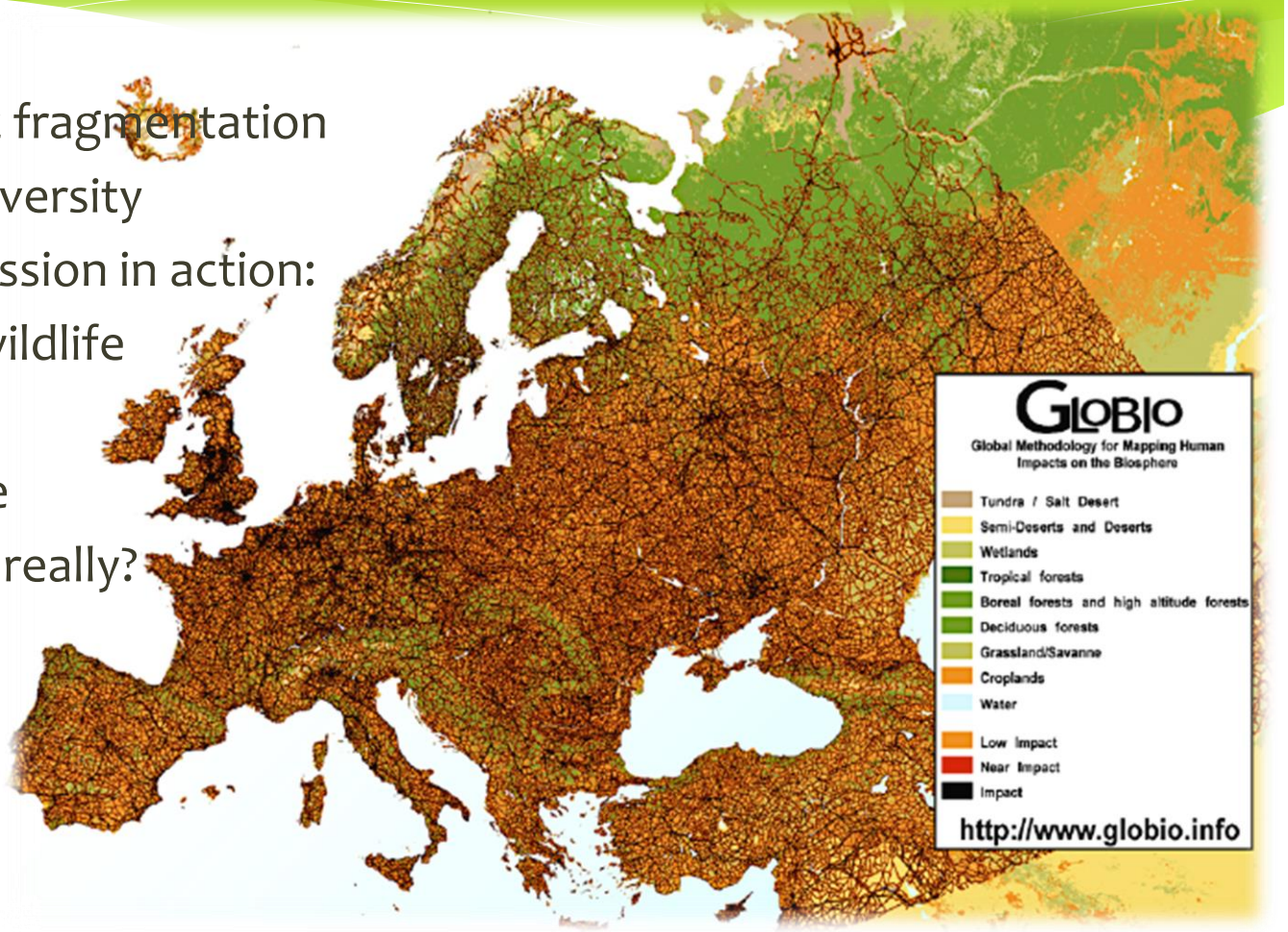
Spatial and temporal extent of the effectiveness of wildlife passages on metapopulations

Maud Segal, Caroline Geeraerts, Joachim Mergeay

1. Introduction

* Increased habitat fragmentation → threat to biodiversity
* European Commission in action: construction of wildlife passages
* How effective are wildlife passages really?



1. Introduction

* Unrealistically long studies on wild populations to get results on efficacy of ecoducts






* Use of simulation softwares, e.g. MARLIN®
  → possibility to set realistic parameters
  → fast results
  → tool for analysing efficacy of ecoducts

2. Methods

- MARLIN®: create and analyse spatially explicit population genetic simulations.
- Simulation of 3 landscape configurations:

BARRIER

1	2	3	4	5	6	7	8	9	10
11	12	**13**	14	15	16	17	18	19	20
21	22	23	**24**	25	26	27	28	29	30
31	32	33	34	**35**	36	37	38	39	40
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PASSAGE

1	2	3	4	5	6	7	8	9	10
11	12	**13**	14	15	16	17	18	19	20
21	22	23	**24**	25	26	27	28	29	30
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CONTINUOUS

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north

south

2. Methods

* Characteristics of simulation configuration:

→ neutral genetic markers
→ Kimura stepping stone model of population connectivity
→ 1.6 migrants per generation to the next subpop.
→ CONT = 1100 N_e, BARR = 1000 N_e, PASS = 1010 N_e
→ random genotypes
→ 50 loci (two alleles) per indv.

→ overall standardized genetic variance F_{st} = c. 0.25
→ pairwise F_{st} among neighbour subpop = c. 0.05 – 0.10

2. Methods

* 10 runs per landscape configuration
* Output at 20, 100 and 1000 generations

* Statistical analyses:
  1. AMOVA among clusters (north VS south) = F_{ct}

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  1. AMOVA among clusters (north VS south) = F_{ct}
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  3. Pairwise genetic differentiation « D_{jost} » at distance 1, 3, 5 and 7

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→ANOVA on each measure of genetic differentiation and Post-hoc Tukey's HSD tests

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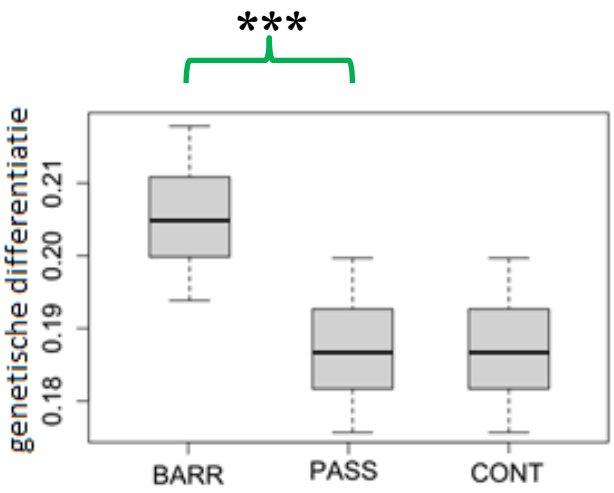
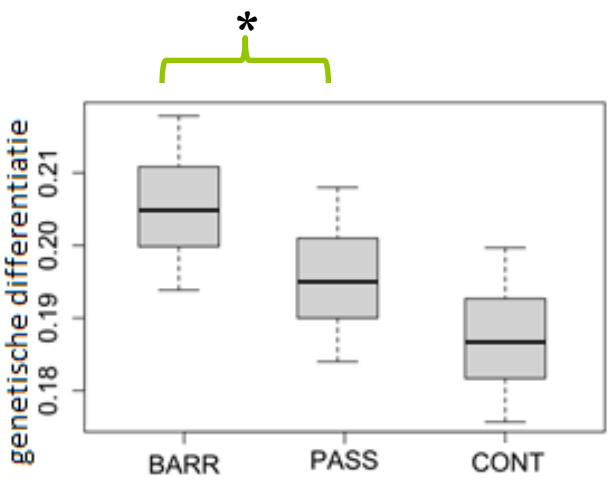
2. Methods

* Manual to interpretation of results:

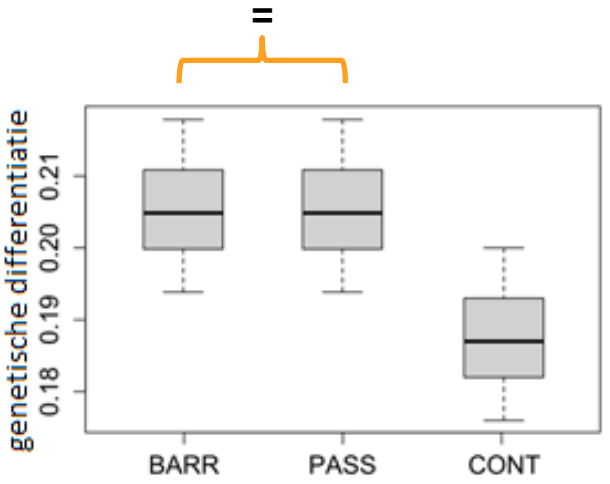
Ecoduct very efficient



Ecoduct efficient



Ecoduct inefficient



3. Results

* 20 generations

Genetic differentiation (F_{sc} and F_{ct})

F_{sc} →

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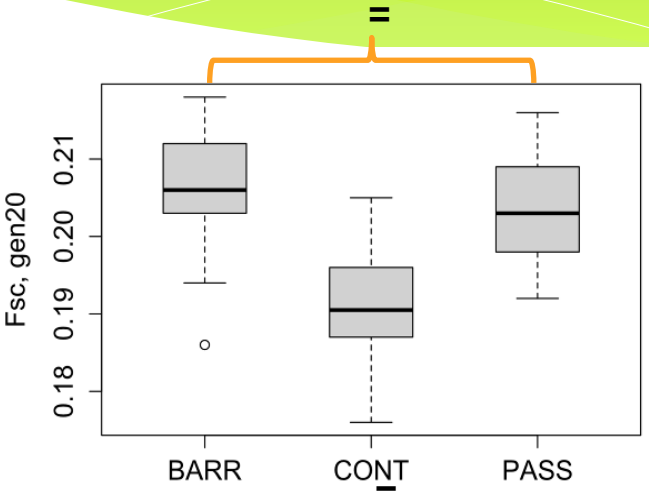

F_{ct} →

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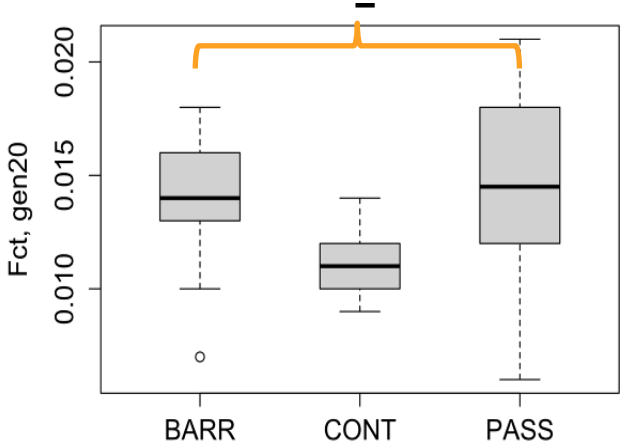
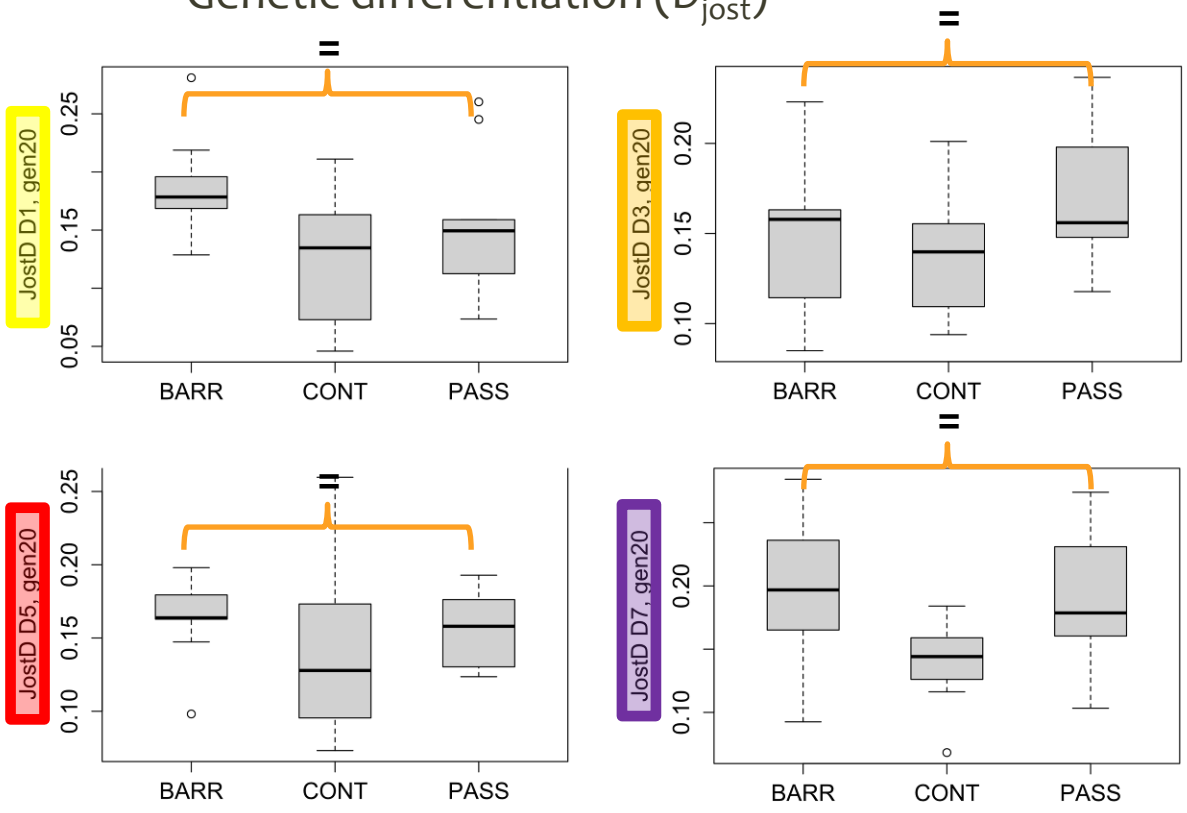


3. Results

* 20 generations

Genetic differentiation (D_{jost})



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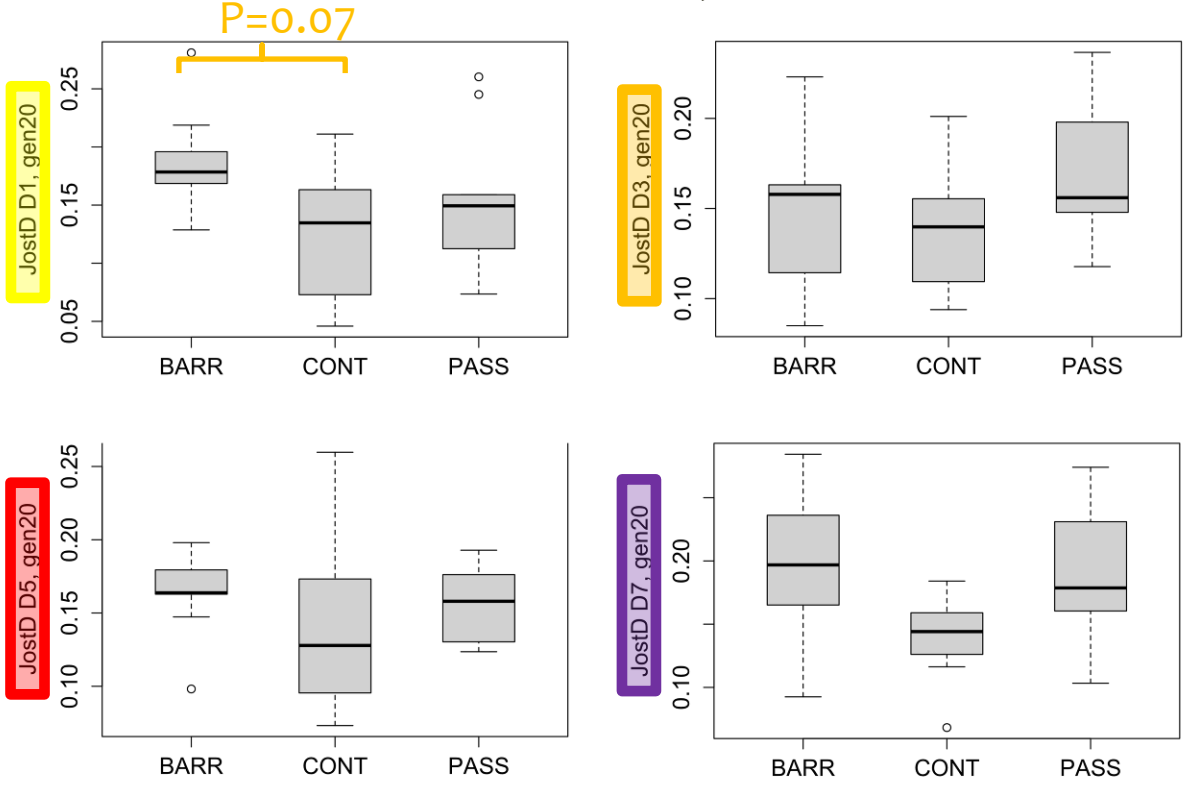

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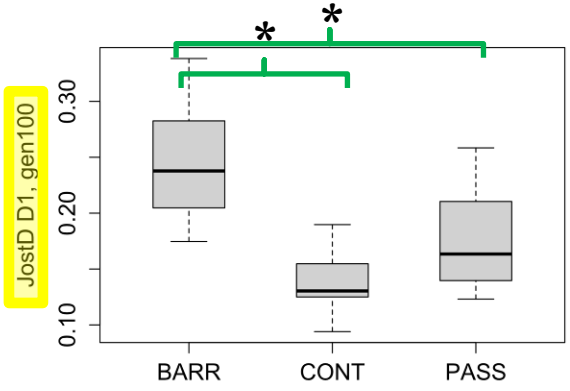
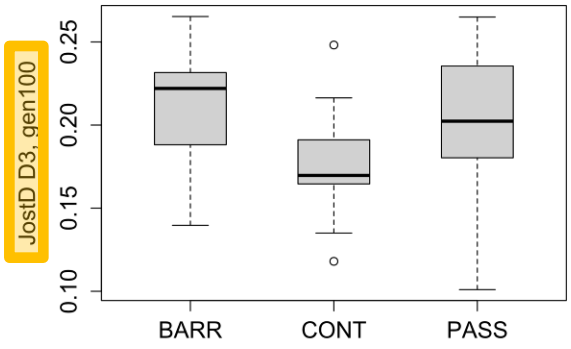
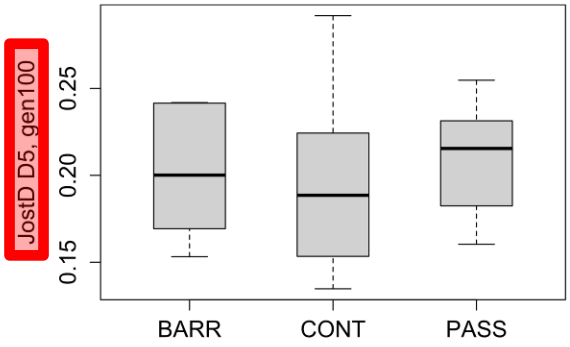
3. Results

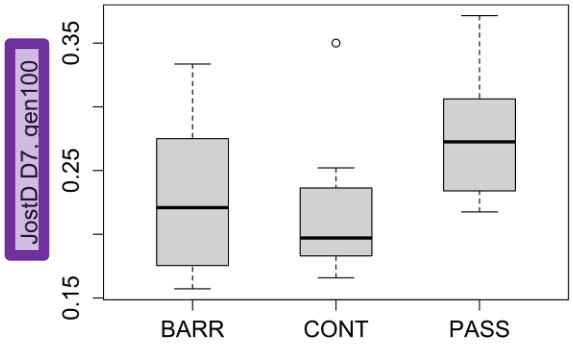
* 100 generations

Genetic differentiation (D_{jost})









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3. Results

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Genetic differentiation (F_{sc} and F_{ct})

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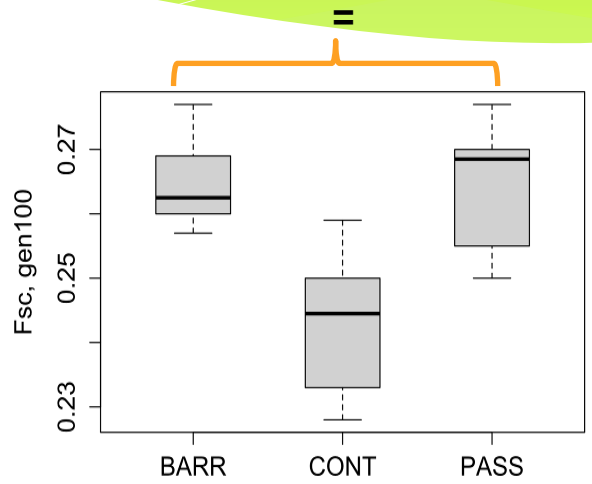

F_{ct} →

1	2	3	4	5	6	7	8	9	10
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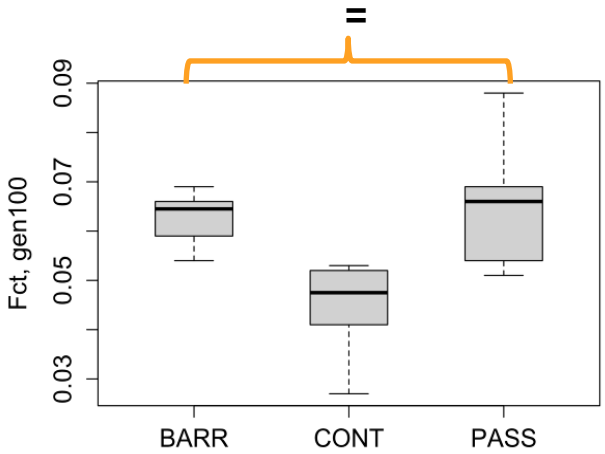
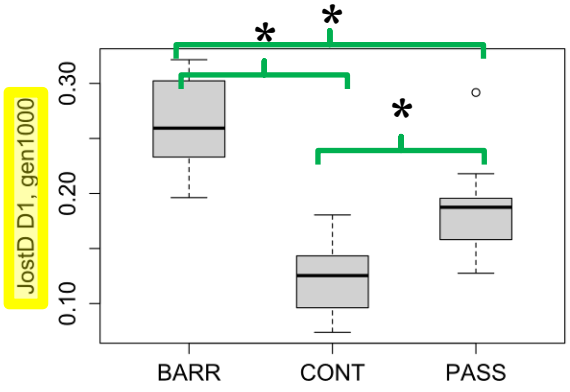
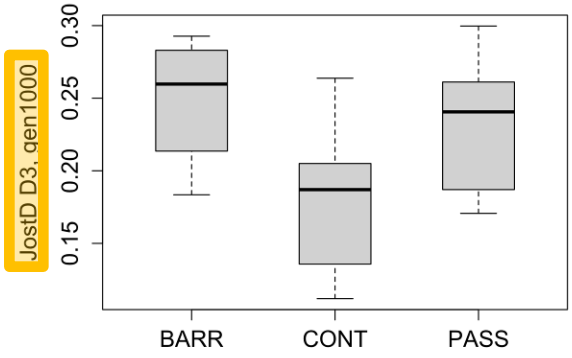


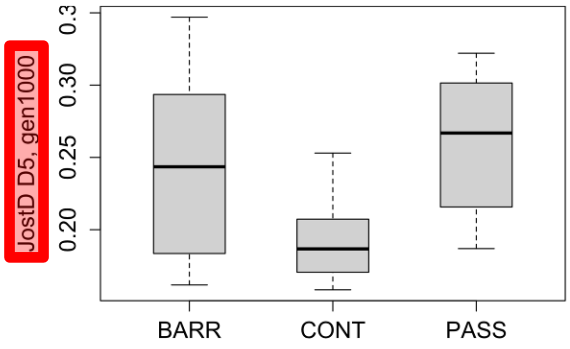
3. Results

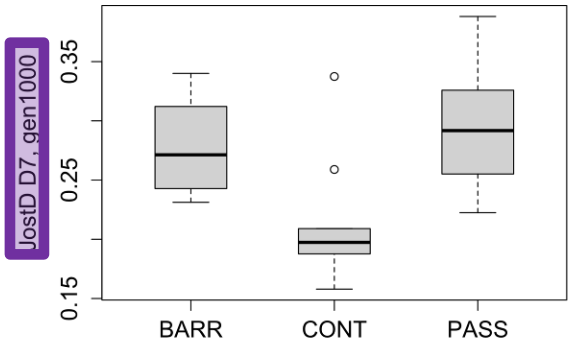
* 1000 generations

Genetic differentiation (D_{jost})









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3. Results

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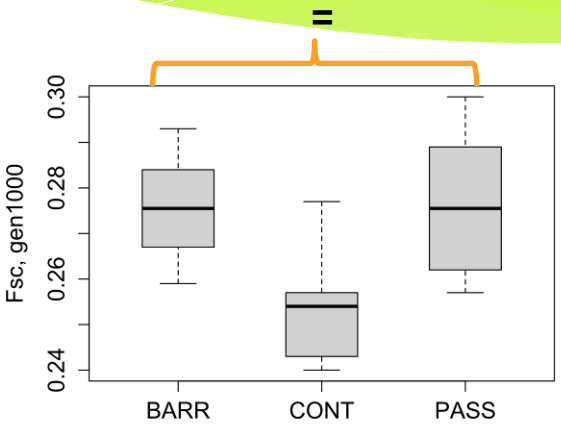

F_{ct} →

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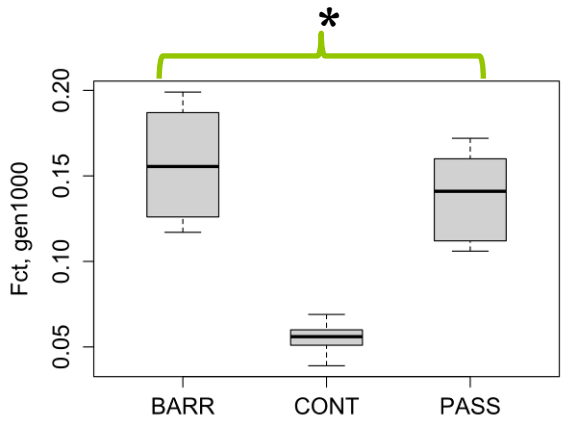
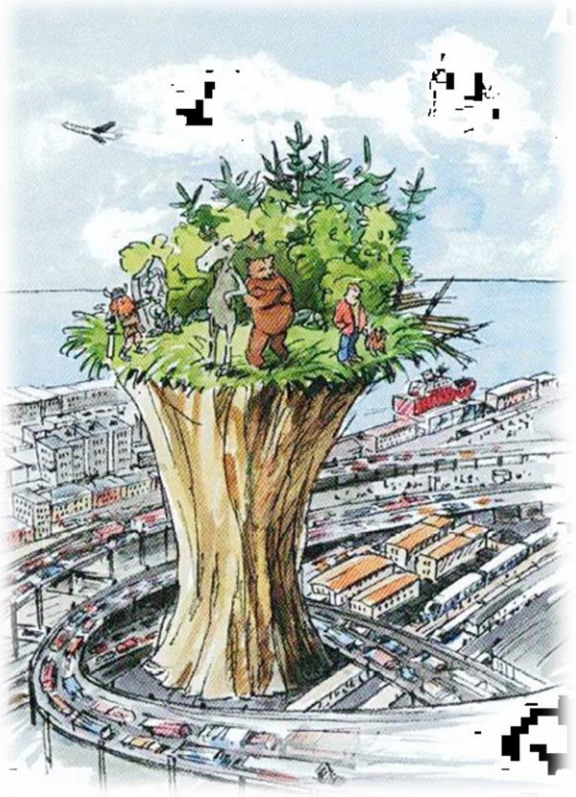


4. Discussion

* Effect of ecoduct almost negligible, except for local populations close to the ecoduct
* caveats of simulations
* How useful is parameter space?



4. Discussion

* Consequences for green infrastructure policy:

→ current ecoducts: 50 m wide, 1 per 50km

= 1/1000th of the lenght of the barrier

≈ 9 hours per year open

4. Discussion

Sawaya, M. A., S. Kalinowski, and A. P. Clevenger 2014. Genetic connectivity for two bear species at wildlife crossing structures in Banff National Park. Proceedings of the Royal Society B 281:201131705

5. Conclusion

* Wildlife passages should only be constructed when they can directly connect subpopulations that are close to each other

* ecoduct has a very limited spatial effect: a passage is required every other « cell »

  → e.g. for medium-sized mammals: every 10 km

  for amphibians or reptiles: every 1-2 km

  for the smallest species: every few 100 m

5. Conclusion

* Final remarks: anthropogenic misconceptions on ecoducts

  → green connection does not entice functionality, and vice versa!

  → organisms do not actively search for ecological connections!

Thank you for your attention!

ANOVA	D1	D3	D5	D7	F_{sc}	F_{ct}
GEN20	0.0717!	0.2640	0.3544	0.0579	0.1070	0.0535!
GEN100	<0.0001*	0.1250	0.7540	0.0466*	<0.0001*	<0.0001
GEN1000	<0.0001*	0.0059*	0.0082*	0.0016*	<0.0001*	<0.0001*
Post-hoc pairwise effect						
GEN20						
CONT-BARR	0.0294*!	NA	NA	0.0345	NA	0.0593
PASS-BARR	0.3651	NA	NA	0.9424	NA	0.9110
PASS-CONT	0.5688	NA	NA	0.0660	NA	0.0659
GEN100						
CONT-BARR	<0.0001*	NA	NA	0.8226	0.0000*	<0.0001*
PASS-BARR	0.0012*	NA	NA	0.1542	0.9996	0.7645
PASS-CONT	0.0537*	NA	NA	0.0467*	<0.0001*	<0.0001*
GEN1000						
CONT-BARR	<0.0001*	0.0069	0.0316	0.0118	0.0019	<0.0001
PASS-BARR	0.0010*	0.8004	0.6275	0.7564	0.9971	0.1575
PASS-CONT	0.0046*	0.0313*	0.0075*	0.0020*	0.0016*	<0.0001*