The fragmentation challenge - latest scientific findings on possible solutions for connectivity

Ruud P.B. Foppen

Sovon

Contents

- Fragmentation as a biodiversity problem
- How does it affect populations?
- Connectivity as a solution? How does it work?
- Ecological networks

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Fragmentation, a biodiversity problem!?

Where did it start?

- MacArthur & Wilson 1968: island theory
- Levins 1969: metapopulation theory
- Ilkka Hanski: metapopulation in real world situations

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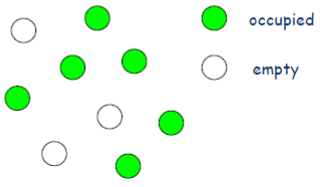
Typical metapopulation model

- The Levins model (occupancy model)



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What effects can we predict?

- Species have a lower occupancy in isolated patches
- (Local) population extinctions in isolated (small) patches
- Recolonisations occur in well connected metapopulations
- Existence of fragmentation thresholds

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Terminology

- Size: patches, metapopulations (MVP, MVMP, MAR)
- Configuration: distances, % habitat, connectivity, corridors
- Processes: fragmentation (local)extinctions and colonizations

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The fragmentation process

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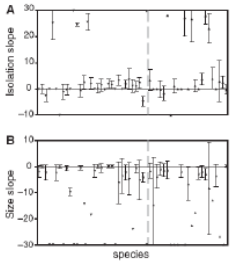
Negative impacts shown for many birds, mammals, amphibians and evertebrates

Large-scale experimental habitat destruction experiment in Brasil
(13 years, 23 patches)
12 pristine forest patches
11 isolated patches from 10 to 600 ha

Monitoring of the bird community and analysis with a statistical model of patch turnover in species presence/absence



Extinction rate according to the « best » statistical model



Positive effect of fragmentation on extinction rates, but results are highly variable and many species are insensitive to habitat fragmentation

Negative effect of patch size on extinction rate

Ferraz et al.. Science. 2007.

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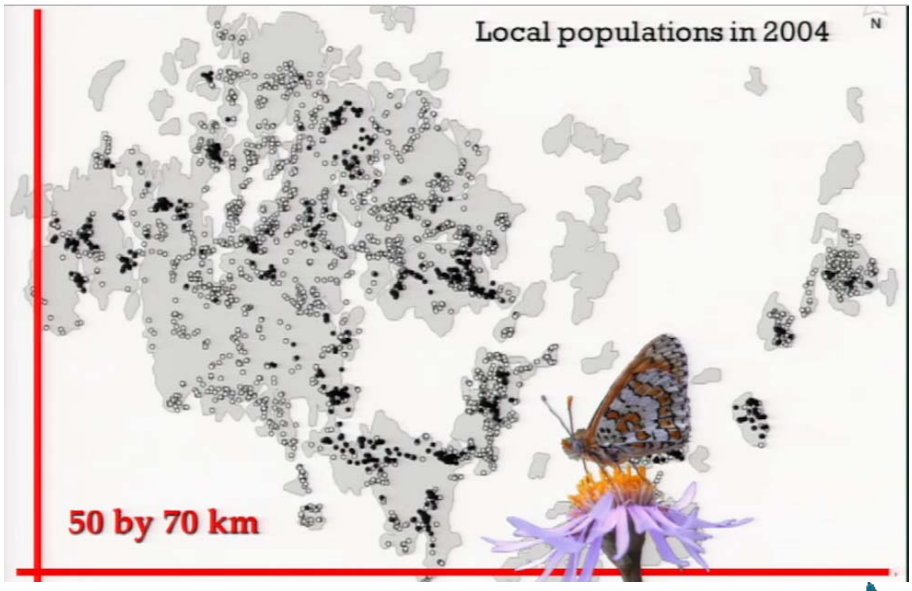

Glanville Fritillary

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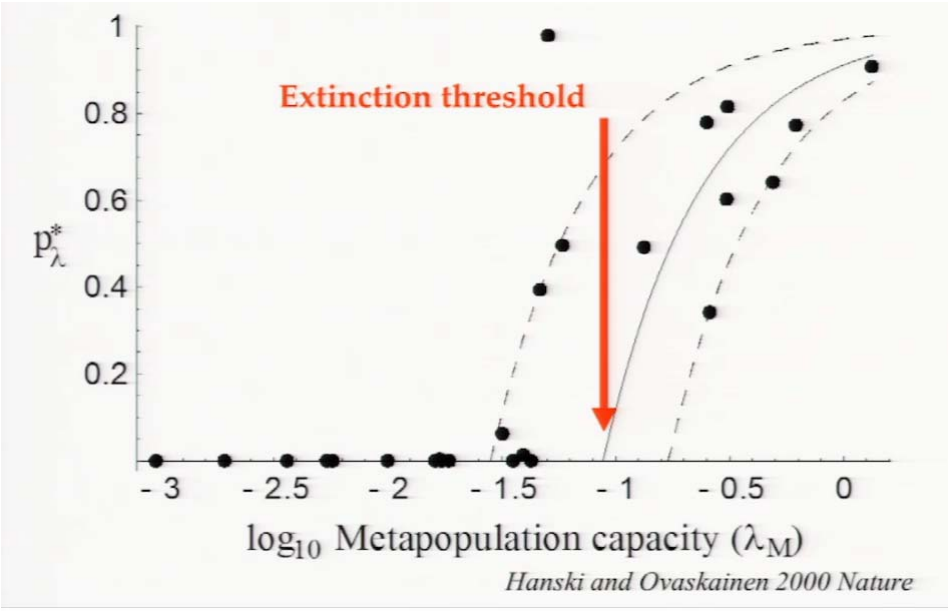
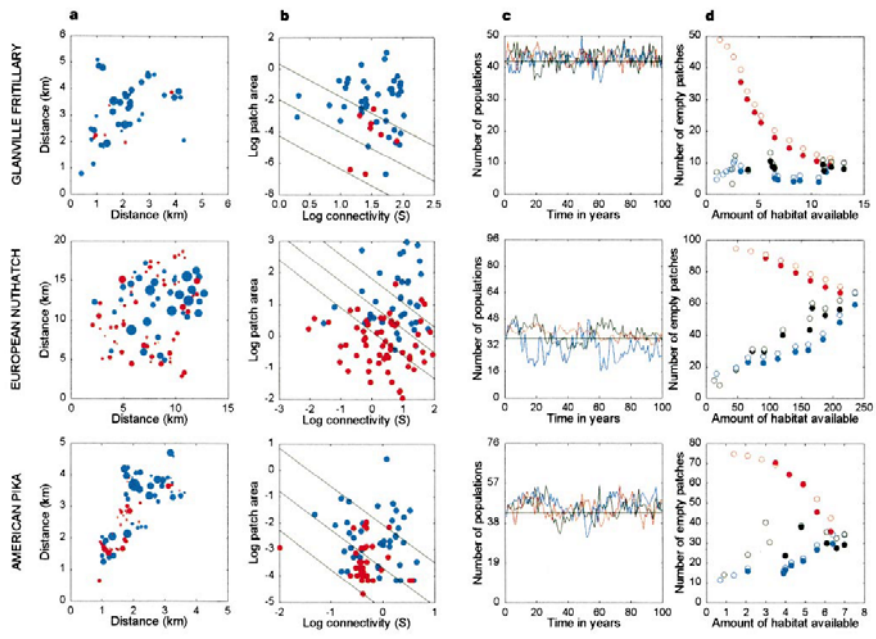
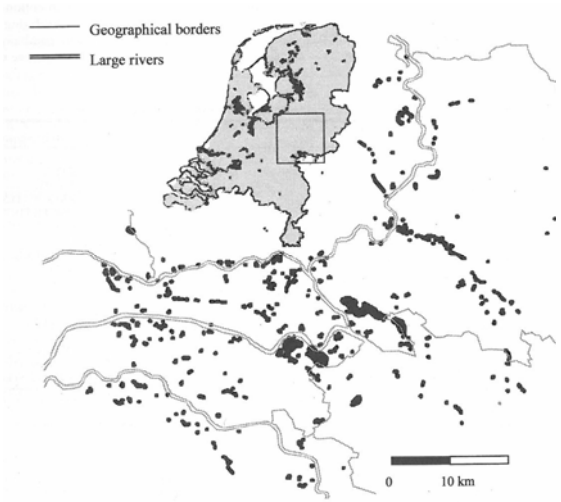




Often also source-sink



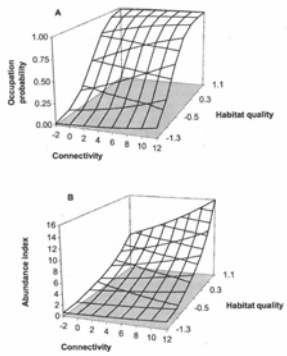


Figure 3. Three-dimensional view of the predicted effects of habitat quality and connectivity on occupation probability and number of Reed Warbler territories. Predictions are for an area with edge length 400 m (1 ha): (a) occupation probability and (b) abundance index.

Foppen et al. 2001

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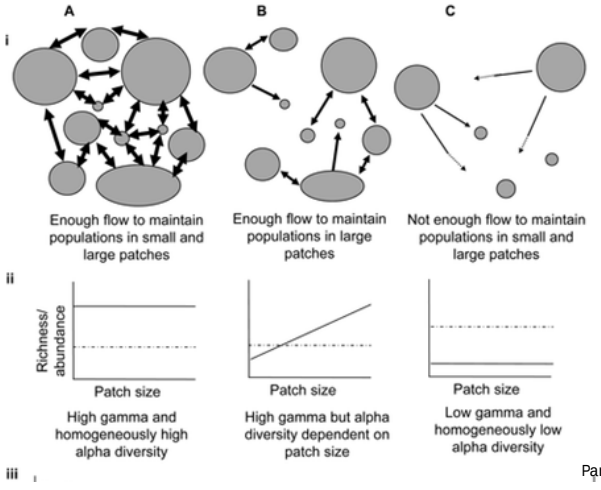
Solution: create viable metapopulation networks



Pardini et al 2010

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Are there thresholds for the % of habitat?

Table 3. Large-landscape studies of the shape of the relationship between habitat proportion and ecological responses

Source and study design (PL: patch landscape; WL: whole-landscape)	Response variable	Taxon	Landscape characteristics: Disturbance type[1]	Range of habitat cover (%)	Landscape size (ha)	Relationship(s) found[2]: Threshold (%)[3]	Linear?	Species (S) or Landscape (L) effects looked for; effect (*) on threshold presence/value[4]
Cushman & McGarigal (2003) (WL)	community (species evenness)	birds	F	0–100	250–3000	no	yes	n/a
Cushman & McGarigal (2003) (WL)	community (species richness)	birds	F	0–100	250–3000	0[20][5]	no	n/a
Lindenmayer *et al.* (2005) (PL)	community (species richness)	birds, lizards	F	0–100	314–1256	no	yes	n/a
Radford *et al.* (2005) (WL)	community (species richness)	birds	A > F	2–60	10 000	10	no	n/a
Schmidt & Roland (2006) (PL)	community (species richness)	insects	A	5–95	12.6	20	no	n/a
Schmidt & Roland (2006) (PL)	community (total abundance)	insects	A	20–95	50–113	40–50	no	S*
Cadson (2000) (~WL)	prevalence (abundance)	bird	V	8–18	Finland	10	no	n/a
Thies & Tscharntke (1999) (PL)	prevalence (parasitism rate)	insects	A	3–65	177	20	yes	S
Imbeau & Desrochers (2002) (PL)	prevalence (presence)	bird	F	0–100	28	no	yes	n/a
Lindenmayer *et al.* (2005) (PL)	prevalence (presence)	birds	F	0–100	314–1256	no	yes	n/a
Bergman *et al.* (2004) (PL)	prevalence (presence)	insects	A	0–30	7850	5–15	no	S*
Radford & Bennett (2004) (PL)	prevalence (presence)	bird	A	0–40	10 000	10–20	no	L*
Guerry & Hunter (2002) (PL)	prevalence (presence)	amphibians	A	10–98	314	no	yes	S, L
Kerkhoff *et al.* (2000) (WL)	prevalence (presence)	mammal	A, U	3–70	90 000	no	yes	n/a
Homan *et al.* (2004) (PL)	prevalence (presence)	amphibians	S, A	0–100	0.3–314	10–50[6], 34–55[7]	yes	S*, L*
Gibbs (1998) (WL)	prevalence (presence)	amphibians	U	8–98	180[8]	50–60	yes	S*
Reunanen *et al.* (2004) (WL)	prevalence (presence)	mammal	F	0–90	100	40	no	n/a
Andrén (1994) (PL)	consistency of results with random sample hypothesis[9]	birds, mammals	V	5–70	various	10[30]	no	n/a

Source: Swift & Hannon 2009

Andren 1994 birds and mammals:10-30%

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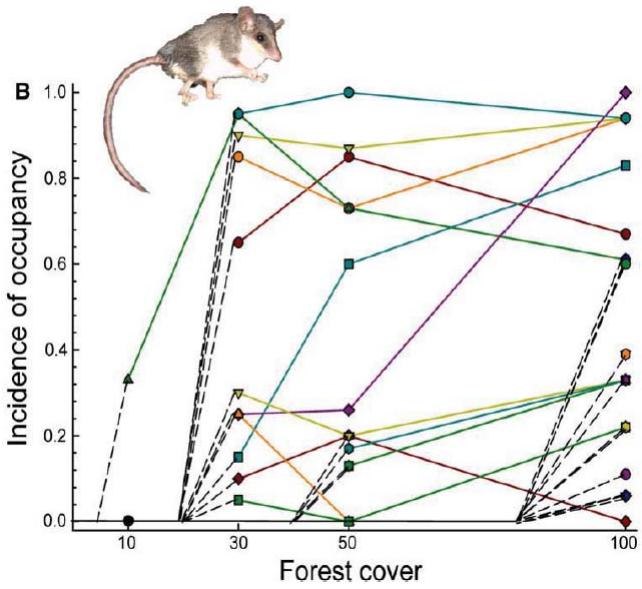

Source: Pardini et al (2010)

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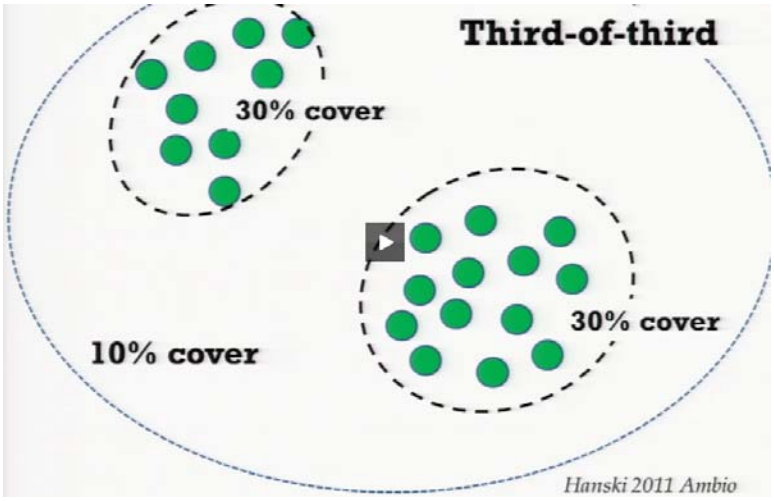
http://www.uttv.ee/naita?id=6768

Third-of-third (Hanski 2011)



- Multiuse conservation landscapes, which are so large that they retain demographically and genetically viable metapopulations (10,000 ha) with in individual habitat fragments (10-100 ha)
- Retain large scale connectivity if conservation landscapes are spread across the country

Hanski 2011

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What about connectivity?

- Linkages in the landscape
- Connections
- Corridors

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Functional role of linkages/corridors

migration: connecting staging areas

(1) commuting: connecting breeding and foraging sites

(2) Dispersal

- Population demography: (re)colonization, rescue effects
- Gene flow
- Range expansions: 'climate proof' landscapes

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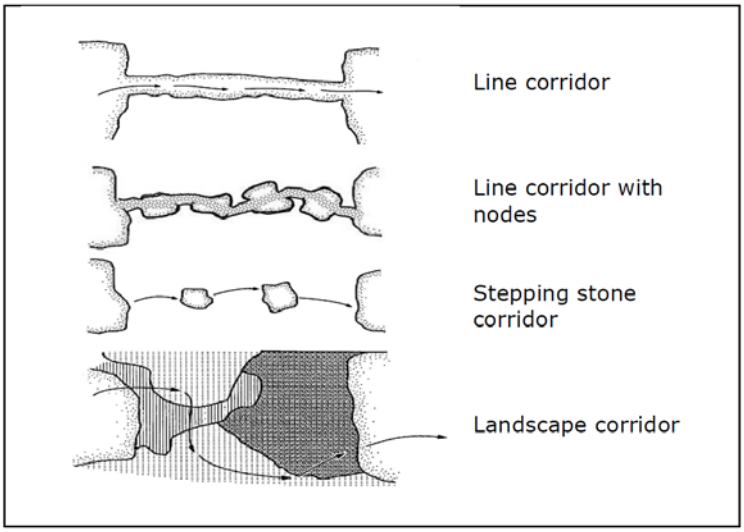

Figure 3: Corridor types (adjusted after Bennett, 1999)

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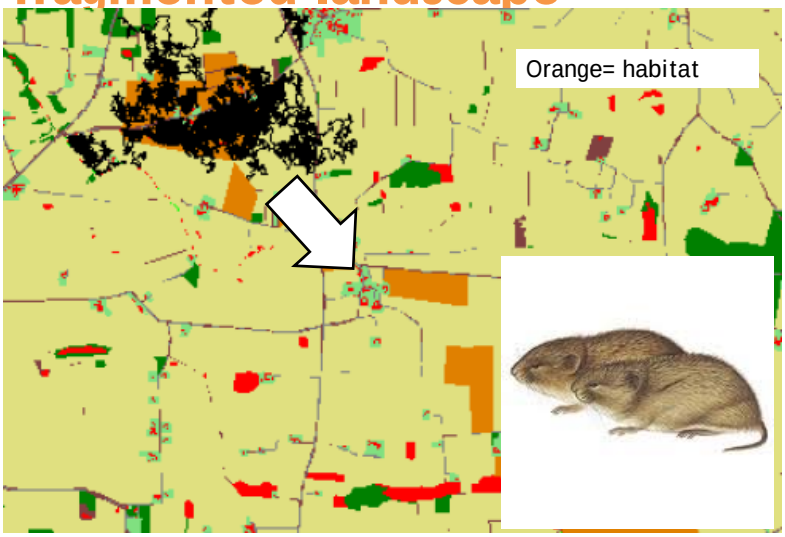
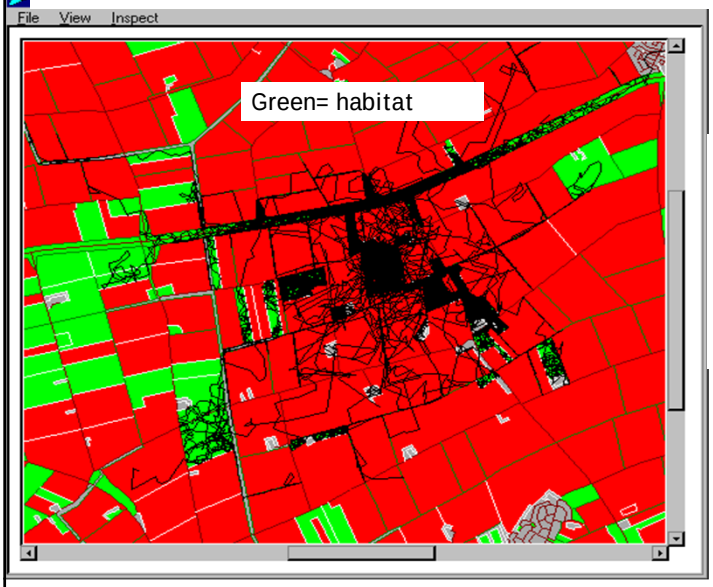
Root vole movements in a fragmented landscape



Tree frog dispersal



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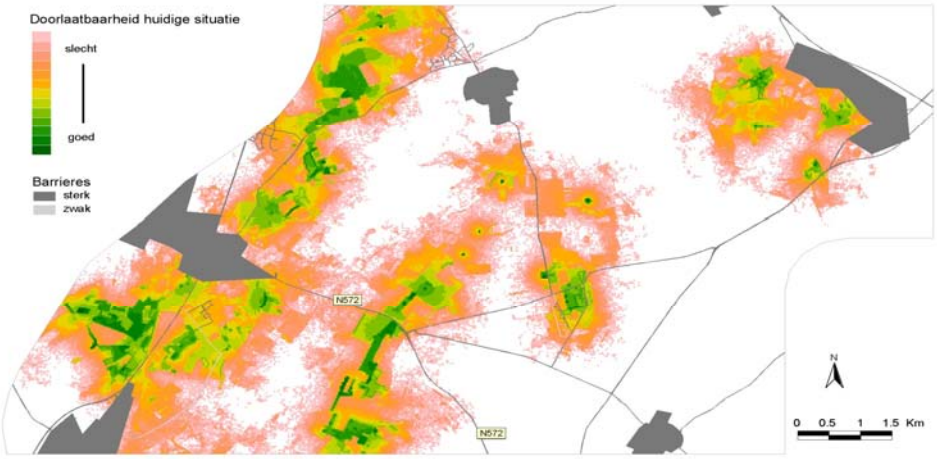
Permeability of the landscape is key question



Is habitat a corridor or corridor habitat?

Notice that there is no clearcut distinction

From habitat patch to corridor is a continuum

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Review

Do Habitat Corridors Provide Connectivity?

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"The evidence from well-designed studies suggests that corridors are valuable conservation tools"

Yes (very probable)!!!!

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What about birds?

They can fly, do they need corridors?

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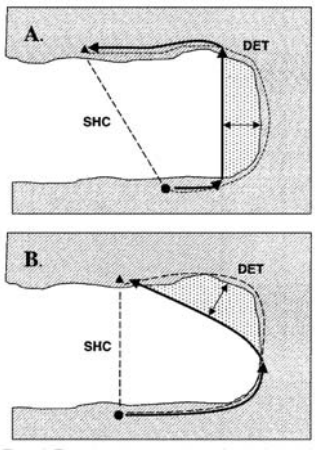
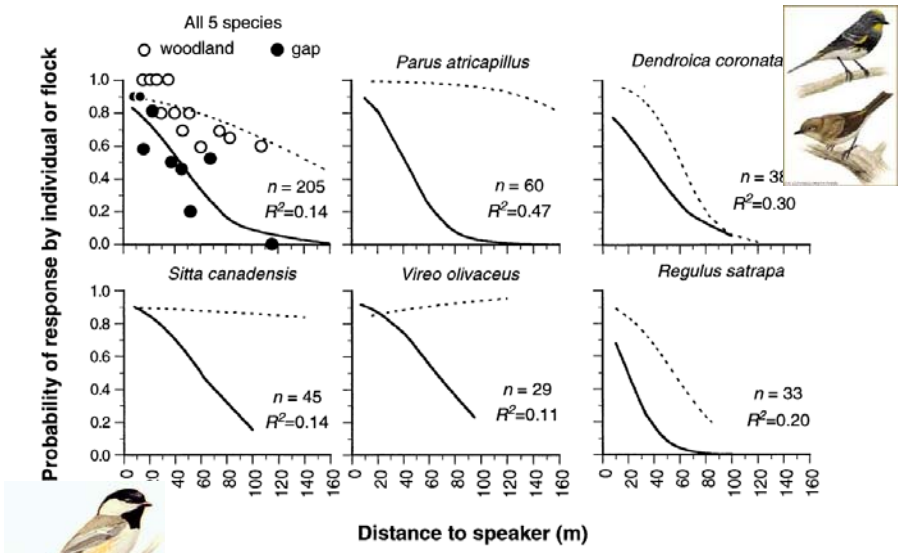
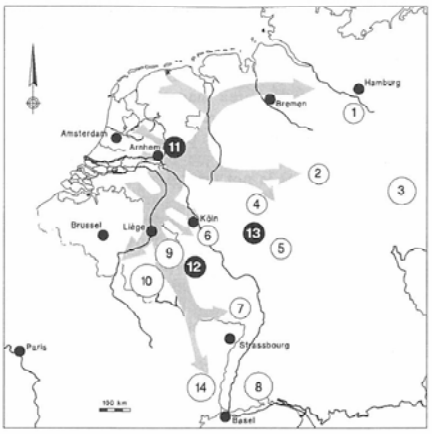
Gap crossing studies Desrochers and Hannon





Landscape planning issues



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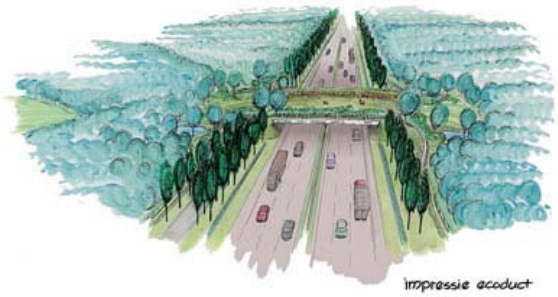
Not: barrier crossings and other green infrastructure



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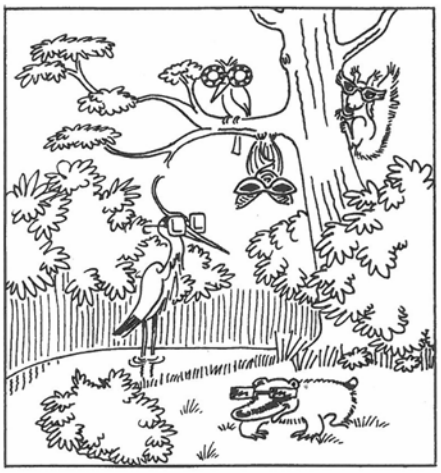
Key message: relevant scale is species dependent



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Corridors function species specific

FIGURE 8.6.
Bird's-eye view of the model 'Crested newt', characterised by hedgerows, small wetlands and ponds.

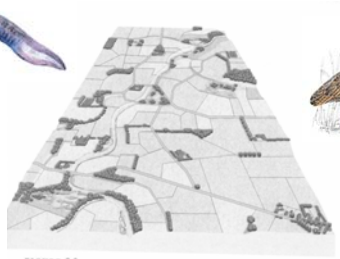

FIGURE 8.8.
Bird's-eye view of the 'Ide' model, dominated by a stream and stream-related wetlands.

FIGURE 8.7.
Bird's-eye view of the 'Badger' model, characterised by small forests, hedgerows and grassland.

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Species specific corridors

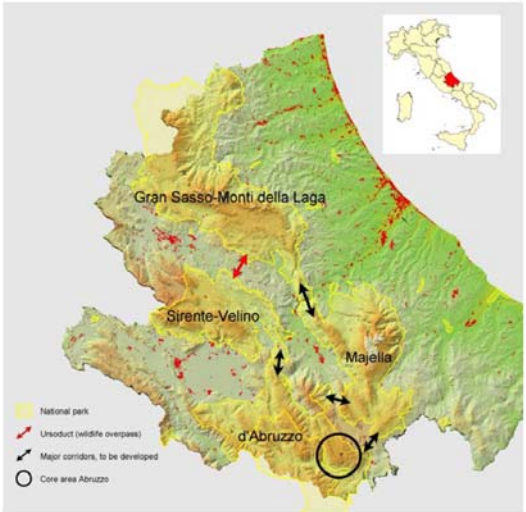

Figure 6: Solutions to defragment Bear habitat in Abruzzo (Van der Sluis et al., 2003a)

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Even on European scale

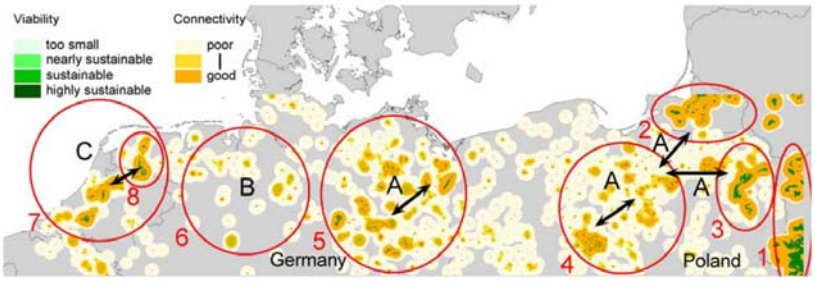

Figure 10: possible corridorrs connecting existing core areas of Large copper

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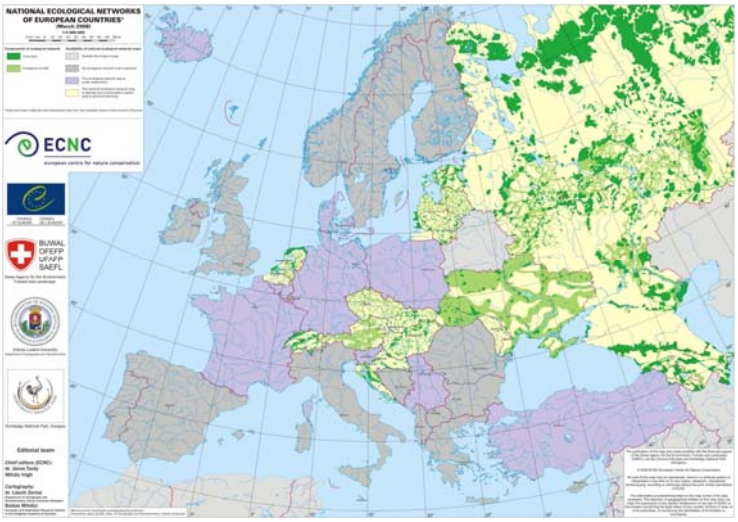
Ecological networks usually habitat connections



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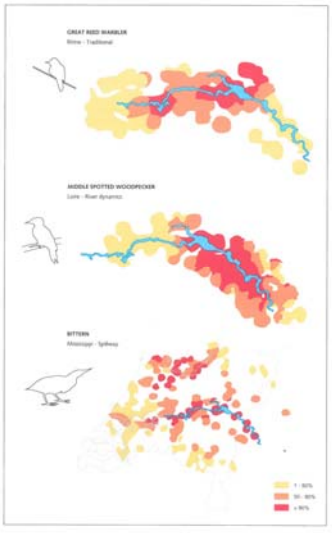
Landscape planning applications

Riverine habitats are ‘natural’ corridors



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Example: rivers in Netherlands ‘connect’ large marshlands

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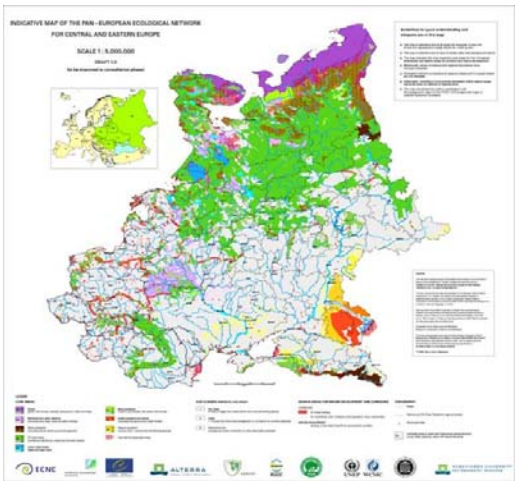
Some indicative maps have been produced including corridors



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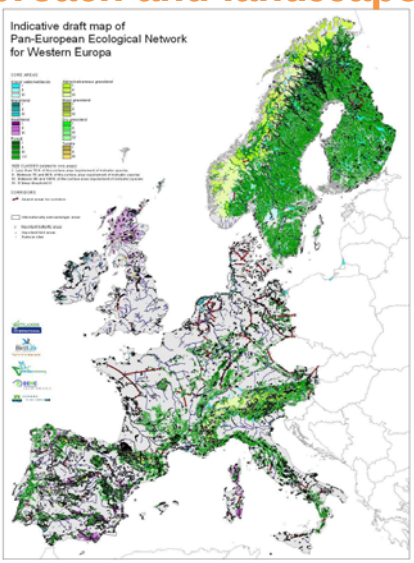
There is a tension between species specific approach and landscape approach



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Suggestions for corridor planning (1)

- Start with proper questions and problem analyses (why, what, where, how)
- Either work with target species and consider appropriate scale ….. or….
- Work with ecoprofiles of a wide range of species
- Consider a variety of corridor types

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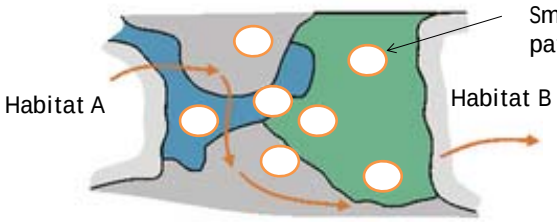
Suggestions for corridor planning (2)

Probably for regional (or national) applications combinations of corridor types most effective: permeable landscapes with metapopulation habitat structure

(consider third of third principle?)



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Thanks for your attention!

Thanks to Elwin van der Kolk for (most of) the illustrations