A Predictive Model for Preventing Wildlife-Vehicle Collisions and Habitat Fragmentation

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PhD Chapters

Context:

- Roads and Wildlife-vehicle collisions (WVCs)
- habitat fragmentation and threaten animals/motorists.

PhD Chapters

1. Wildlife Exclusion Fences
2. Wildlife Passages
3. Research Creation

Chapter 1: Wildlife Exclusion Fences

How effective is wildlife fencing at preventing animals from stepping onto a road?

- How does the length of a fence influence its effectiveness?
- How does the fence-end effect influence fence effectiveness?

Case Studies:

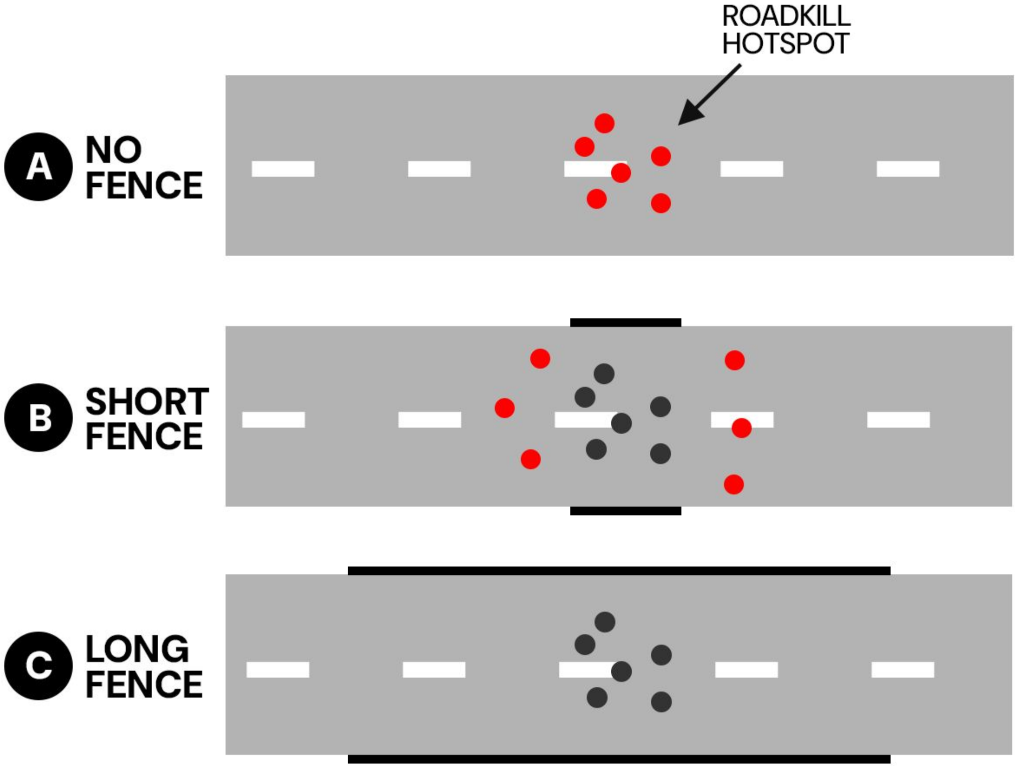
1. Wood Turtle
2. Deer
3. Wishlist: road/river scenario

- Wildlife-vehicle collisions: kill animals and reduce biodiversity
- fences prevent animals from accessing roads
- What length of fence is needed?

The fence-end effect

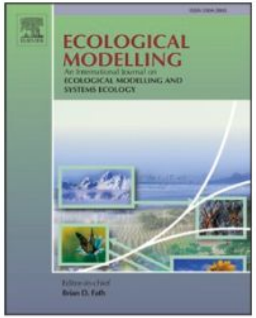
Shifting of roadkill hotspots towards the fence ends

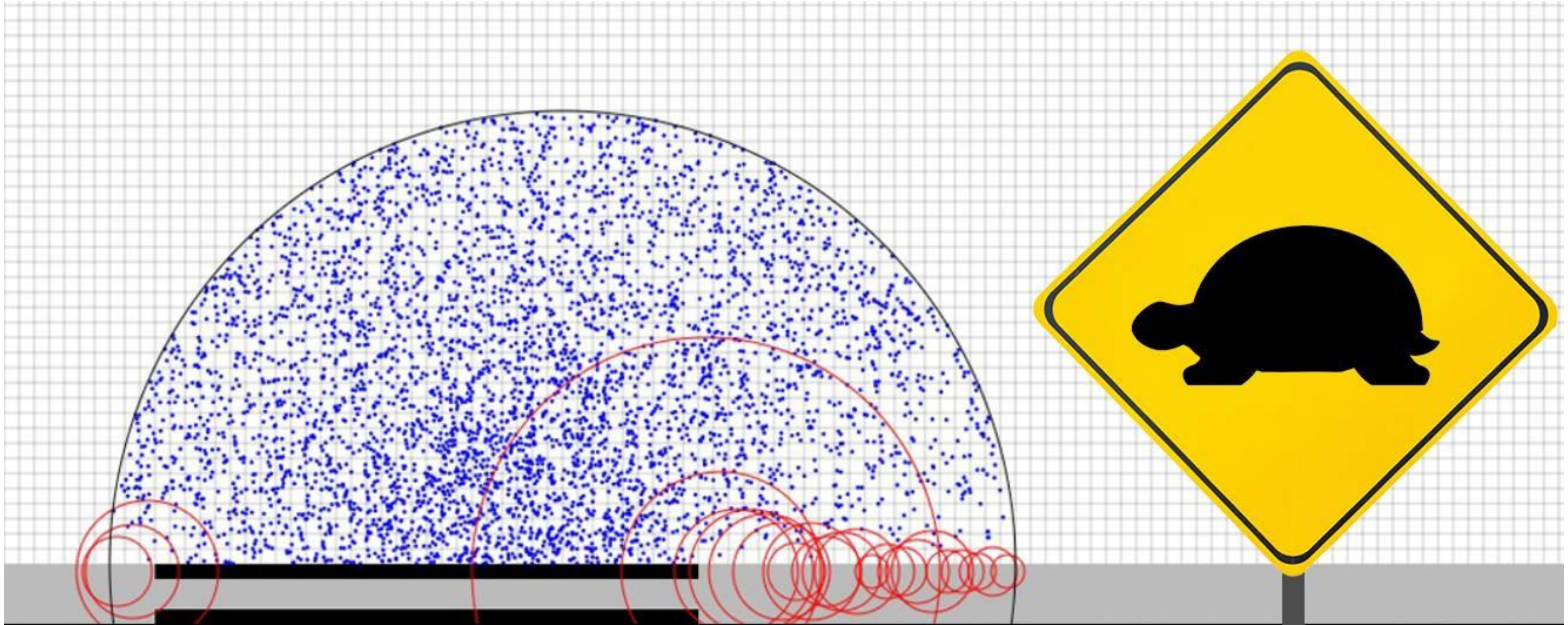
(Clevenger al., 2001; Plante et al., 2019; Lafrance and Alain, 2019)



Predicting the effectiveness of wildlife fencing along roads using an individual-based model: How do fence-following distances influence the fence-end effect?

Wilansky, J., & Jaeger, J. A. G. (2024). Ecological Modelling, 495, 110784.
https://doi.org/10.1016/j.ecolmodel.2024.110784
Model: https://jonathanwilansky.com/ibmdev/model/





Methods

IBM created using JavaScript

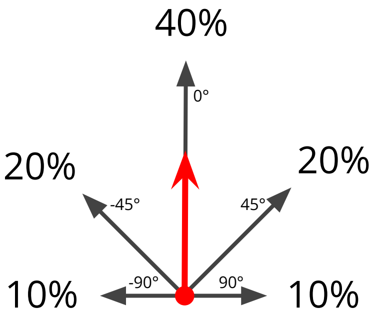
Model variables → Wood Turtles (Arvisais et al., 2002)

- Movement distance = 1630 m/year
- Home range radius = 300 meters
  ↳ Fence length = 600 meters

Simulations parameters:

- 5000 turtles
- 1 year of movement
- 8 Fence-following distances

Movement Behavior Profiles



Direction Change Probabilities

		Fence Following Distance	
		Steps	Meters
1	Random	0	0
2	Directed Random	0	0
3A	Follow Fence SHORT	5	5.6
3B	Follow Fence MEDIUM	20	22.3
3C	Follow Fence LONG	35	39
4A	Follow Fence ¼ D	135	150
4B	Follow Fence ½ D	269	300
4C	Follow Fence ¾ D	404	450
4D	Follow Fence MAX	538	600

Retreat Distance:
5 steps / 5.6m

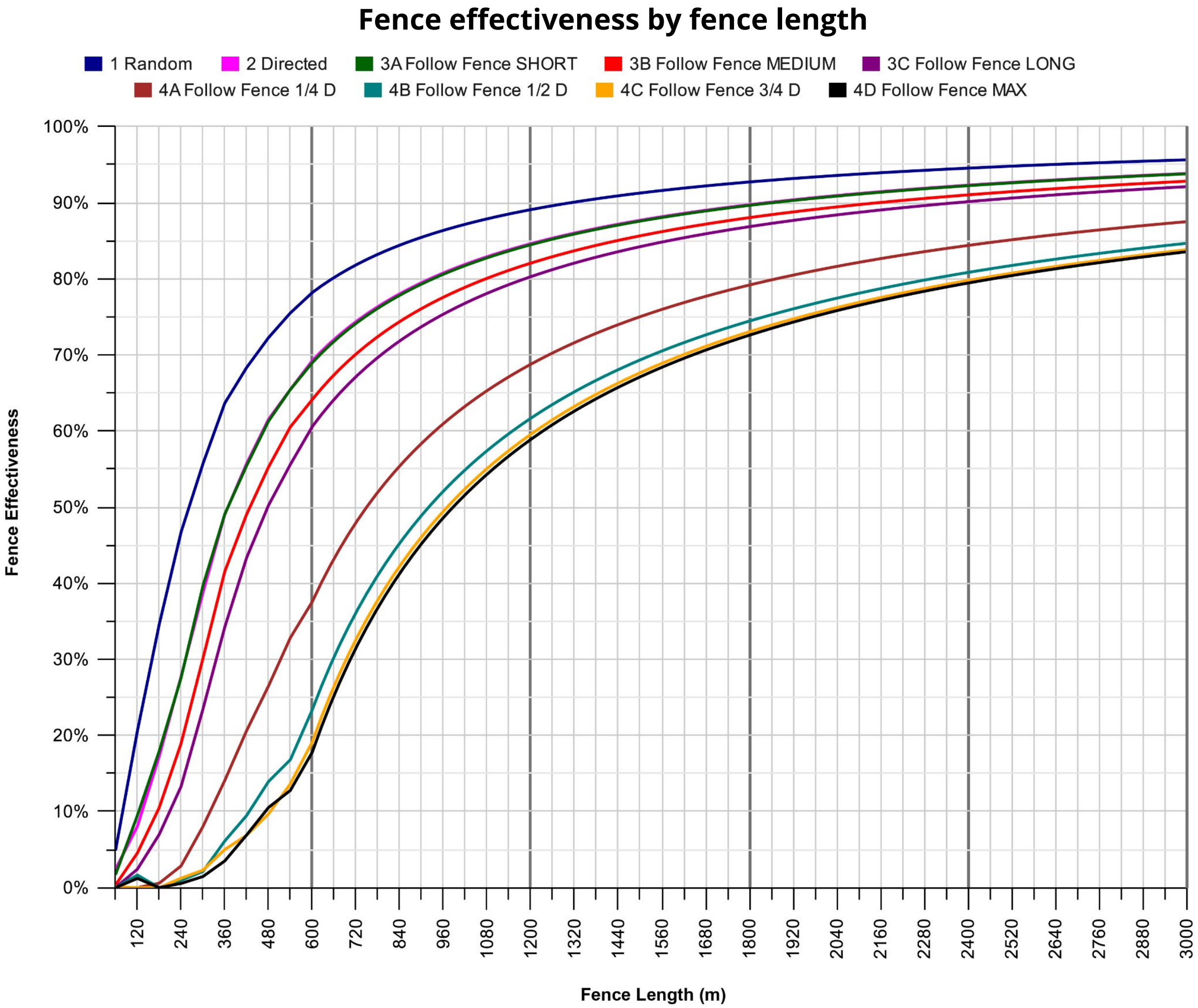
Results + Discussion

Long fences prevent significant numbers of road encounters

Fences with open ends can never be 100% effective because of the fence-end effect

Short fences vary significantly in their effectiveness

Effectiveness is reduced by fence-following behavior



Next Steps...

White-tailed deer: 7200 WVCs per year in Québec [TQ]

Model variables

- Movement distance = ?
- Home range radius = ?

Simulations parameters:

- 5000 deer
- X years of movement
- X fence-following distances

Wishlist: Road-River Scenario

A

B

Chapter 2: Wildlife Passages

How ‘effective’ are wildlife crossings at maintaining habitat connectivity?

How does fencing and passage design influence animal movement patterns and habitat connectivity?

Case Studies:

A. How does the guide fence length influence the number of successful road crossings and the rate of road mortality?
B. How does the number of crossing structures influence the number of successful road crossings?

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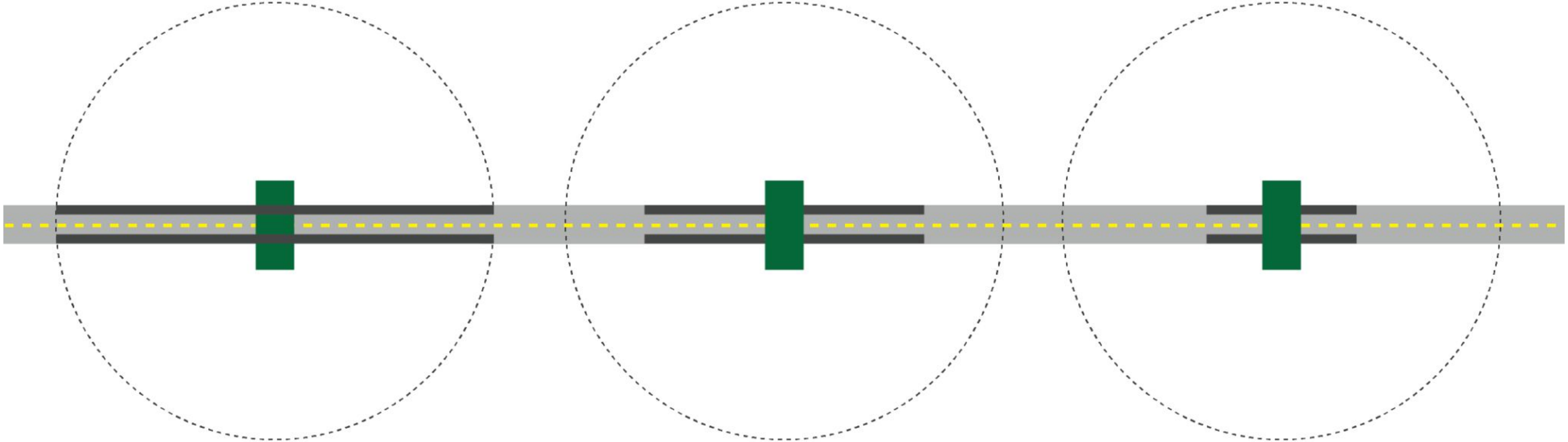
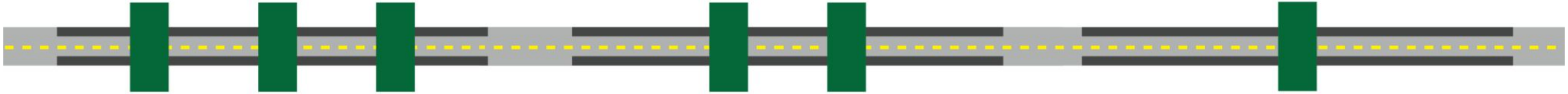


B. How does the number of crossing structures influence the number of successful animal crossings?



Chapter 3: Research Creation

How can an ecology based IBM translate into a visual/interactive medium to communicate or teach ecological processes to a non-expert audience?

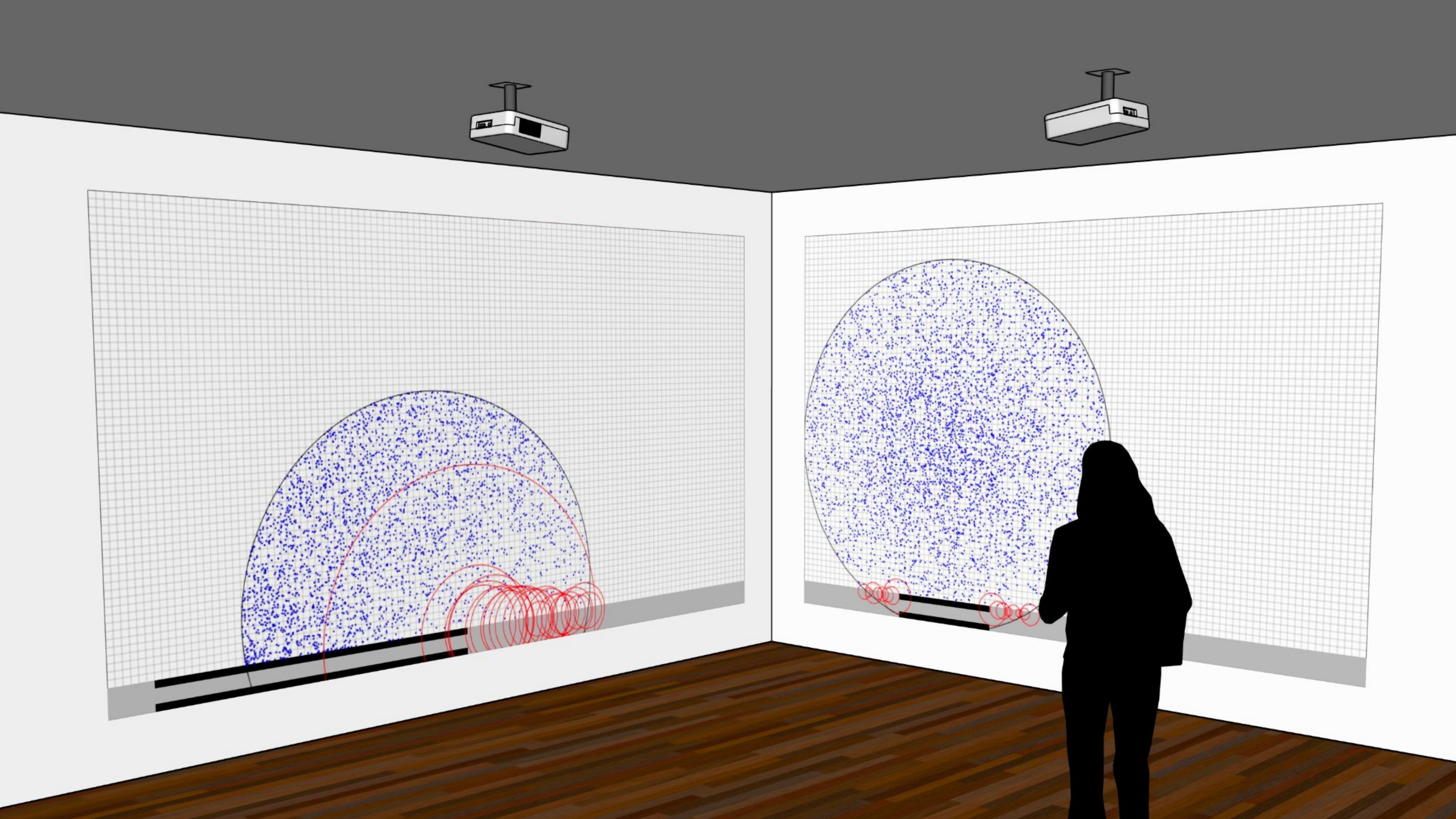
Is embedding ecological modeling within a creative installation or game an effective interdisciplinary collaboration between science and art?

Option 1: Art Installation

1. project the IBM model visualization on the walls to spread awareness of the impact of roads on wildlife populations

Option 2: Serious Game

2. Given a fixed budget, the user must implement fences/passages to maximize animal survival and maximize habitat connectivity



IBM Wood Turtles

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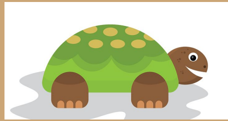
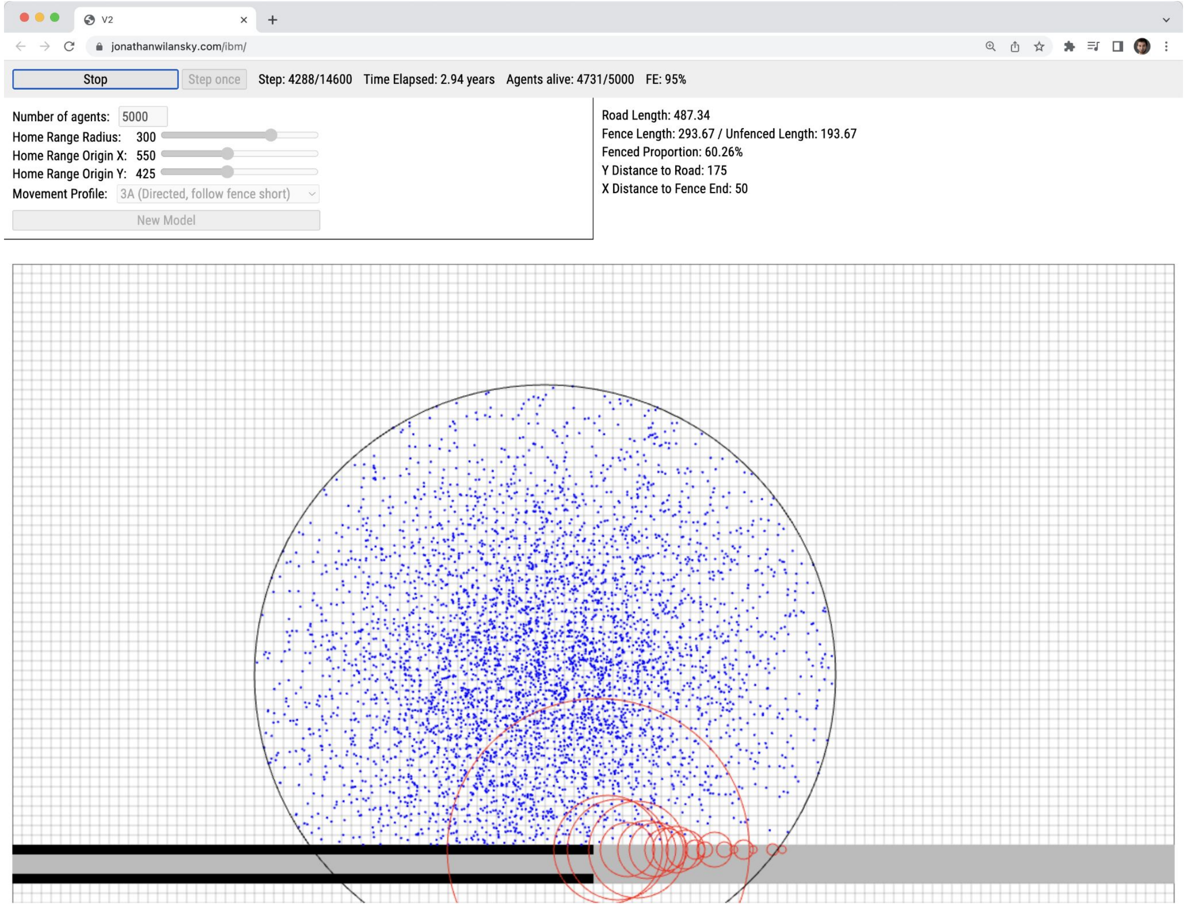


The IBM

https://jonathanwilansky.com/ibm/

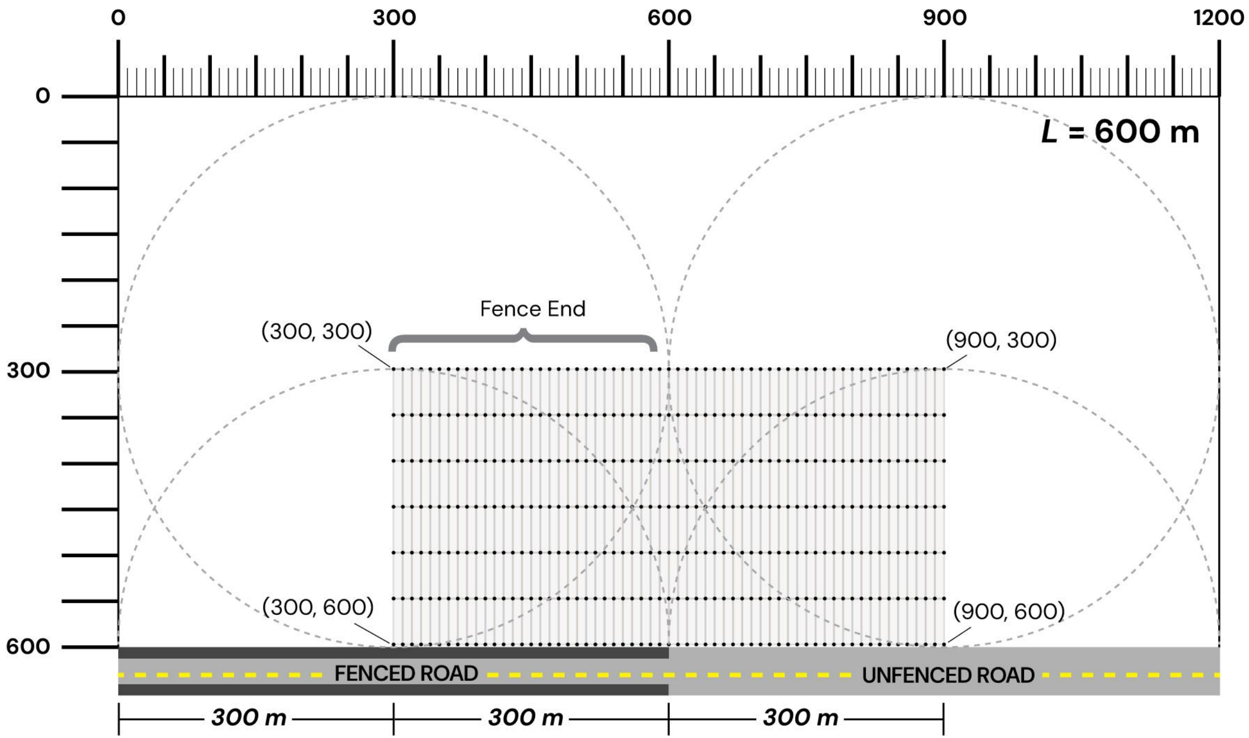


Survival Ratio

= percentage of agents alive* at the end of a simulation

*alive → did not step on the road

The IBM Environment and Fence Effectiveness ($L \leq 2r$)



Fence Effectiveness (FE)

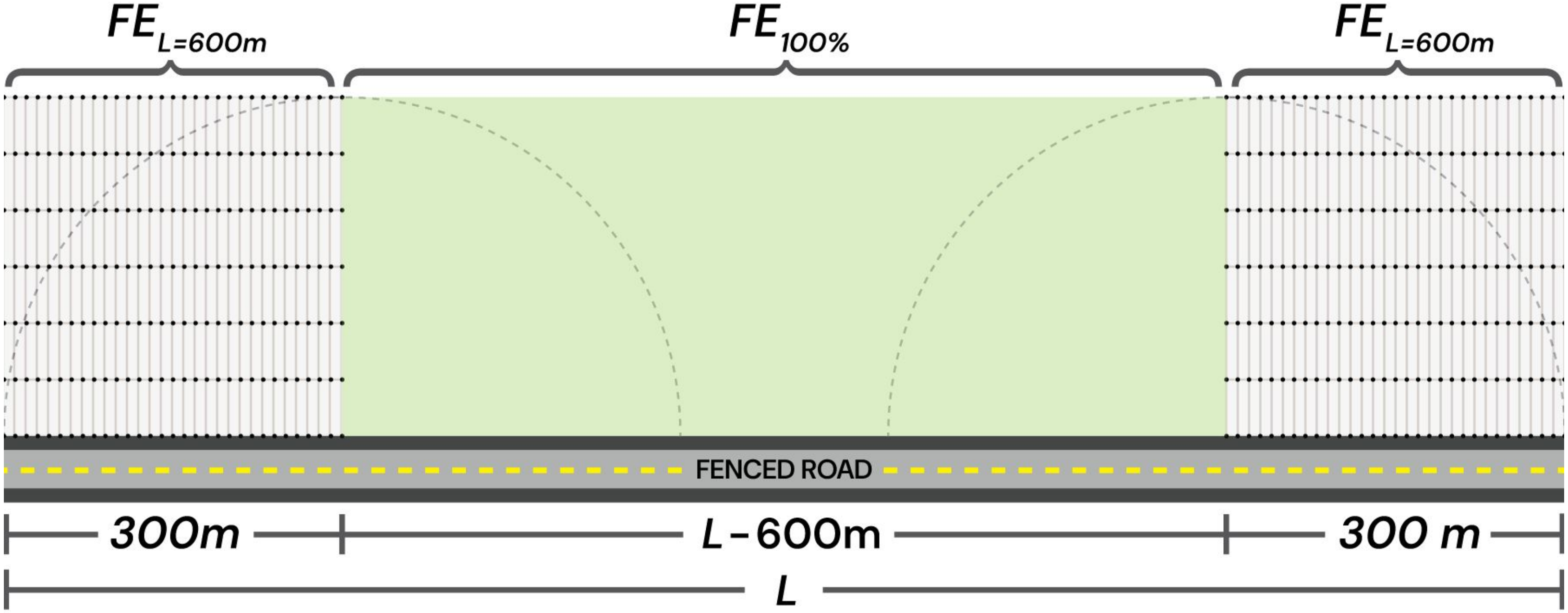
$$= (SR_F - SR_{NO\_F}) / (1 - SR_{NO\_F})$$

road encounters prevented by the fence

road encounters with no fence

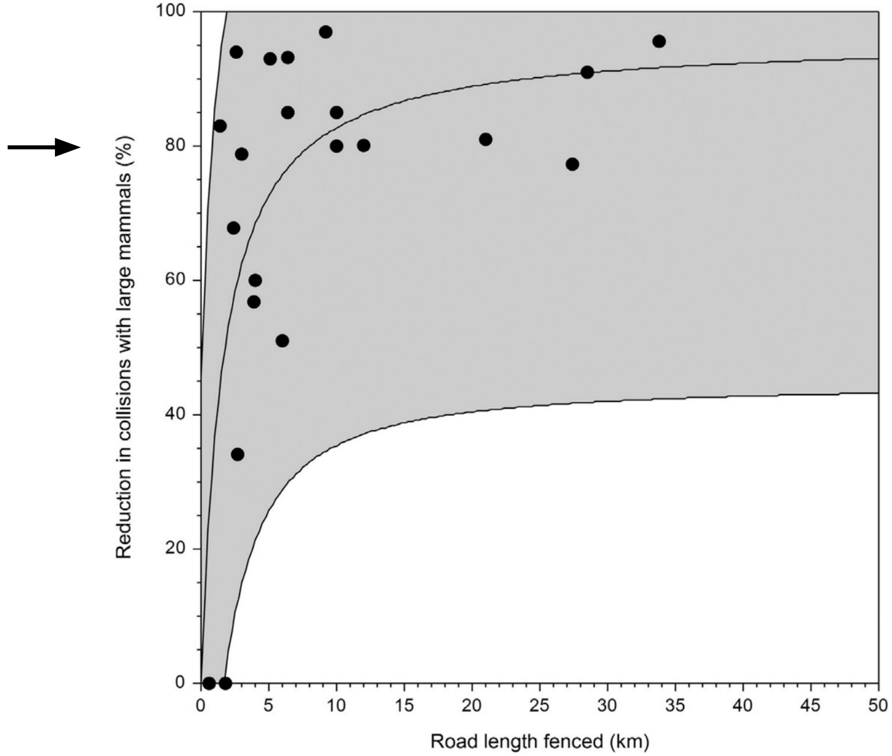
Method for $L > 600$ m

- Fences with length $L > D$ can be determined mathematically using results from L = 600 m
- any additional length contributes 100% effectiveness



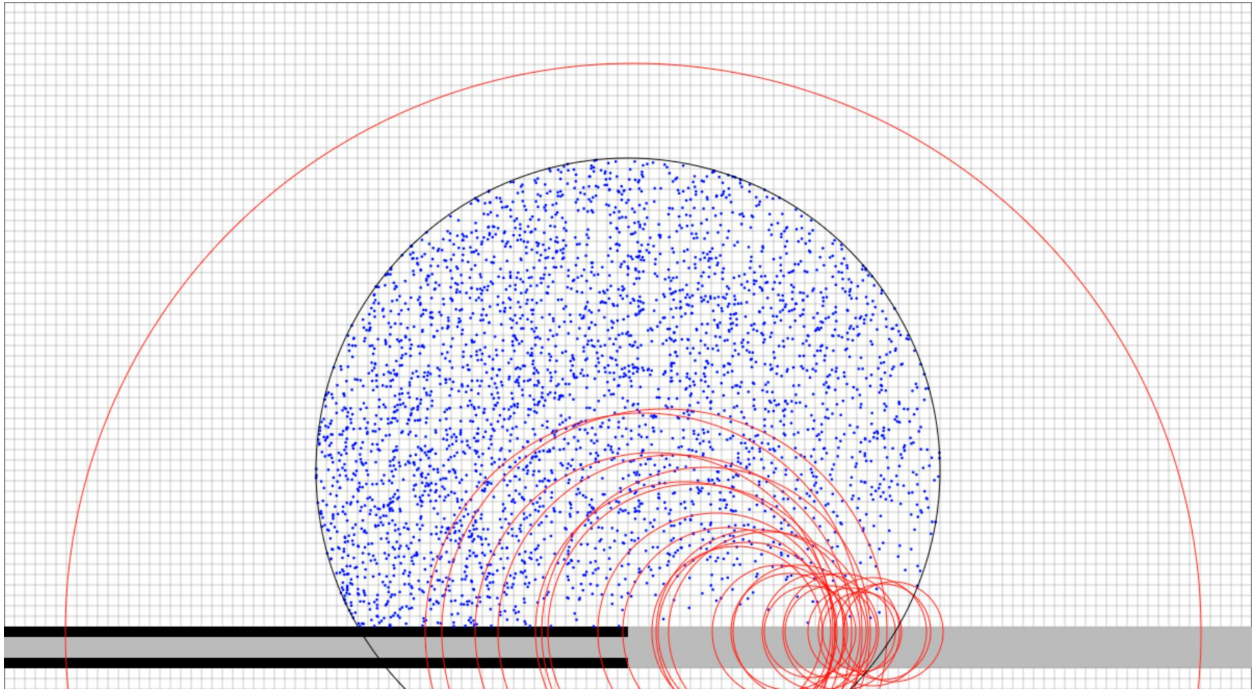
Comparison with Real-World Data

- Empirical data from Huijser et al. (2016) comparing reduction in collisions across different fence lengths…
- However, making a direct comparison is difficult
    - different species (large mammals)
    - collisions vs road encounters

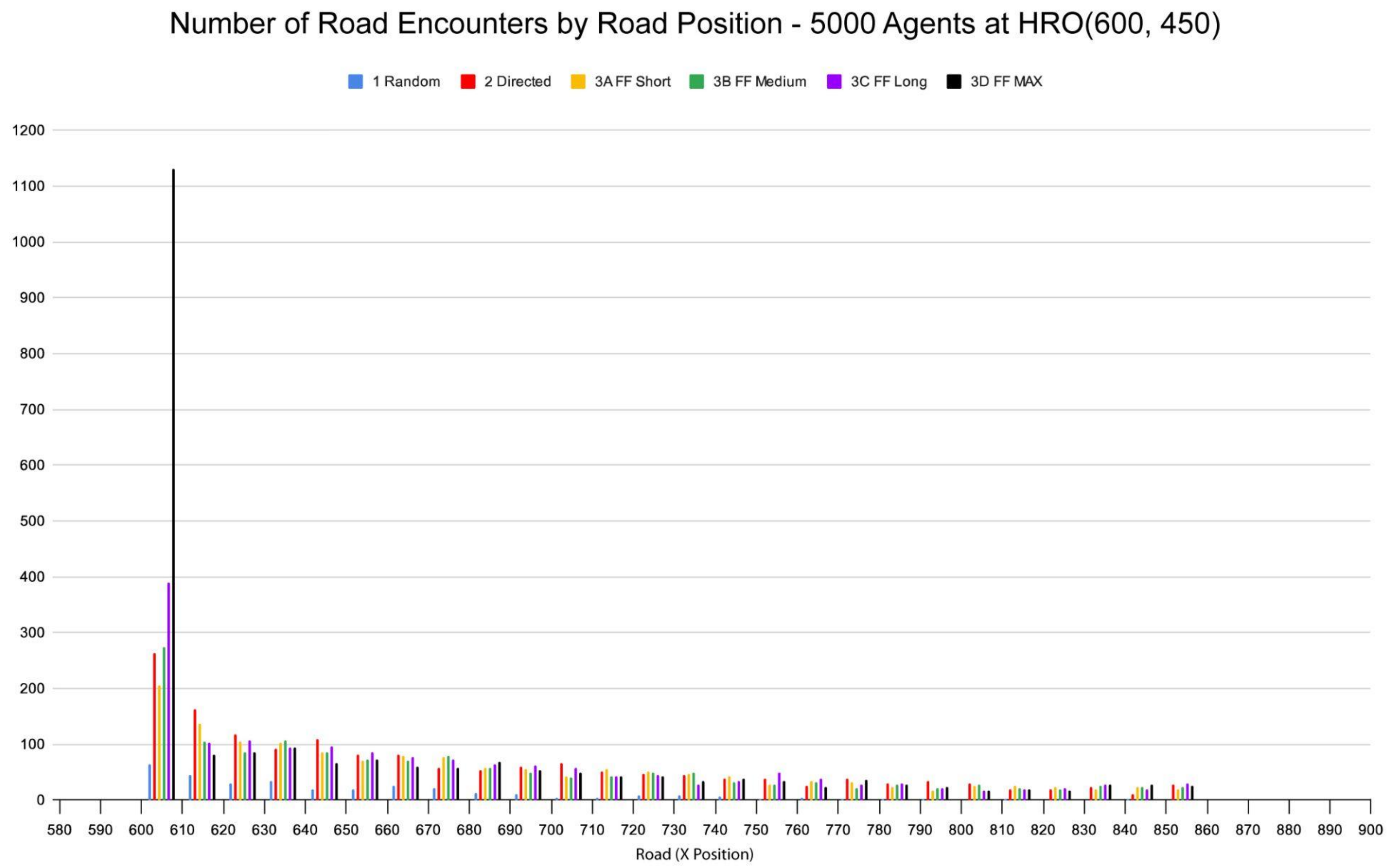


Discussion

- Confirmation of the fence-end effect



Profile 3B @ (600, 450)



Number of Road Encounters by Road Position - 5000 Agents at HRO(600, 450)
1 Random
2 Directed
3A FF Short
3B FF Medium
3C FF Long
3D FF MAX
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
580
590
600
610
620
630
640
650
660
670
680
690
700
710
720
730
740
750
760
770
780
790
800
810
820
830
840
850
860
870
880
890
900
Road (X Position)

Fence-Following Distances

- **Yosemite Toads**
  - average distance of **46 m** before “giving up” (Brehme et al., 2022)
- **Common Toad**
  - “gave-up” after an average of **40 m** if they did not reach a tunnel passage (Ottburg and van der Grift 2019)
- **California Tiger Salamanders**
  - moved an average of **40 m** along barrier fencing when migrating before turning back into the habitat (Hobbs and Brehme 2017)
- **Other species…?**

Conclusion

- Confirmation of the fence-end effect for theoretical movement behaviors
- Preliminary results for a 600m fence

Future Work

- Define movement profiles based on literature
- Model Validation
- Convert to mathematical model

Other Applications

- FLOMS Tradeoff
- Wildlife passages
- Mitigation at fence ends
- Interactive model

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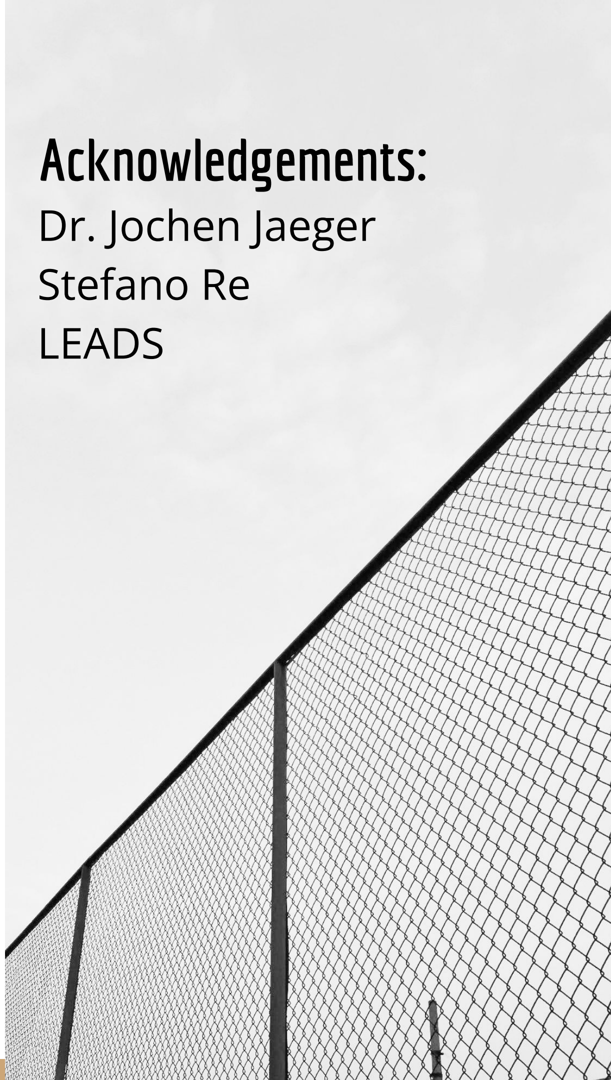
LEADS



IBMs and WVCs

IBM: Eurasian Otters

- Simulating animal movements to predict wildlife-vehicle collisions: illustrating an application of the novel R package SiMRiv. (Quaglietta et al. 2019)
- Created a computer model to simulate animal (Eurasian otter) movement patterns and predict high-risk areas for roadkill.
- landscape structure (water-dependance)
- estimated number of road crossings
- used real data to validate the model

IBM: Moose and Salt Pool Displacement

Reducing Moose–Vehicle Collisions through Salt Pool Removal and Displacement: an Agent-Based Modeling Approach (Grosman et al. 2009)

- IBM to predict how removing salt pools deposited near roads could influence the number of road crossings by moose.
- habitat data, moose behaviors (foraging, ruminating, resting, and traveling) and habitat-use rules to guide the model moose's movement.
- GPS data was used to calibrate and validate the model.
- The model predicted a reduction in the number of road crossings.

IBMs

- Effects of Road Fencing on Population Persistence (Jaeger & Fahrig, 2004)
  - Individual-based model: to predict when fencing is good or bad for population persistence
  - Roads: barrier to movement, road mortality, reduce amount & quality of habitat
  - Fences: reduce mortality but increase the barrier effect
- Predicting When Animal Populations Are at Risk from Roads: An Interactive Model of Road Avoidance Behavior (Jaeger et al., 2005)
  - predicts the effect of roads on population persistence, incorporating general avoidance behaviors and road characteristics. Rank risks based on relative values.