and therefore the program are built on the meta-population theory. After 10 years: In 2014, 10 years after starting the program, this paper presents the results in numbers of provisions realized and what will be realized in the coming years. The way of working, the processes and the co-operation related to such a program will be described. The paper will present the benefits and the (sometimes hard) lessons learned. The outcome of the evaluation of several projects will be presented. Regularly the political circumstances ask for other solutions. To continue realization these changes

ask for flexible management and adaptation in procedures of decision-making. Accountability to political levels, decision makers and the public appear to be crucial. The changes in several organizations (task, structure or people) caused changes in levels of awareness. New procedures for tendering ask more reliable risk systems in the way of working of the contractor. Contractors, project and program management had to learn to act with that (see paper Victor Loehr). Good communication inside and between the involved organizations and with the decision makers, the press and the public help the continuity of the involvement at the long run. Knowledge: The start of the program was just after the closing seminar of the COST 341 project (Brussel 2003) in which the European Handbook Wildlife and Traffic was presented. This knowledge was very useful especially because the handbook could be translated to the Dutch circumstances. The (inter) national knowledge-networks increased the theoretical and practical knowledge, needed in the program. This was necessary to improve the designs regarding the changes in circumstances. The need to realize solutions forced all kind of innovations and research. After the first deliverables of the program monitoring for the use of the provisions started. This was not enough more questions came up. The most urgent were around effectiveness and efficiency of the provisions. Where ecoducts were built logically requests for co-use by recreational passages came up. Immediately walkers, hikers, bikers and horse riders asked for permanent co-use. That was reason for political discussions, decisions and more fundamental research about the impact. The paper presents the variety of answers given at some questions.

## A life cycle approach to defragmentation

**Marguerite Trocmé**

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A new Swiss guideline to fauna passages examines defragmentation measures throughout the road infrastructure life cycle. For each phase of the life cycle, a specific mitigation and defragmentation strategy is described, with a checklist of aspects that must be addressed by engineers and biologists. When planning new roads, the avoidance of new fragmentation of natural habitats is prioritized. The new alignment should strive for good landscape permeability by maximizing the possible multi-use of structures, such as culverts, bridges and viaducts. Where wildlife corridors are crossed fauna specific passages are required. When widening existing roads, present fragmentation should be reduced. A portfolio of measures is suggested, from structure adaptation enhancing joint use by fauna, to fauna specific passages to mitigate wildlife corridors. Most road projects concern maintenance programs of the existing net-

work. For maintenance projects it is required that all fauna relevant structures be examined and where pertinent adapted to improve their joint use by fauna. Culverts are to be optimized to allow aquatic ecosystem continuity and where necessary dry ledges be added. Where wildlife corridors of supra-regional importance are impacted by the existing highway, a wildlife specific passage is to be planned as remediation. A nationwide survey in the 1990's identified 51 conflict points. More than an a half have been remediated. The importance of coordinating mitigation measures with local authorities to ensure the long term ecological continuity through appropriate spatial planning is stressed. A databank has been developed to facilitate the maintenance of all road structures. In addition to the guideline, the relevance for fauna of all crossing structures has been analyzed and identified. By ensuring the proper identification of joint-use passages and fauna specific passages, the long term upkeep of the passages can be guaranteed and misuse better avoided. The databank provides the necessary information for a defragmentation strategy covering the life cycle of the road infrastructure.



## Parallel session 6B

# Integrating decision planning tools into road mitigation planning for small and large animals in Ontario, Canada

**Kari E. Gunson**

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In the 1990's the Europeans developed a comprehensive system of integrating the environment with transportation planning at the national and Pan-European level by identifying conflicts between linear infrastructure and ecological networks. In the last ten years, the United States has followed suit with an explosion of statewide maps that integrate ecological and transportation networks and subsequent systems developed to prioritize locations for road-wildlife mitigation. In Canada, no similar approach has been initiated until the development of a Wildlife Mitigation Strategy (WMS) led by the Ontario Ministry of Transportation (MTO) and described below. The main objective of the strategy is to integrate available data, expertise and tools, into a first generation framework that will define where road mitigation should be prioritized for both large and small animals in the provincial road network. Components include processes to define road mortality hotspots (decision tools), evaluation of wildlife habitat awareness (WHA) signs, and a review of tools used for data collection and management, as well as public awareness strategies. The strategy targets data sharing and knowledge transfer among engineers, and transportation and environmental planners with the MTO, as well as biologists, and analysts with the Ministry of Natural Resources. The development of the strategy is a timely, and proactive step towards implementing recovery strategies that meet both road safety and conservation policies in the province. Animals targeted include Species at

Risk (SAR) turtles, snakes, small mammals, and birds that are protected under the Endangered Species Act (2007) as well as large animals, e.g. moose, deer, and black bears that pose a safety issue. The first iteration of the strategy is complete, and key components include a small and large animal decision tool (supplementary flow chart submitted). The large animal tool details where high risk collision zones occur along provincial roads using Ontario Provincial Police crash data and includes metrics such as proportion of wildlife vehicle collisions, and crash severity. The small animal tool focused on habitat models that predicts where road mortality will occur for habitat specialists, e.g. Blanding's turtle, Foxsnakes, and Massasauga rattlesnakes and includes integration of Circuitscape modelling tools and effective mesh size. Essential components were synthesized to provide recommendations for a clearing-house of data and resources for improved research and informed transportation planning. In addition, evaluation of WHA signs is underway at six hotspots prioritized from hotspot mapping and will include on-road monitoring for snakes and turtles, traffic speed studies and motorist surveys. Probably the most significant achievement is the integration of the decision tools into mainstream web-based transportation mapping interface developed by the MTO that can be easily accessed by staff at their desktop. It is anticipated that the strategy will lay the groundwork for continued collaborations to fill in knowledge gaps due to data accessibility, and completeness. In addition, collaboration among municipal and provincial transportation jurisdictions is essential to ensure placement of effective mitigation strategies across a dense road network.

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## Green infrastructure: from policy to tailor-made action!

**Sandra Vandewiele**

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**Objectives:** The project 'biodiversity landscape images' intends 1. to facilitate the establishment of more high-quality green infrastructure and 2. to improve existing green infrastructure in order to come to functional green infrastructure networks in the landscapes outside nature reserves. These areas include industrial areas, agricultural landscapes, transport infrastructure, land property of a local government, private gardens ... The 'biodiversity landscape images' are used to communicate a landscape-scale vision on green infrastructure. Meetings are organized to build networks between the numerous stakeholders that are working on biodiversity in these areas and to stimulate cooperation between different sectors when planning or executing a project. **Methods:** The province of Antwerp (Belgium, 2867 km<sup>2</sup>) was divided into 19 regions. For each of these regions a vision on green infrastructure was developed. To come to this vision, consultants analyzed the characteristics of the landscape of each region as well as the plant and animal species that use the landscape in this region to feed, to breed, ... These landscape characteristics and the ecological needs the species have regarding green infrastructure, formed the basis to determine the measures that need to be taken in each region to increase biodiversity. Local stakeholders are brought together through local meetings. They are the necessary partners to translate the vision of the 'biodiversity landscape images' to the local level. The meetings form the bridge

between policy and practice and initiate tailor-made plans and ideas. Results: 19 'biodiversity landscape images' have been completed and a first local meeting was organized. Different projects have been initiated since then:

- A GIS-based online application/database was developed for municipalities. With this application, they can make an inventory of the green, planted elements on their territory (trees along roads, plants around buildings ...) . Knowing which kind of green infrastructure is present is an important first step in the process of improving existing green infrastructure.
- A project on tree bridges for squirrels and pine martin was initiated. Based on an analysis of dangerous roads (animal traffic victims) municipalities were contacted to look at the possibility to install tree bridges.
- One of our partners will develop a vision for several pieces of land owned by the railway company. These lands are located alongside the high speed rail, in an area from the city of Antwerp to the border with the Netherlands. They are situated outside the safety perimeter of the railroad. They could be used for forest compensation projects, bicycle roads, habitat restoration... The 'biodiversity landscape images' will form a good basis to look at the different possibilities regarding green infrastructure for these lands.

**Conclusions:** The 'biodiversity landscape images' give a vision on green infrastructure outside nature areas. Investing in a network of stakeholders from different sectors that work together to realize this vision is of the utmost importance. Green infrastructure should be taken into account starting from the planning process to ensure that functional networks are maintained/developed.



## Parallel session 3B

# Wetland fragmentation due to the road construction

Isin Barut

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Tuzla wetland, as one of the most important bird area in Turkey, is heavily suffering from road constructions and urban settlement because of the noise, air/water pollution and lost ecological connections. There is a highway and secondary road that fragment the wetland and disturb the special habitat types. This cause a significant decrease especially on the amount of migratory birds. This research is the first to try to understand fragmentation due to the road construction in Tuzla wetland. Our objective is to create a smart landscape plan for better distributed land uses around wetland and for better landscape protection in the wetland by zoning approach. We strongly offer to remove the secondary road from the wetland and to change the direction of the highway to the out of the wetland boundary and to create a noise band by local trees nearby it. This will ease the

negative effects of roads such as habitat mortality, noise and more. The method is first to analyze the fragmentation effects in the case study area and to designate the most vulnerable spots. Than depending on the surveys, SWOT analyzes, expert's opinions and mapping results to create the landscape plan. This plan will include the detailed solutions about the phenomenon of creating balance between land uses and protection issues and further involve some ecological design solutions. Materials are the 1/25.000 scale topographic maps, satellite images, shp. files to use in ArcGIS software, google earth maps and photographs taken as the field survey. The results indicate that by better and smart land management the area can be more livable for natural habitat, locals and future generations. The transportation alternatives can be created but the ecosystem alternatives cannot be created with the same quality from the beginning. To change the direction of highway in the case study area does not damage the people's life but can seriously help natural habitat to survive and live in a better coherent landscape.

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## Using multiple research methods to understand movement patterns and choices in road crossing locations by black bears for mitigation planning

**Daniel J Smith**

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The greater Ocala National Forest area is approximately 2,000 km<sup>2</sup> and provides habitat for the largest population (approx. 1,225) of black bears in Florida, USA. Vehicle collisions are the primary mortality threat to the population (i.e., on avg. about 80 bears killed per year over the last 10 yrs.). Current plans to construct a multi-lane road expansion through the heart of the forest may result in significant additional impacts including fragmentation of the population. It is widely recognized by biologists that crossing structures are often needed to allow wildlife to successfully cross highways and maintain connectivity and gene flow within and among populations. The effectiveness of wildlife crossing structures is dependent upon location, adjacent suitable habitat, structure design, and the use of fencing adjacent to the crossings. It is essential that planners identify where wildlife are most likely to cross roads so that costs can be minimized and mitigation measures are best employed in the reduction of collisions and population bisection. A number of studies have discussed methods for determining appropriate locations for crossing structures. For example, GIS-based habitat models

for species of interest, data on roadkill locations, radio telemetry, remote camera photos, known migratory paths of animals, and animal sign such as tracks, can identify useful sites for highway crossing structures. Using multiple methods and data types provides an advantage over one-single method or data source in improving accuracy of the results. We will present results from a recent study and previous work that used road-kill and track surveys, telemetry, genetics and landscape analysis to identify and evaluate black bear habitat use, preferred movement pathways and highway crossing locations. This project emphasized the importance of collecting and analyzing coarse and fine scale data for more precise mitigation planning including pinpointing locations for mitigation. These studies are critical to maintaining or improving landscape integrity and the continuity of wildlife populations bisected by roads and other linear infrastructure. In this case, we were able to introduce more accurate recommendations into the highway planning process on mitigation needs for black bears, thus saving public expenditures and improving the potential performance of the mitigation. The results from these studies have been extrapolated throughout the length of the highway corridor (approx. 90 km). While some highway segments have already been constructed, others are in different stages of the planning process.

## Parallel session 6C

# Identifying the optimal locations for new habitat creation in ecological compensation

Céline Clauzel

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**Objective:** In France, as in other European countries, transport infrastructure projects must include ecological compensation to offset their negative impacts on the environment. These measures often involve the creation of new habitat patches to replace those destroyed by the construction of the infrastructure. But how do we know where these new habitat patches should be placed? Currently, landscape managers lack guidance for answering this question. An empirical approach based on experts' opinions is often used because they have specific knowledge of the field and of local ecological processes. But for animal populations living in fragmented habitats and which are highly dependent on fluxes between patches, the search for such locations must include regional-scale connectivity in order to maintain their viability. In this case, the empirical approach may be difficult to set up for a large study area because it requires huge amounts of data. **Method:** We propose to set up a systematic and cumulative protocol for adding new habitat patches using graph modelling. A graph is a set of nodes corresponding to habitat patches potentially connected by links representing the functional connectivity between each pair of nodes. Experiments have shown that landscape graphs provide a simplified and relevant representation of ecological networks. The process begins by the creation of a graph, representing the ecological network of a given species and inte-

grating barrier effect induced by the presence of the infrastructure. Within this graph, a search algorithm tests successive locations for adding new patches and connectivity is compared before and after the virtual addition of each new patch. The location that increases connectivity most is identified. This algorithm is then repeated until the desired number of patches is reached by including elements already added at each step. This analysis is applied to a pond network in eastern France using Graphab 1.2 software (<http://thema.univ-fcomte.fr/productions/graphab/en-home.html>). The 53 km<sup>2</sup> zone is considered strategic for amphibian conservation. Since December 2011, the area has been crossed by a high-speed railway line (Rhine-Rhône TGV), which is supposed to act as a barrier to wildlife movements, especially amphibians. In order to reduce the barrier effect, several wildlife-crossings were built and several habitat restoration measures implemented during construction. The creation of several new ponds is planned in 2014 to maintain the viability of amphibian populations. Locations for new habitat patches identified by our method could be thus compared with those suggested by naturalists. **Results and conclusion:** The results show that the locations identified by our method increase connectivity more than locations suggested by naturalists. This patch addition method provides information about strategic areas and also about the number of new habitat patches to be created to reach a given improvement threshold of network quality, e.g. the initial state of connectivity before the implementation of the infrastructure. This approach appears to be a useful tool to guide ecological compensation measures, like habitat creation, in the field.

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## Does daily movements can predict the genetic structure of small mammal populations?

Clara Grilo

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Roads can constrain movements of individuals and consequently gene flow across landscape. There is a consensus among experts that some species show road surface and width avoidance behavior. However, little attention has been paid on how spatial behavior can be translated into mortality risk and population genetic structure. With this study we examine the strength of the barrier effects of different roads types (4-lane highway, 2-lane paved road and unpaved road) on three rodent species with varying life-history traits: water vole *Arvicola sapidus*, pine vole *Microtus duodecimcostatus* and algerian mouse *Mus spretus*. More specifically, we address 1) the influence of traffic on individual movements, 2) the effect of road type (width/pavement) on crossing rates, 3) the annual risk of mortality and 4) the genetic structure of populations on both sides of the different roads. A total of 79 voles were caught in the vicinity of roads and 6481 locations were recorded through radio tracking. We used generalized linear mixed models to evaluate the effect of traffic on individual movements, compared ob-

served crossing rates with simulations without roads, and used the information of number of crossings per individual and the probability of being killed while crossing a road to estimate the annual mortality risk. We also obtained 200 tissue samples for pine vole and Algerian mouse and estimate the genetic differentiation (FST) among groups of samples on both sides of roads. As expected, paved roads function as artificial territorial boundaries for the three species. Traffic intensity had only negative influence on water vole movements. Crossing rates decrease as the road width increase and paved roads have a negative effect on individual's crossings, except for pine vole that had the highest crossing rate, and the 2-lane highway show a neutral effect. The likelihood of being killed during a crossing event at high traffic highway segments for pine vole and Algerian mouse at 4-lan highways were 0.22 and 0.05, respectively. Unexpectedly, pine vole populations show genetic structure at 4-lane highways while Algerian mouse populations did not show significant genetic structure for all type of roads. Our study shows that daily movement patterns of small mammals towards roads cannot be translated on dispersal and gene flow. Further information is needed to understand the implications of mortality risk in the viability of pine vole population occurring in the vicinity of heavy traffic roads. We recommend that only complementary studies of spatial behavior, population density and genetics may explain the mechanisms underlying the barrier effect of roads on wildlife.

## Parallel session 6C

# Using Circuit Theory to Rewire Roads for Wildlife

**Kerry Nicholson**

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Anticipated population growth and ongoing road improvements, coupled with resounding concern for maintaining landscape connectivity for wildlife populations has generated increasing interest in developing wildlife infrastructure crossing management tools. Yet, currently there is limited technical guidance or decision-support tools on evaluating the impact of implemented wildlife mitigation measures on region wide scale. Procedures for mapping connectivity across large areas such as state wide, provinces or ecoregions are limited and are still under development. Highway E20 in southwestern Sweden is being upgraded to a higher standard, involving a widening of the road, increased vehicle speed and fencing for human safety. Our study provides a method to describe the

ecological flow in the landscape and the effect of wildlife passages to increase the connectivity for ungulates and large carnivores. We evaluated connectivity using Circuitscape; a program that measures the electrical current or the theoretical ecological flow in the landscape for ungulates and large carnivores as model species groups. We evaluated the connectivity by creating an "idealized" resistance landscape one in which major infrastructure (i.e., highways like the E20) did not exist and would not impede animal movement. Next, we incorporated infrastructure with proposed wildlife friendly passages. With this tool, we were able to identify geographical boundaries along highway where it may be desirable and effective to implement mitigation measures for wildlife. We were able to assess the distance in which a particular wildlife passages affected the ecological current. The use of Circuitscape is an effective tool to visualize landscape patterns and ecological flow for a variety of different species groups. However, the method needs further evaluation for a network connectivity planning.

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## Integrating landscape connectivity analyses into the decision making process of linear infrastructure track location

**Xavier Girardet**

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**Objective:** Before the final decision for the construction of new infrastructure, several tracks are proposed. The locations of these tracks are based primarily on economic considerations and technical criteria depending on the topography of the area. However, ecological networks and the impact of each scenario can lead to habitat connectivity issues missing to decision-making. Here, the methodology proposed aims to evaluate each scenario based on the potential impact they induce on the connectivity of an ecological network. **Method:** To model the ecological network of several species, two landscape graphs are constructed depending on (1) the minimum required habitat patch area and (2) the maximum dispersal distance. These two graphs represent the ecological networks of two species profiles living in forested areas. To assess the impact of each track on the connectivity of each landscape graph, we construct nine landscape maps; each of them includes one potential track. From each landscape map, we construct two graphs (one for

each species profile) leading to the construction of eighteen landscape graphs. Each of these graphs is intersected by one track scenario, and all transportation infrastructures are set as barriers. By calculating the rate of change of a global connectivity metric (the Probability of Connectivity) for each scenario, we are able to rank each track from the less impacting to the most impacting one on the two profiles of species. The methodological approach is applied in France in the Bresse lowland where is planned a TGV line from the town of Dole to the north of Lyon. Here, nine tracks were proposed. **Results and conclusion:** Results show that the less impacting track on the ecological network of forest is located near a highway in the north of the study area and completely in the west of the study area for the second part of the track. According to the model, the planned project by the infrastructure manager, the nearest track to the existing highway, is not the less impacting one. In order to precise these results, the methodology is applied with other types of habitat, as open area and wetlands. This methodological framework could be useful to locate the less impacting track scenario on the ecological network of several species and best support decision-making in the mitigation process of linear infrastructures.



## A unifying framework to define and identify movement corridors and barriers using Step Selection Functions and Randomized Shortest Paths

Manuela Panzacchi

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1. Hands-on and analytical tools to identify animal movement corridors are proliferating due to concomitant increases in conservation demand and in the availability of high-resolution movement- and environmental data. However, advances in theoretical and applied corridor sciences are hampered by the lack of empirical support and a unifying conceptual framework. 2. We attempt to fill this gap as follows. First, we review use of the terms “corridors” and “barriers”, and propose a framework to define, classify, and unite these interdependent concepts at multiple scales. Second, we perform a cross-disciplinary review of analytical tools and propose a novel, comprehensive, scale-invariant approach for predicting simultaneously corridors and barriers using high-resolution animal movement data. We illustrate this approach by identifying migration corridors and barriers for GPS-monitored wild reindeer (*Rangifer t. tarandus*) migrating between summer and winter ranges in Norway. 3. First, we identified Functional Areas to be connected. Then, using Step Selection Function we quantified the degree to which each landscape feature could be traversed by

a step, and we predicted a tactic-movement friction-map illustrating the degree to which each resource unit (pixels) impeded or facilitated movements. We applied to this map a novel algorithm - Randomized Shortest Path, RSP - to predict landscape regions allowing (corridors) or impeding (impermeable barriers) strategic-movement flow between Functional Areas. Altering the parameter  $\theta$  allows predicting RSPs based on different degrees of randomness in movements, and validation against observed data (represented by Brownian Bridge Movement Models) allows predicting the RSP more closely representing the observed animal movement strategies. 4. RSP bridges the gap between the unrealistic assumptions of optimization- (e.g. Least Cost Path) and random walk-based approaches (e.g. Current Flow Models) to identify corridors, thus providing realistic representations of movement paths. Reindeer overall migratory movements were neither fully optimized nor random, but the degree of randomness increased when approaching the disturbance associated to a road intersecting migration routes. 5. By visualizing different strategic-movements' options, the model output suggests a wide range of mitigation opportunities, ranging from restoration of vulnerable pinchpoints, to proactive protection of wide corridors, to obstruction of dispersal routes for invasive species and disease vectors.

## Workshop: Railways and wildlife - conflicts and solutions

*Wildlife-train collisions are an overlooked problem causing high corporative and societal costs and a potential threat to traffic safety! This workshop shall help to establish an international working group that can act for better knowledge and effective mitigation of wildlife and railways.*

### Moderator: Andreas Seiler

Contact: Andreas Seiler, Swedish University of Agricultural Sciences, Dep. of Ecology, Grimsö Wildlife Research Station, email: andreas.seiler@slu.se

### Panel:

Mattias Olsson (research, SE): What is known about train and wildlife accidents? How are they perceived and studied?

Ulrika Lundin (government, SE): How are wildlife-train collisions dealt with in Sweden?

Pär Söderström (train operator, SE): Consequences of wildlife-train collisions to corporate economy and traffic flow?

Michael Below (railway agency, DE): (High speed) railway network - Regulations in Germany concerning collisions incidents

Marina Stanimirov (railway authority, NO): About train-deer collisions and mitigation approaches in Norway

### Abstract:

Collisions with wildlife have become an increasingly frequent and recognized issue on Swedish railways. Train drivers report several thousand incidents per year and new statistics suggest astonishing economic costs and traffic safety effects. We fear that wildlife-train incidents may have been largely underestimated in Europe, partly because train operators and railway providers may deliberately ignore wildlife or lack appropriate data to identify wildlife related costs.

With this workshop, we intend to put a head-light on wildlife and railway traffic. We present statistics on train-deer collisions from Sweden, indicate direct corporative costs and illustrate their large-scale effects on traffic flow. Together with the panel and the audience, we collect comparable data from other countries and discuss the implications for counteractive measures. We also discuss requirements on new research and experiments. Above all, we intend to initiate an IENE working group on Wildlife and Railways that helps in compiling and discussing new empirical data and act towards other organizations such as the UIC.

### Discussion:

The following questions have been asked online prior to the conference (sent to the IENE members list and to registered participants) and also during the workshop. The online survey received 23 responses.

- How are wildlife-train collisions perceived and valued in your country?

*Wildlife-train collisions are generally perceived as of little significance, but some countries report a growing awareness. Wildlife receives thus typically rather little concern in rail planning, albeit when species or areas are affected that protected by the EU Birds- and Habitat Directives. In The Netherlands, Sweden and Estonia, rail and road casualties are treated rather similarly. In Estonia, as well as in France, governmental agencies and private companies have started to pay a growing attention to collisions with wildlife, especially in concern for high-speed railway projects.*

- What statistics are available on wildlife-train incidents at national or corporate level?

*Only a few countries appear to have records on wildlife-train collisions, yet of varying or uncertain quality. In Sweden and Estonia, drivers are obliged to report any incidents with large game species. Also in Norway and Spain, records of collisions with larger wildlife are kept. In Hungary, records exist at corporate level. In Germany, special concern seems to be paid to birds of prey and bats.*

- What is known about the economic, traffic safety, and ecological effects of these incidents?

*Some countries or companies have scattered information about delays and costs, mostly from single incidents that received special attention. Few respondents (Spain, France, Sweden) mentioned more elaborate statistics on costs.*

- How are wildlife-train incidents dealt with in practice? Who owns the problem and is responsible for compensation and mitigation?

*Incidents are typically a shared problem of the infrastructure owner and the train operator. In many countries, both ownership and operation are in private or corporate hands, in some (e.g., Norway, Sweden), rail infrastructure is governed by public agencies or administrations.*

- What is done to prevent wildlife-train collisions?

*Despite the limited knowledge, many countries seem to be engaged in some mitigation activities. Some just have started to monitor incidents to obtain better empirical data, while others already employ fences and fauna passages, albeit mostly along new or planned railway lines. Reflectors and acoustic-optical deterrents are used in e.g. Poland and Hungary, but knowledge about the efficacy of these measures is missing or uncertain. In Germany, a new concept for risk-management and accident prevention is being prepared.*

- How can you contribute to foster international cooperation on the development of cost-efficient mitigation measures?

*Not surprisingly, the majority of the respondents are interested and willing in either sharing experiences, actual monitoring data or engaging in new research. Some countries (Spain, Germany) are already involved in practical research.*

## Conclusions:

There is clearly an interest if not need in obtaining better empirical knowledge about wildlife-train collisions. The current low esteem of the issue may be due to a lack of data and knowledge. Some countries are already active in either mitigating collisions or doing research to monitor or prevent incidents. The general impression was, that there is scattered information and statistics available and that it will be of value to compile this knowledge systematically.

The participants at the workshop support the establishment of an IENE working group on Railways and Wildlife. The secretariat of this WG is proposed to be in Sweden and linked to the recently started project on wildlife and railroads.

Requests to join the working group can be sent directly to Andreas Seiler ([andreas.seiler@slu.se](mailto:andreas.seiler@slu.se)) or to the IENE secretariat ([info@iene.info](mailto:info@iene.info)).

## Wildlife crossings through existing culverts and bridges, at grade crossings and road mortality along the Ring Changbai Mountain Scenic Highway, China

Yun Wang

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The Ring Changbai Mountain Scenic highway is located adjacent to and inside the Changbai Mountain Nature Reserve, a popular tourist destination in north-east China. The road was recently upgraded from an unpaved forest and logging road to a two lane paved highway. We investigated wildlife crossings through existing 27 culverts and 2 bridges, at grade crossings and road mortality along the Ring Changbai Mountain Scenic Highway for two years (1 May 2010 - 29 February 2012). Road crossings were recorded through snow tracking in winter and we conducted year-round road mortality surveys from a slow moving vehicle. We compared road crossings and road mortality to the relative abundance of medium and large mammal species recorded along transects in a zone adjacent to the road that were sampled year-round. In winter the observed frequencies of mammals crossing the road (total crossings) were significantly different from the expected frequencies based on snow tracks in a zone adjacent to road. Most notably, wild boar (*Sus scrofa*) was not observed crossing the road at all in winter, likely because of high snow banks along the roadsides from snow plowing. Siberian weasel (*Mustela sibirica*) crossed the road more frequently than expected. In winter the observed frequencies of mammals crossing the road through the culverts or bridges were significantly different from the expected frequencies based on at grade road crossings. Siberian roe

deer (*Capreolus pygargus*), Eurasian red squirrel (*Sciurus vulgaris*), and Manchurian hare (*Lepus mandschuricus*) used the culverts or bridges not at all or less than might be expected. Conversely, Siberian weasel used the culverts and bridges more than might be expected and this species appeared to use larger sized culverts more frequently than smaller sized culverts. Amphibians represented the vast majority (77.4%) of all recorded roadkill. The observed frequencies of mammals killed on the road were significantly different from the expected frequencies based on direct sightings and tracks in a zone adjacent to road. Most notably, wild boar, Siberian roe deer, Siberian weasel, sable, and Eurasian red squirrel were not observed as road mortality at all. However, Siberian chipmunks (*Tamias sibiricus*) were killed more frequently than expected (87% of all reported road-killed medium and large mammals). Currently direct road mortality along the Ring Changbai Scenic Highway does not appear a substantial problem for mammals. However, while traffic volume was very low during the study period, it is likely to increase substantially as the number of vehicles in China and tourism are growing rapidly. The highway appears to be an absolute or near absolute barrier for wild boar though in winter and the absence of wildlife fencing may have affected the use of the culverts and bridges by wildlife, expect perhaps for Siberian weasel. Habitat loss, habitat fragmentation and poaching are a serious threat to many wildlife species in China. With the rapid expansion of the road and rail-road network, including expressways and high speed railroads, protected corridors that lead to transportation infrastructure and safe crossing opportunities for wildlife become increasingly important.

## Parallel session 7B

# Wildlife fauna pipes efficiency in two motorways located in Western France studied during a two years survey with infra-red-operated cameras

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In many countries, railroads, roads and motorways are the main factor disrupting landscape. They limit wildlife movements and exchanges between populations and causes road kills. Road mortality is now considered to be a major issue in wildlife conservation and can be one of the main causes of decrease for widespread species, such as the European hedgehog *Eri-naceus europaeus* and the Barn-owl *Tyto alba*, but also for rarer species such as the European otter *Lutra lutra* and the European mink *Mustela lutreola*. In 2009, ASF-Vinci Autoroutes (Autoroutes du Sud de la France) launched an ambitious environmental requalification program of its existing highways in five experimental departments/regions of France. This work was undertaken with local conservation NGOs and engineering consulting firms, and managed with the support of a dedicated scientific and technical Committee. From 2010 to 2012, 25 developments had been realized, whom 9 pipes in our study area (Charente-Maritime), under 130 km highways A10 and A837. Eight of them are situated in river valleys and one in a forest. They are 1200mm diameter (except one in 800mm), and about 53m in length with fencing leading

animals to the underpass. In order to assess their use by fauna after building, a follow-up inside and outside each site was undertaken with 20 infra-red cameras. The monitoring period range from 12 to 27 months. More than 47 000 shots (photos and videos) were got with 25 000 releases. Inside cameras give more useful data (fauna shots) than outside cameras (79% vs 23%). A total of 19 mammal species using the underpasses were shot, as well as some amphibians, reptiles, insects etc. Some important use fluctuations were observed and can be explained by different causes: species biology (seasonality, diurnal/nocturnal), pipe habituation by fauna, surrounding habitat etc. For example, use of underpasses by fauna starts slowly between 4th and 5th months after building, then grow up to +275% between 5th to 24th months, that indicates a progressive pipe appropriation by fauna. This monitoring also reveals that Wild boar *Sus scrofa*, Roe deer *Capreolus capreolus* or Brown hare *Lepus europaeus*, several species that are usually considered to be reluctant to enter small entrance underpasses, occasionally enter such structures/devices to cross motorways. Moreover predators and preys often use the same underpasses, sometimes very frequently without any trouble noticed. The important database of this study can be used as a tool to interpret fauna comportments, and improve monitoring protocols of underpasses.

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## Getting the full story: evaluating the impact of crossing structures on the movement, gene flow and survival of the squirrel glider

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Millions of dollars are spent on wildlife crossing structures to mitigate the negative impacts of roads on wildlife. However their success is largely unknown due to a lack of research on population-level impacts. We used before-after-control-impact (BACI) population monitoring to evaluate the effectiveness of crossing structures for the squirrel glider (*Petaurus norfolcensis*), a threatened arboreal mammal, along a freeway in south-east Australia. The crossing structures, canopy bridges and glider poles, were retrofitted to the 30 year old freeway in 2007 to provide safe passage for squirrel gliders. We used radio-tracking and mark-recapture surveys to collect data on movement, gene flow and survival at mitigated, unmitigated and control sites, before and after the structures were installed. We found that prior to mitigation the unmitigated freeway restricted squirrel glider movement and gene flow. After crossing structures were installed squirrel gliders were able to cross the freeway, while unmitigated sites remained a barrier to movement. Radio-tracking suggested that crossing structures only partially mitigated the barrier effect of the

freeway relative to non-freeway (control) sites. However, genetic analysis revealed that there was no difference in cross-freeway dispersal between control and mitigated freeway sites. Genetic analysis also provided early evidence that the restored movement across the freeway results in successful reproduction and gene flow. Previous analysis of squirrel glider survival rates based on 2.5 years of surveys showed that the freeway reduced squirrel glider survival. However, when we repeated this analysis, including data collected over a longer survey period (6 years), we found no difference in the survival rate of squirrel glider populations living adjacent to the freeway and those at non-freeway sites. This suggests that the barrier effect of the freeway is more important for squirrel gliders than the effect of road mortality. Our work shows that survey duration and BACI study design are critical aspects of road ecology research. Studies that are too short or that lack 'before' data risk misinterpreting the impacts of roads on wildlife and the effectiveness of mitigation. Furthermore, genetic approaches provided a more comprehensive understanding of the impacts on movement and gene flow at fine spatial and temporal scales. When these principles are applied to population-level monitoring we gain a much better understanding of the success of mitigation efforts.



## Vegetated fauna overpasses enhance crossing rates by small forest birds

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The effectiveness of fauna overpasses (ecoducts) for safe passage by small birds remains a neglected area of road ecology. Building on earlier research conducted in Queensland, Australia, we present findings of studies of the movements of birds over the structure and in equivalent habitat within adjacent forest. These studies are focused on the Compton Road fauna overpass near Brisbane which was built to enhance connectivity between two important conservation reserves. Since its construction in 2005, this fully vegetated overpass has been monitored continuously, with bird studies commencing in 2008. Although the impacts of fragmentation associated with roads is now widely recognized, many critical questions remain concerning the utility of crossing structures for both populations and communities of forest-dwelling birds living nearby. Which species use the overpass to cross the road and which do not? Which species cross within the foliage and which cross above the canopy? Is the crossing rate over the overpass different from typical movements within the adjacent forest? Here we report on a full year of weekly counts of birds

from transects (15m x10m) on the overpass and similar transects within the neighboring forest. Both abundances and species richness were significantly greater on the overpass than in the forest sites. Of even greater importance, the rate at which birds moved directly through the overpass vegetation (as a true crossing as opposed to simply foraging) was many times greater than equivalent movements along the forest transects. To our knowledge, this is the first study to quantify bird crossing rates over vegetated overpasses. Moreover, our findings demonstrate that smaller forest insectivores were the most frequent avian guild to utilize the overpasses with the larger generalist species the least likely. In addition, we asked which species and guilds readily cross roads of differing widths and, more importantly, which will not? The relative reluctance of bird to cross three busy roads of 20m, 60m and 90m width was determined with smaller species generally being the most reluctant, though relative traffic volume had little influence. These results have many implications for the design and effectiveness of vegetated fauna overpasses, especially where busy roads bisect forest areas. Our research strongly supports the proposition that providing vegetated safe passages can reconnect fragmented bird assemblages.

## Amphibian rescue at a narrow-gauge railway - wetland area conflict area at Balatonfenyves, Hungary

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Conservation interventions are becoming more and more common along European transport infrastructure networks. While the construction of mitigation measures along high conflict sections is a routine operation in many European, especially European Union, countries, unexpected events are, and will always be, a challenge for both transport infrastructure and conservation specialists. Sudden amphibian rescue operations at previously non-problematic sites are not uncommon on roads. In Canada, for example, a British Columbia highway was blocked by the migration of millions of American toads, while in Europe a similar event resulted in the temporary closure of the Egnathia highway near Thessaloniki, Greece. In July, 2013 a similar event developed at the maintenance unit of the narrow-gauge railway line south of Lake Balaton, Hungary. It is an area where canals connecting Lake Balaton with an extensive wetland area in the south cross villages and linear transport infrastructure, railway lines, roads and the M7 motorway. Following the unusually hot and wet weather before the outbreak of the migration, thousands of European spadefoot toads (*Pelobates fuscus*) infested the area, where rail-

way carriages are kept. Two meter deep shafts used for washing wagons over served as traps collecting thousands of animals. The local railway staff had not got similar experience before and contacted their head environmental office. In the lack of a protocol for such events they got into contact with the MTA Centre for Ecological Research for theoretical advice and involved Varangy Akciócsoport Egyesület, a 27 year-old NGO specialized on amphibians and reptiles, into the rescue operation. Similarly to other cases, the event was species-specific, only one species, *Pelobates fuscus* was involved. A total of over 1,800 individuals were collected from 2 meter deep wagon washing chambers, and released in nearby, suitable habitats. Only one individual was observed to have deformities. As these events may become more common due to extreme weather conditions, several lessons are to be learnt from this successful operation. 1) Mass migration/appearance of amphibians along linear transport infrastructure may be expected more frequently in the future if extreme weather conditions develop. 2) Events can be site- and species-specific, as such, the creation of a standard protocol giving solutions to all possible events in every possible locations seems to be an unrealistic goal. 3) As a result, closer connection between amphibian specialists and railway and motorway staff is a desirable aim in minimizing wildlife loss and lowering related transport problems.

## Parallel session 7B

# Effectiveness of wildlife passage and new monitoring techniques on the road

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In many countries, several mitigation techniques are in use to minimize road-kill, habitat loss, and reduced habitat quality. In Japan, the significance of road ecology is currently uncertain, and no standard procedures are being used to minimize the detrimental effects that road systems can have on wild mammals. In the first part of our work, we studied the ecological impacts of roads in this country and analyzed the biological and physical factors that contribute to the selection of wildlife-crossing structures (WCSs) by wild mammals. In the second part of our work, we also developed a method to assess the effectiveness of WCSs and environmental impacts by identifying individual mammals using fecal DNA analysis. In our first study, we investigated the availability of various WCSs (box culvert, pipe culvert, underpass, overpass, eco-bridge, drift fence, planting, other) for focal species of conservation on 86 roads (13 roads in Hokkaido, 30 roads in East Japan, 34 roads in West Japan, and 9 roads in Okinawa and Tsushima). We selected 2 roads (Higashifuji-Goko Road and Toyotomi Bypass) from these 86 and set up infrared sensor cameras to investigate

WCS use by species of wild mammals. WCSs in Japan are mainly box culverts intended for large (e.g., sika deer *Cervus nippon*) and mid-size (e.g., red fox *Vulpes vulpes*) mammals. There are few WCSs intended for arboreal mammals (e.g., Japanese squirrel *Sciurus lis*, Japanese dormouse *Glirulus japonicus*, Russian flying squirrel *Pteromys volans orii*). Camera trap results show that large mammals such as deer, boar (*Sus scrofa leucomystax*), and several other species preferred the underpass WCS. Box culverts were used frequently by foxes and masked palm civets (*Paguma larvata*). Pipe culverts in Hokkaido were favored by sable (*Martes zibellina*) and rodents *Apodemus* spp (*Apodemus speciosus*, *Apodemus argenteus*). In summer, box culverts in Hokkaido were used by cave-dwelling bats. Preference of WCSs are attributed to biological and physical factors. In our second study, we selected the Japanese hare, *Lepus brachyurus*, as target species for the DNA analysis. A total of 36 hares (28 males and 8 females) were identified from 344 fecal samples, and 4 of them have crossed both sides of the road. I suggested that the individual identification method by fecal DNA would be applicable to study movement of difficult-to-capture mammals, herbivorous mammals and more sedentary mammals along roads. The significance of our study results and the future direction of road ecology studies and mitigation techniques in Japan will be discussed.

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## A standard methodology to be used for fauna survey and monitoring in Brazilian roads' and railways' environmental licensing

**Juliana Ribeiro Rocha**

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Environmental licensing in Brazil is necessary for all establishments and activities that use environmental resources, effectively or potentially polluting, or which may cause environmental degradation. One of the steps of licensing process is evaluating the methodology that is going to be used for fauna survey and monitoring, as part of environmental impacts assessment. In case of roads and railways, until 2013 July, environmental consultants could propose any methodology they considered appropriate for each case and the Brazilian Environment and Renewable Environmental Resources Institute (IBAMA), bureau responsible for federal environmental licensing, should judge if the proposal is suitable for that particular case. It permitted several different methodologies to be submitted and approved, making the process slower and less objective, besides hindering results comparison among different constructions. This work intends to discuss the standard methodology defined by IBAMA to be used in all fauna studies related to roads and railways, including road-kills surveys and monitoring. The process has begun at the request of National Department of Transport Infrastructure (DNIT), bureau responsible for the operation, maintenance, restoration and extension of federal roads. Due to this request, IBAMA has mobilized itself to define such methodology, in order to smooth DNIT's internal processes at the time of hiring environmental consulting companies and in

order to optimize IBAMA's own internal processes as a result of a quicker and more efficient licensing process, as well as receiving more relevant results. Standard sampling module comprises a 5 km long transect and an equal length parallel access trail, 600 m far from each other. A sampling cell shall be installed every 1 km. Sampling cells comprise pitfalls zones and live-traps (Sherman and Tomahawk) zones for capturing herpetofauna and small non-flying mammals as well as mist net zones installed perpendicularly to the first ones for capturing birds. In case of the non-existence of areas long enough to house a 5 km long module, sampling modules may be reduced until 1 km long. In addition to this, visual and hearing active search shall be done for herpetofauna and birds sampling. Medium and large bodied mammals shall be sampled by transection surveys as well as by camera traps and track plots installed in spots with high probability of finding these animals. Aquatic fauna shall be sampled outside sampling module boundaries using gillnets, casting nets, dip nets, trawls, sieves and Surber samplers. Beyond this, road-kills shall be surveyed and monitored monthly. Road-kills sampling shall be done by car at a maximum speed of 40 km/h through all the road or railway extension and on feet at some random stretches. The latter intends to provide a correction factor that may be estimated from the number of animals found during on-feet sampling. Upon these circumscriptions, IBAMA's Normative Instruction 13/2013 was published in 2013 July. Since it is recent, there are not enough results capable of attesting its effectiveness. Nevertheless, it is expected licensing process becomes more agile and, mainly, more transparent and objective, besides making different constructions results comparison possible.

## SUNRA - a tool to assess the sustainability of road administrations and road projects

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For national road administrations (NRAs) to effectively contribute to sustainable development, they need to have a clear understanding of sustainability and how sustainable development is applicable to road network development and management. There is therefore the need for a tool to benchmark sustainable development by NRAs and also to assess the sustainability of road projects. The ERA-NET Road project SUNRA (Sustainability—National Road Administrations) addressed this need. Its objectives were to provide i) a definition of sustainable development within the context of European road authorities; ii) a common system of measurement of sustainability performance at NRA level; and iii) a framework for sustainability assessment of a road project. Based on an international literature review and consultation with NRAs and other stakeholders, the 6-country project team developed three interlinked frameworks for NRAs to use when considering their contributions to sustainability. Taking the variety between countries into account, Framework 1 helps NRAs consider the principles of sustainable development from viewpoints appropriate to their legal setting, organizational structure, planning tradition and ambition level. Framework 1 guides the NRA's work with defining sustainability, identifying sustainability considerations at a strategic level, defining a commitment and identifying an implementation approach. This framework addresses a broad variety of economic, social and environmental aspects of sustainability. Framework 2 provides a matrix of sustainability performance levels for managing and monitoring require-

ments at project, program and board level. It is supported by example metrics for 24 sustainability topics distributed between the environmental, economic and social pillars of sustainability. This framework allows benchmarking between NRAs by allocating themselves into one of four performance levels and then work their way up the matrix as they extend their sustainability work and improve their performance. Framework 3 provides NRAs, the road-construction industry and other stakeholders with a tool to assess the sustainability of individual road projects and report on the performance of the project over time. The framework addresses the planning, design, construction, maintenance and decommissioning phases. Procurement is one of the key intervention points at which the framework can be used. This Excel-based framework addresses 26 topics pertaining to the three pillars of sustainability. Examples of topics are "Landscape and ecosystem health", "Cultural heritage", "Light pollution", "Water resources and quality", "Environmental Impact Assessment" and "Follow-up". For each topic, several aspects have been identified. Each aspect has a scoping question to help determine whether the aspect is relevant to the particular project. For each aspect, information has been provided to allow discussions related to goal setting. In most cases a potential target has been suggested, accompanied by an indicator or metric. A summary sheet shows the progress being made towards achieving each target. Framework 3 can be used without prior use of Framework 1 or 2. Unlike many of the existing sustainability rating systems, the SUNRA tool does not result in a score and does not require accreditation. SUNRA thus provides an easy-to-use tool to assess the sustainability performance of NRAs as a whole and the sustainability of individual road projects.



## Assessing the Ecosystem Service loss due to new alignments, using a spatial analysis toolkit

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The Terrestrial Transport Infrastructures and the associated urban developments are major factors of biodiversity erosion. In the EU we witness a growing artificial land use, covering the equivalent of the cumulated urban areas of Copenhagen and Malmö, each year. For infrastructure projects, the direct impacts on nature heritage and biodiversity are sought to mitigate as possible. However the loss of services provided by the existing ecosystem to the communities is neglected. Egis Environment has cooperated with the LAMETA laboratory in Economic Sciences to develop an innovative method to appraise the loss of Ecosystems Services induced by an Infrastructure Project, from the planning to the final design stages. The Methodology relies on sequential appraisals tools, but with a cutting edge research program on the indicators for a better relevancy of the hypothesis:

- Identification of the Ecosystem Services provided, using documented indicators which connect the land cover to the likely Ecosystem Services,
- Identification of the economic value that could be reasonably associated to this likely Ecosystem Services,
- Definition of the typical impact for each kind of Ecosystem Services and for each kind of Transport Infrastructure project,
- Forecast of the loss of Services using biophysical units, and then economic units through a Geographic Information System database,
- Evolution of the loss of Services over the infrastructure's life span.

These results could bring an additional approach of the impact of the Transport Infra-

structure projects, at each stage of design and are described as following as the Egis' Ecosystem Services Toolkit: A guideline, for definition, control and cost Ecosystem Services with assessment method for presence/importance, has been consolidated to be able to depict the services available in any area. This in-depth work aim to be used at preliminary stages of infrastructure projects, in order to highlight red flags areas for Ecosystem Services, and assume the possible demand (by locating beneficiaries), and then inspire shift of alignment. In addition a method for appraisal of the Ecosystem Services loss induced by a Transport Infrastructure project has also been consolidated. This ready-to-use classification is differently used depending on the stage of the project.

- For the comparison of alignment alternatives, to depict the order of magnitude of the possible Ecosystem Services loss per alignment, for decision making,
- For the project optimization at detail design, the Toolkit helps to locate the areas showing the most important loss, to design efficient mitigation measures, and to conduct cost-effectiveness analysis,
- For the afterward Cost-Benefit Analysis, the toolkit helps to take into account the improvement generated during the design for a lower Natural footprint.

The Egis' Ecosystem Services Toolkit has been tested for a 110km long and 2km wide rail corridor. Beyond the three different types of services – provisioning, regulating, supporting – 15 have been evaluated in particular the regulating services (floods, drought, etc.). Two contrasted study areas with alternative alignments have closer examined, and the results are discriminant. It is interesting to note that some of those services have not been examined in the ESIA even if compliant with the best practices.



## Parallel session 7C

# Managing a green infrastructure in planning, building and maintenance of roads and railroads.

**Anders Sjölund**

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Over the last few decades more intense land use, urban sprawl and a rapidly increasing transport network has degraded the European ecosystems to a serious level with grave consequences. At the same time the rapid and large-scale development of infrastructure is surprisingly indistinct. The Swedish National Audit Office recently called attention to the actual statements of account which reports the length of new roads and railroads built each year, but not inform the government which influence the money used have on accessibility, train punctuality, traffic capacity, usefulness of roads and railroads and off course not the effect on the environment and human health. Consequently a new set of indicators are developed including environmental indicators focused on climate change, biodiversity and health. Infrastructure impact on biodiversity is directed on six aspects: barrier, mortality, disturbance, land take, verge management and species invasion. For each, the long-term vision, strategic goal,

present state and any legal requirement is specified. A new web-based database, based on the road and railroad networks, present condition, performed measures, maintenance plans, action plans etc. to support policy makers, planners, project managers, it's very specialists, contractors etc. Overall, the model is promising. In the strategic planning it has proved to be a powerful tool easy to understand by policy makers and planners since it gives a "picture" of the gap between actual and desirable situation. Focusing on certain environmental aspects has facilitated overall assessment of costs, made prioritizing of measures easier as well as following up and have also fostered the development of a uniform method of working within the organization. A close reasoning from ecological foundations to economical and planning tools is hard to achieve. Simplifications are needed which easily brings uncertainties and distrust among ecologists. Huge amounts of data needs not only to be collected but also to be kept up to date with good quality. Available data on avenues, road verges, fauna passages etc. is often not sufficiently documented and recognized inventory standards are missing. Elaboration of existing follow up routines is needed to include aspects of biodiversity.

## Project Laxå - mitigation measures on existing road and railroad

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This study aims to investigate how to mitigate the barrier effect of an existing road and railroad in southern Sweden. The investigated area consists mainly of forested land and is situated in the northern parts of southern Sweden. The road E20 and the railroad Västra Stambanan, connecting Gothenburg and Stockholm, passes through this area. The area is of ecological importance and is strategic for ecological dispersal. It connects the woodlands in southern Sweden with the woodlands in middle Sweden. The road and the railroad are two large barriers. Focus species for the project is wolf (*Canis*

*lupus*), lynx (*Lynx lynx*), moose (*Alces alces*) and wild boar (*Sus scrofa*). The aim of the project is to strengthen the ecological connections and to mitigate the barrier effect of the road and the railroad. The existing passages have been surveyed and information has been gathered from hunters, the county administrative board and from surveys of wolf and lynx in the area. Since the surveyed tract is long and the effects from both the road and the railroad must be handled, a combination of mitigation measures is proposed. Several passages are needed and this can be achieved by adapting existing passages, building new fauna bridges or ecoducts and creating passages with wildlife warning devices. This is an early stage-study and one of the few projects of large scale mitigation on existing roads and railroads in Sweden.



## Parallel session 7C

# Increasing ecological value in a tender for a design, construct, finance and maintain contract for a Dutch road expansion

**Victor Loehr**

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Road construction projects often have little focus on ecological aspects once the planning phase has been completed. European and national legislation require mitigatory and compensatory measures, but opportunities to improve and expand on the minimum measures are not usually taken. Nevertheless, the scale of road construction projects provides excellent possibilities to reinforce ecosystems, with little extra cost. The Dutch National Highway Agency "Rijkswaterstaat" used the tender phase of a DBFM (design, build, finance and maintain) contract for a road expansion to challenge the market to increase ecological value beyond legislative obligations. Highway A12 intersects the largest Dutch terrestrial Natura 2000 site (Veluwe) over a length of 12 km. The contract involves the expansion of the road in 2015-2017 and maintenance for the following 16-year period, and was put out to tender in 2013-2014. Contractors were required to submit qualitative plans seeking an optimum for three specific fields of interest: (1) minimizing impact on nature, (2) minimizing disturbance of road traffic, and (3) minimizing disturbance of railway traffic at a railway crossing. Dialogue rounds were used to reflect on contractors' draft plans and to encourage realistic, well-motivated measures. Minimising impact on nature required contractors to draw up protocols for mitigatory and compensatory measures in the

realization and maintenance phases, an integral land usage plan, and an ecological monitoring plan. Each protocol and plan had several functional requirements, e.g. reduce impact on red-listed species that are not legally protected, connect habitats of reptiles and bats, decrease collisions with pine martens, and use monitoring results to determine the effect of new defragmentation measures. The final qualitative plans were evaluated and awarded fictive deductions on the financial bids with a maximum deduction of 40% (total for all fields of interest) or 11% (minimizing impact on nature) on the ceiling price. The plans of the winning contractor were integrated in the contract to ensure their realization. This methodology encouraged contractors to channel considerable resources into measures that will minimize impact on nature, and improve ecosystems along the road. Furthermore, the integrated approach ensured that legal ecological obligations were taken into account when developing measures that served other interests. Several conditions were identified that contributed to the successful tender process: (a) the maximum fictive financial deductions should be a reasonable proportion of the ceiling price to make it worthwhile for tenderers to invest in the development of measures, (b) the requirements should have a functional level to provide room for distinction between contractors, (c) the ecologists should attend the dialogue rounds, and (d) sufficient physical space should be available for ecological measures (e.g., outside the project boundaries).



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