Identifying connectivity requirements for the Natura 2000 network

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Den Bosch, 08.04.2014

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Natura 2000 is an ecological **network of protected areas**, set up to ensure the **survival** of Europe's most valuable **species** and **habitats**.

The green infrastructure it provides safeguards numerous **ecosystem services** and ensures that Europe's natural system remain **healthy and resilient**.

Natura 2000 is **not a system of strict nature reserves** where all human activities are excluded.

Whereas the network will certainly include nature reserves most of the land is likely to **continue to be privately owned** and the emphasis will be on ensuring that future **management is sustainable**, both ecologically and economically

"Member states must encourage the management of features of the landscape which are essential for the **migration, dispersal and genetic exchange** of wild species"

- **Green network to connect N2000 sites**
- **How to define a functional network?**
  - * The real world is also patchy
  - How much connection is needed?
    - For what means are connections required?

Natura 2000 is the sum of Bird and Habitat directives

Not designed bottom-up

- Not based on spatial coherence
- Not designed a priori as network
- Based on “best remaining sites”
- Influenced by lobbying
- Taxonomically biased
- Heterogenous quality across member states
- Heterogenous fragmentation

Natura 2000 is the sum of Bird and Habitat directives

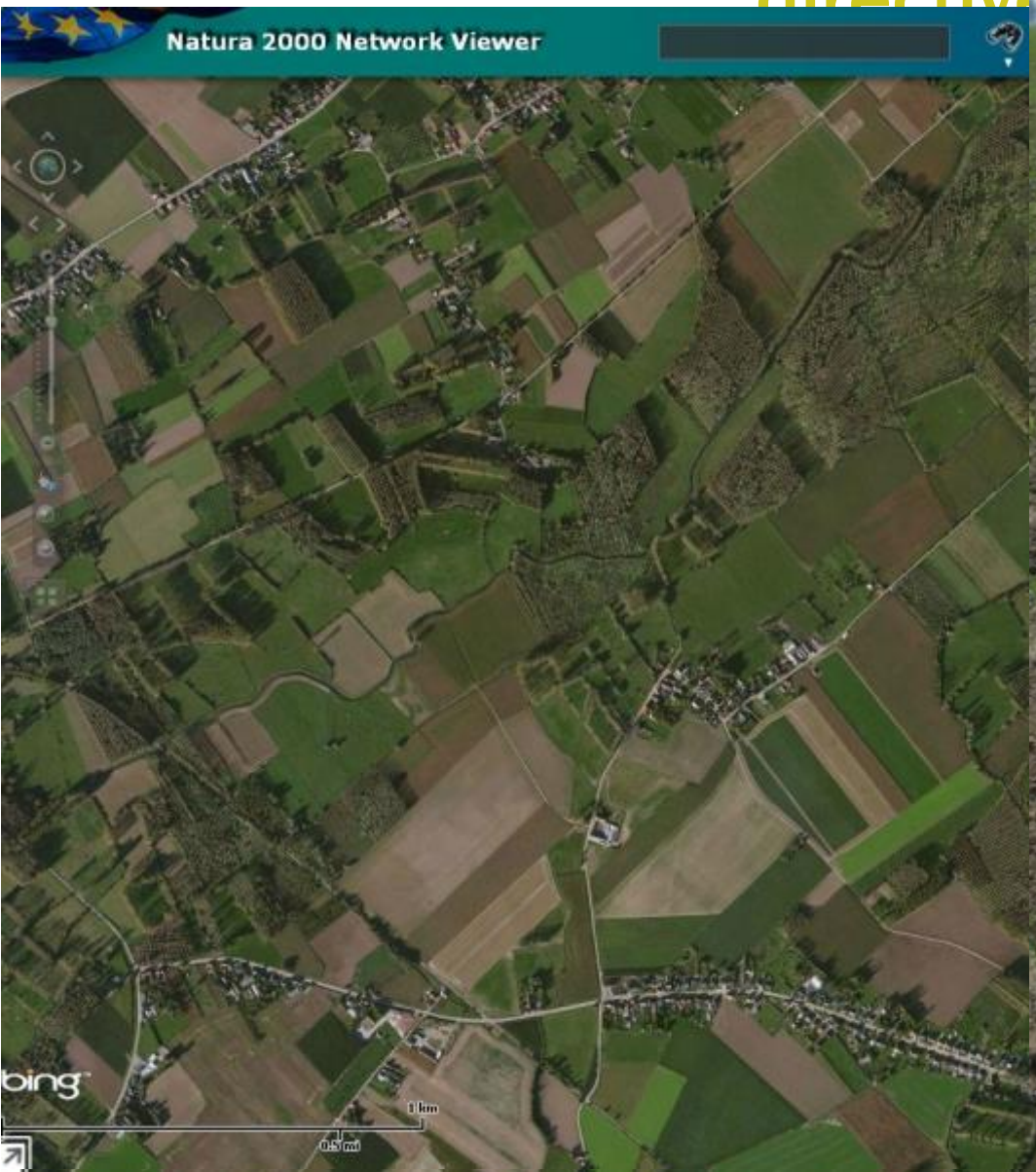
In Flanders: sites often internally fragmented

Area size	Nationally protected areas (CDDA)	Natura 2000 sites
<1	12%	2%
1 - 100 ha	65%	33%
100 - 1 000 ha	16%	33%
1 000 - 10 000 ha	5%	23%
>10 000 ha	2%	9%

Source: EEA Version 9, June 2011 and Natura 2000 data base version 2011

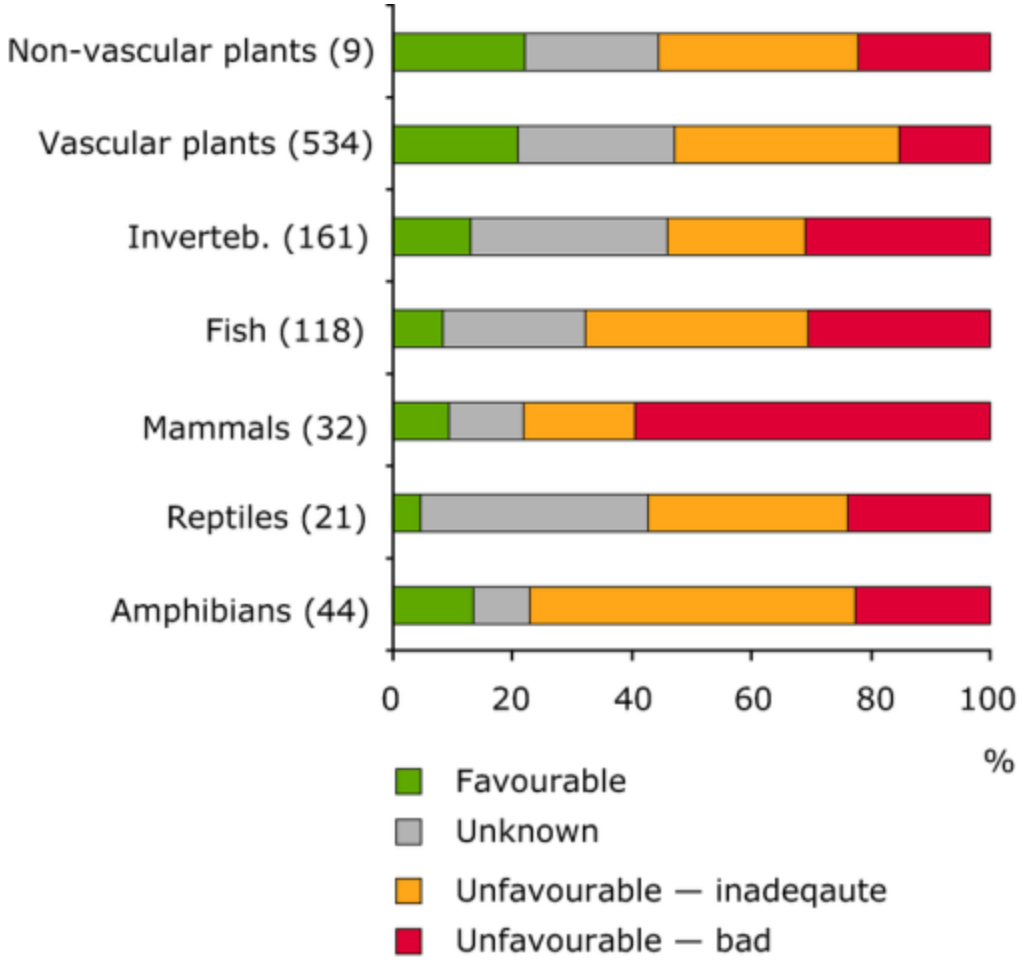
Natura 2000 is the sum of bird and habitat directives

Natura 2000 is the sum



Natura 2000 is the sum of bird and habitat directives

The annex species list: means to conserve nature (sensu lato) or a goal in itself? (Flemish gov?)



Why do we need connections? (and when?)

Extinction - colonization

Drift - Gene flow

Range shifts

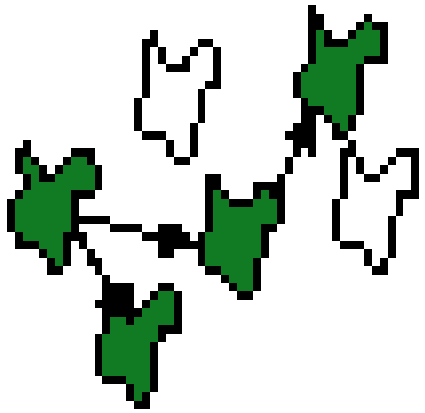
Local adaptation & evolution

Extinction - colonization

Metapopulation dynamics

Populations go extinct due to chance

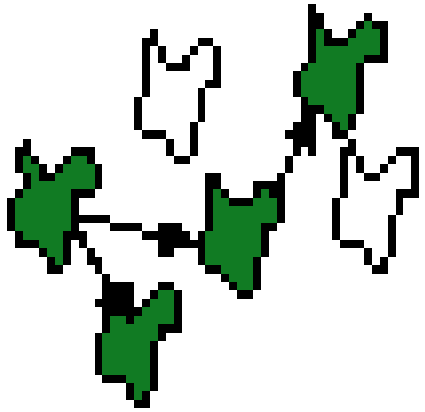
Prob. Extinction is function of size



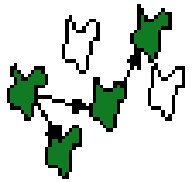
Extinction - colonization

Metapopulation dynamics

Prob. colonization is function of number of occupied patches and distance

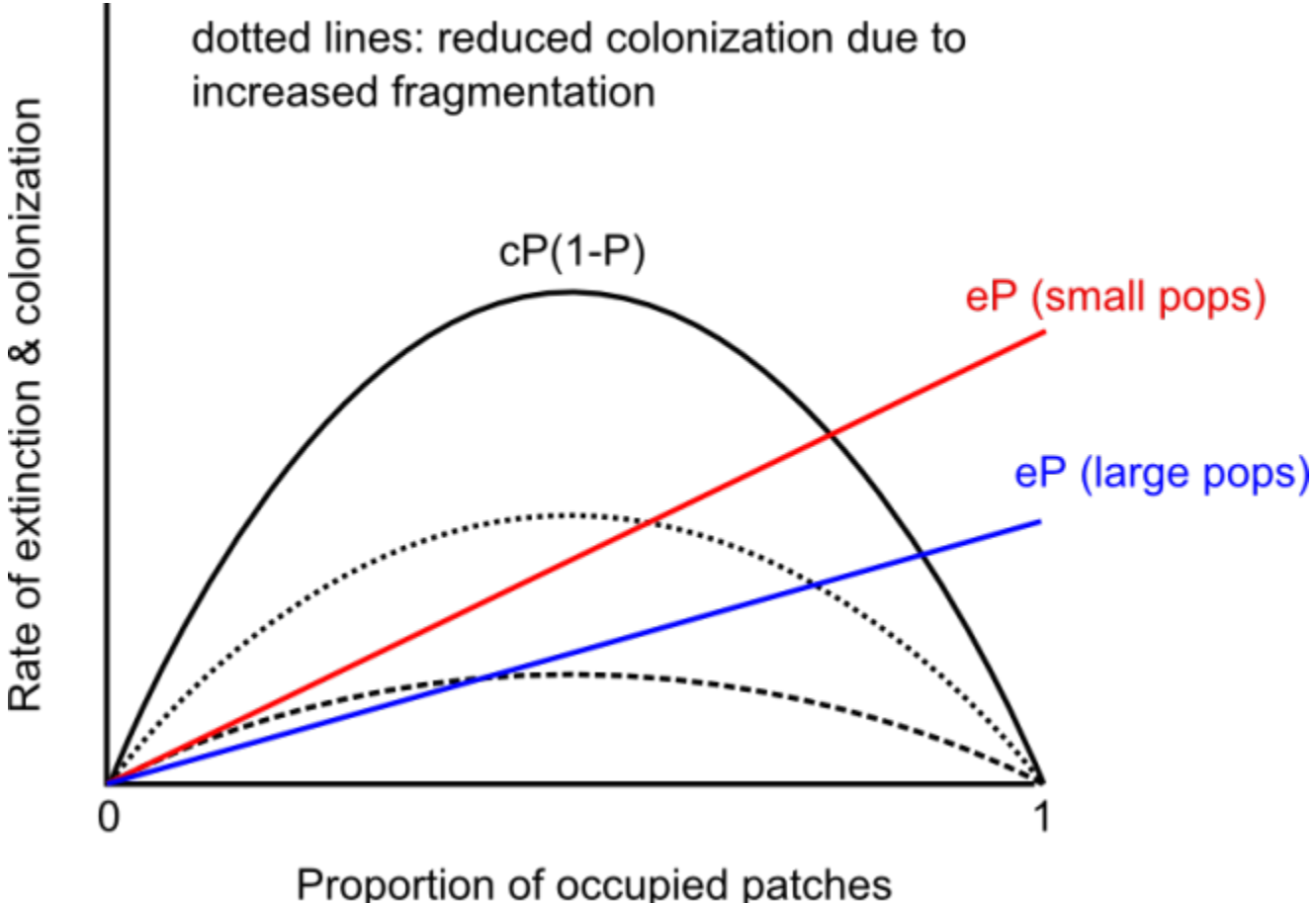


Extinction - colonization



Extinction: local factors

Colonization: regional factors



Extinction - colonization

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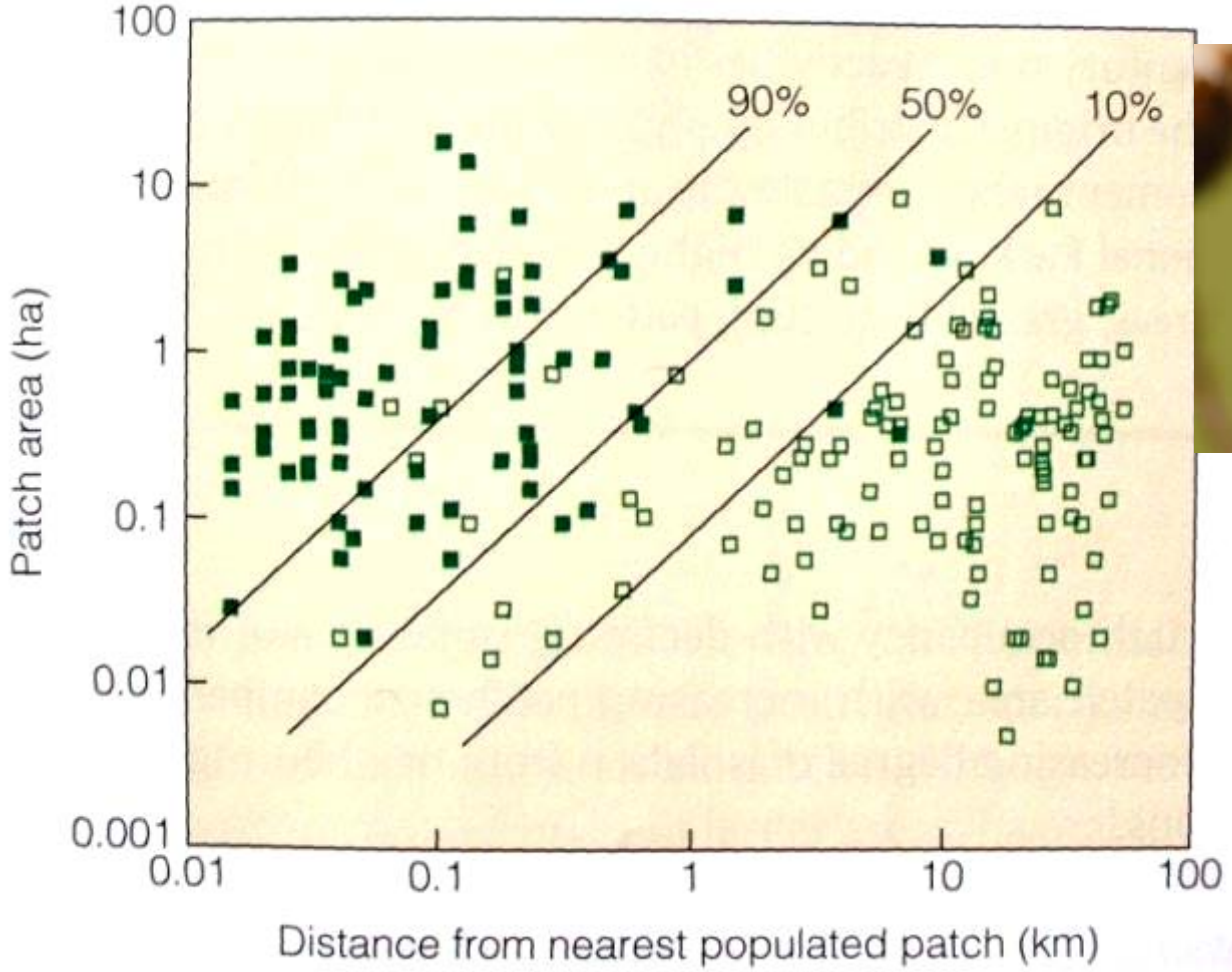


Drift – gene flow

“Extinction - colonization of alleles”

Gene flow compensates for drift-mediated loss of genetic diversity

Goal of connections: retaining genetic diversity

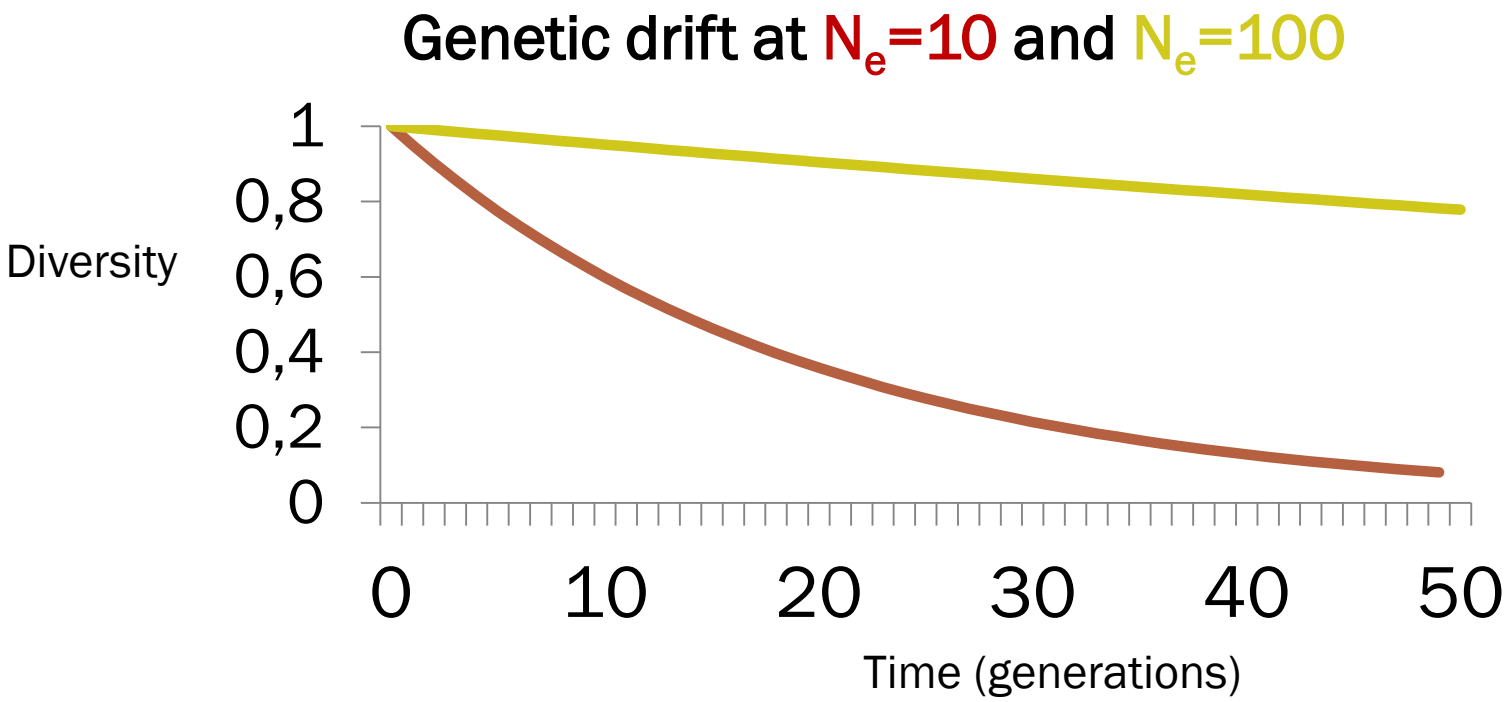
➔ inbreeding, evolutionary potential

Loss if diversity is slower in large populations

➔require less immigration

(note parallel with Levin’s metapopulation)

Drift – gene flow



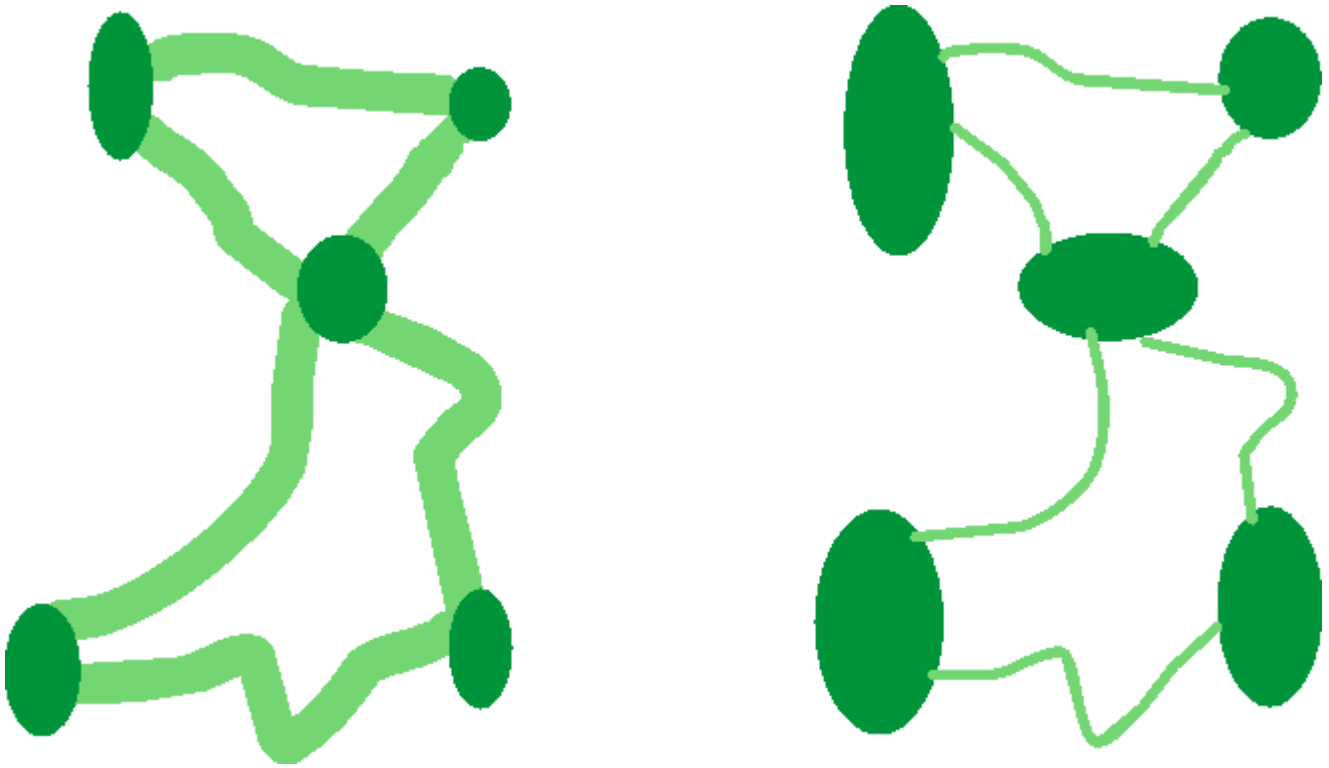
At $N_em > 1$ the equilibrium genetic diversity of each subpopulation is 80% of that of the total population

Drift – gene flow

If N=10, migration rate must be > 5% for Nm>1

If N=100, migration rate must be > 0.5% for Nm>1

Small populations require more robust connections



Drift – gene flow

Critical distance between subpopulations defining functional connectivity?

Evolutionary Applications

Open Access

Evolutionary Applications ISSN 1752-4571

ORIGINAL ARTICLE

Joint effects of population size and isolation on genetic erosion in fragmented populations: finding fragmentation thresholds for management

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Genetic approach towards FRP?

Genetic criteria for

- Total population size $N_e > 500$
- Metapopulation size N_{e95}
- Connectivity $N_e m > 1$

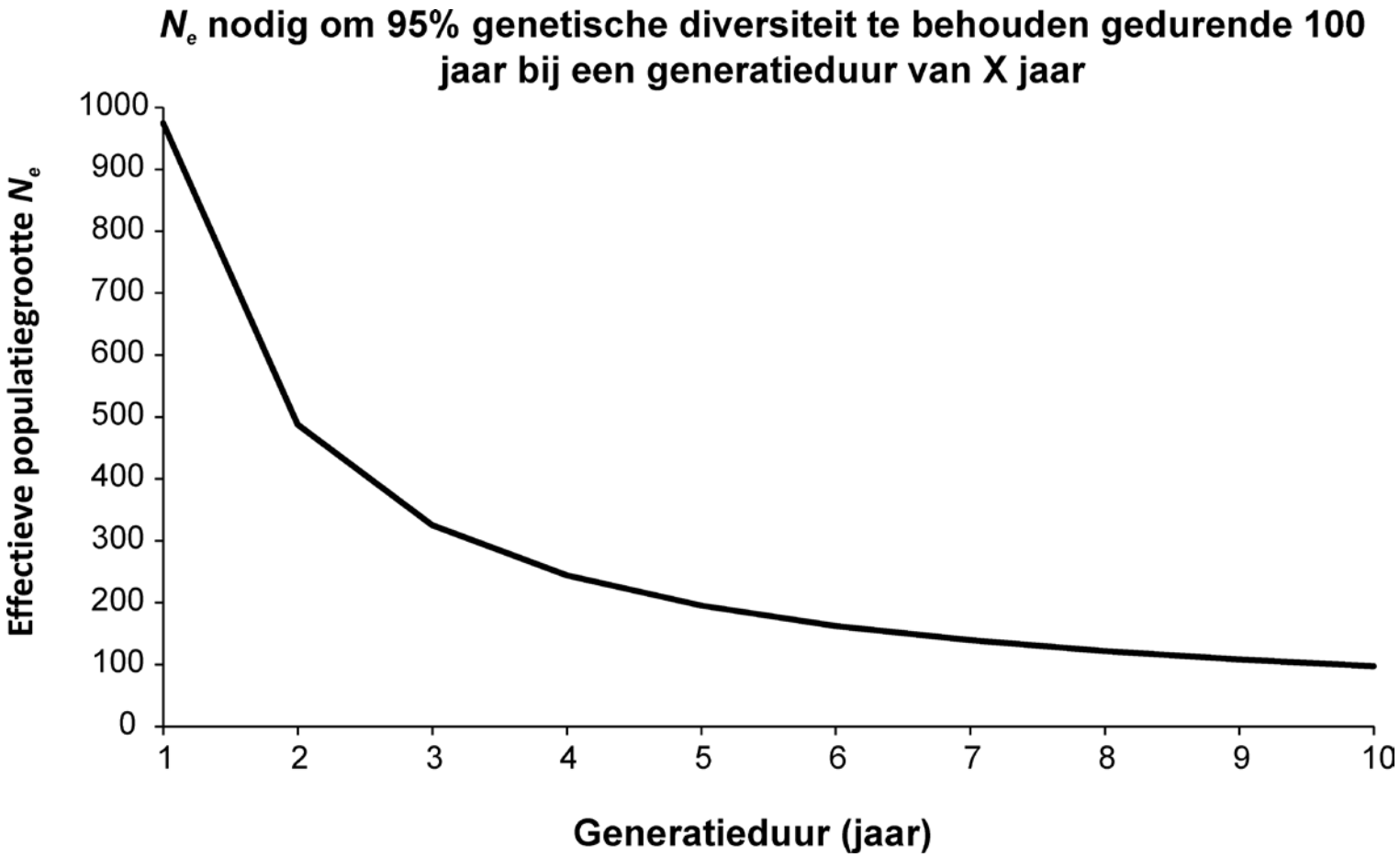
At metapopulation scale: mantain 95% of genetic diversity over 100 years, t generations

$$N_{e,95} = \frac{t}{-2ln(0.95)}$$

Genetic approach towards FRP?

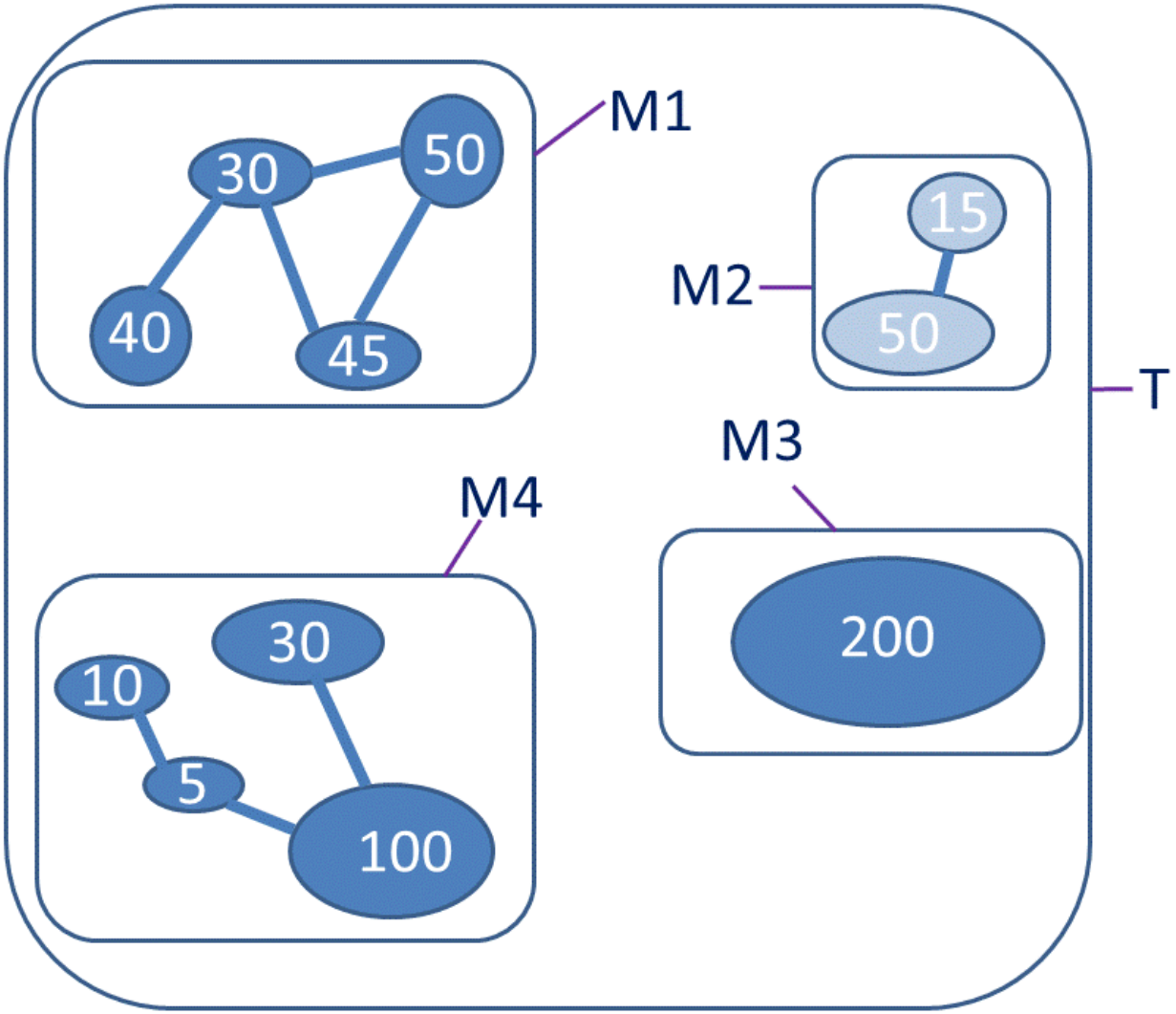
Retaining 95% GD per 100 y ~ *Retaining alleles with frequency > 0.5%*

$N_e \approx t/(-2Ln(Ht/H0))$
$T_{loss} = -4N_e\ P\ LnP/(1-P)$ *(Kimura & Ohta 1969)*



Total meta local criteria

Moor frog– N_{e95} = 139



M1: 165
M2: 65
M3: 200
M4: 145

$\Sigma(M_i > N_{e95}) = 510 > 500$

➔ Favourable total

Identifying bottlenecks in total-meta-local

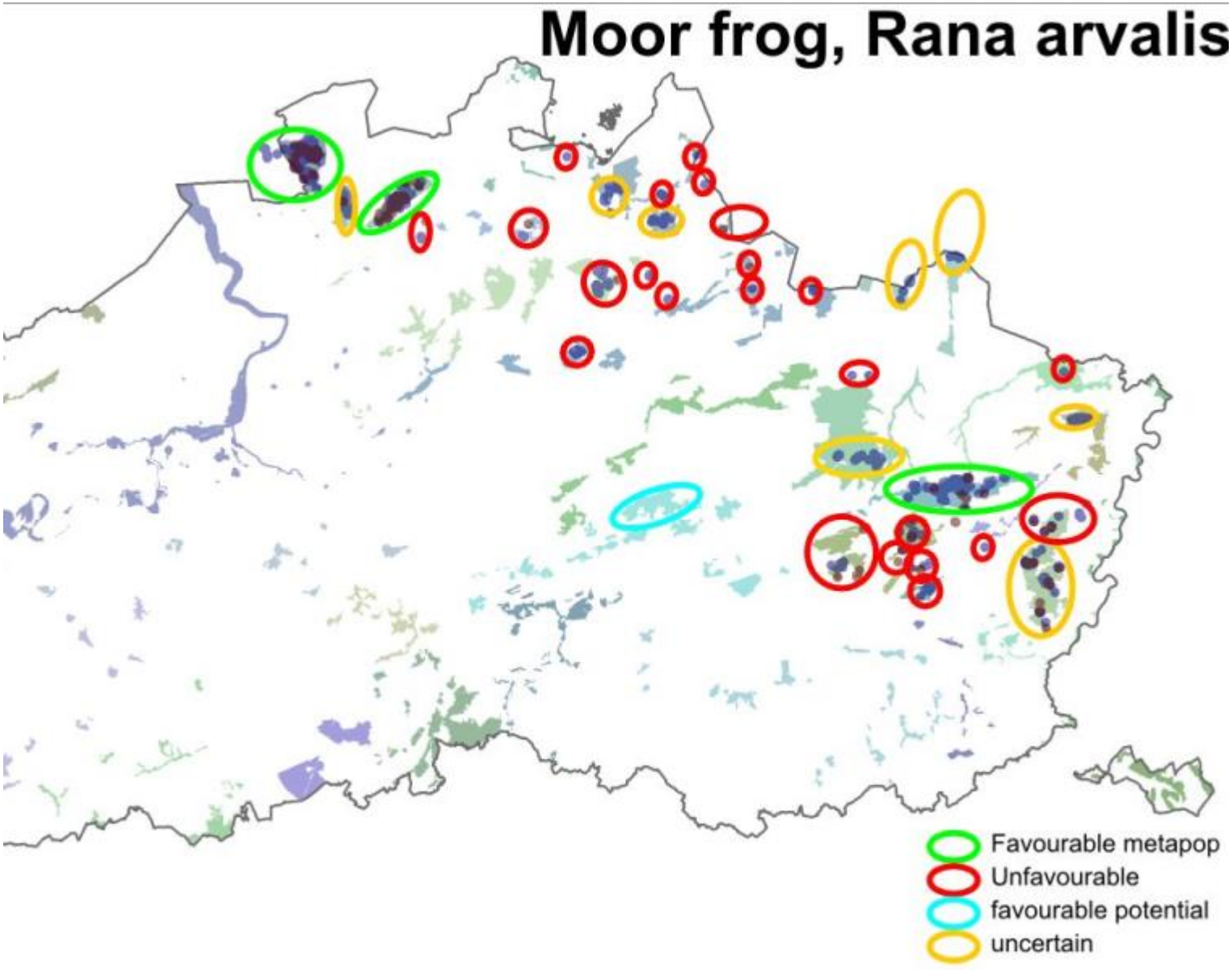
Theoretic test case on amphibians & reptiles

N_e/N_c ~0.1

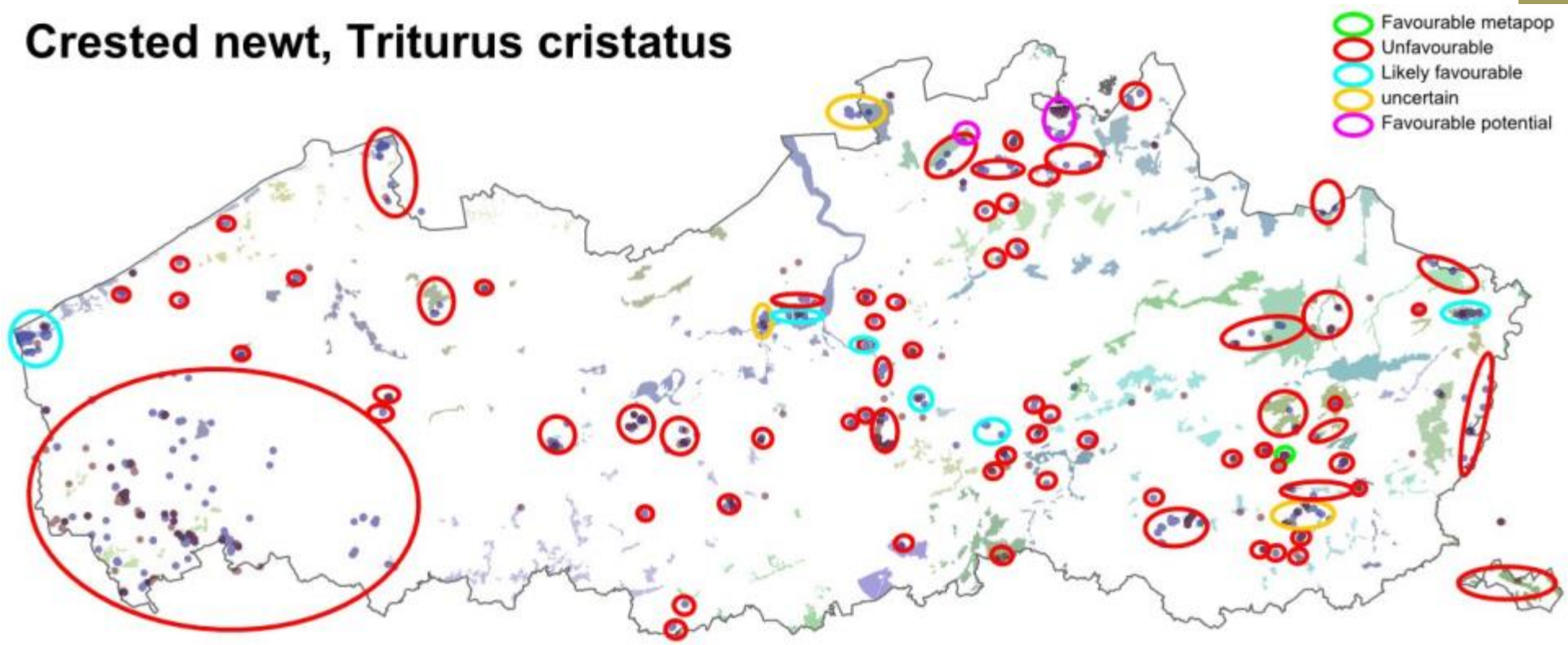
N_{e95} → area requirements of optimal habitat?

Species	gen time	N_{e95}	Est. census size ~ N_{e95}	area requirements per ind in optimal habitat	minimal area for N_{e95}	(size of MVP in LARCH-database, Alterra)
Tree frog	3	325	3250	0.05-0.08 ha	160-250 ha	125 ha
pool frog	3	325	3250	0.05 ha	160 ha	125 ha
moor frog	6	163	1625	0.05 ha	80 ha	125 ha
spadefoot toad	3	325	3250	0.05 ha	160 ha	125 ha
midwife toad	4	244	2438	?	?	NA
Natterjack toad	4	244	2438	0.05-0.09 ha	120-210 ha	125 ha
Crested newt	7	139	1393	0.01 ha	14 ha	12.5 ha
Smooth snake	7	139	1393	0.33 – 1.0 ha	500-1500 ha	900-1500 ha

Total-meta-local



Total-meta-local



Total-meta-local

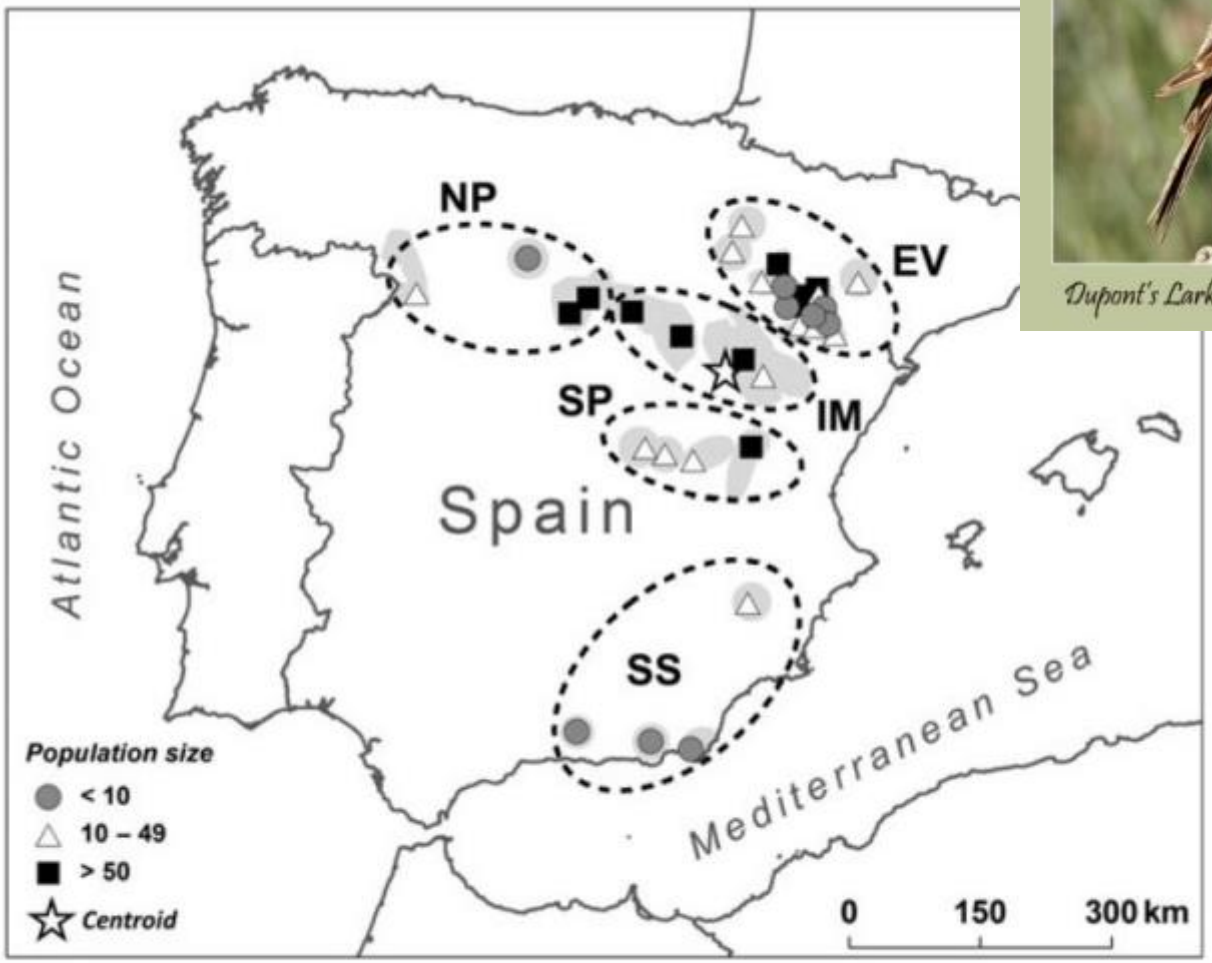


Figure 1 Location of the sampled Dupont's lark local populations in Spain. Different symbols indicate different population sizes (number of

Mendez et al. 2014
Evol Appl
Interaction between Size and isolation identified
Critical tresholds for management of genetic diversity

Natura 2000 and climate change

nature climate change

LETTERS

PUBLISHED ONLINE: 26 FEBRUARY 2014 | DOI: 10.1038/NCLIMATE2113

Life history and spatial traits predict extinction risk due to climate change

Richard G. Pearson[1,2], Jessica C. Stanton[3], Kevin T. Shoemaker[3], Matthew E. Aiello-Lammens[3], Peter J. Ersts[2], Ned Horning[2], Damien A. Fordham[4], Christopher J. Raxworthy[2], Hae Yeong Ryu[3], Jason McNees[5] and H. Reşit Akçakaya[3]*

Extinction risk for N-American amphibians and reptiles in 100 y

23% (mitigation scenario) to 28% (business as usual)

"Occupied area was consistently the most important predictor, most likely because it provides a comprehensive measure of the breadth of climatic and habitat conditions under which a species can persist"

Natura 2000 and climate change

Pearson et al. 2014

need for connections to allow range shifts

←→ Natura 2000 as a static “network” !!

Natura 2000 and climate change

Pearson et al. 2014

need for connections to allow range shifts

←→ Natura 2000 as a static “network” !!

Natura 2000 and climate change

Range expansion requires effective long-distance dispersal

50 YEARS WITH IMPACT

Journal of Applied Ecology

British Ecological Society

Journal of Applied Ecology 2014, **51**, 171–182 doi: 10.1111/1365-2664.12179

Stepping stones are crucial for species' long-distance dispersal and range expansion through habitat networks

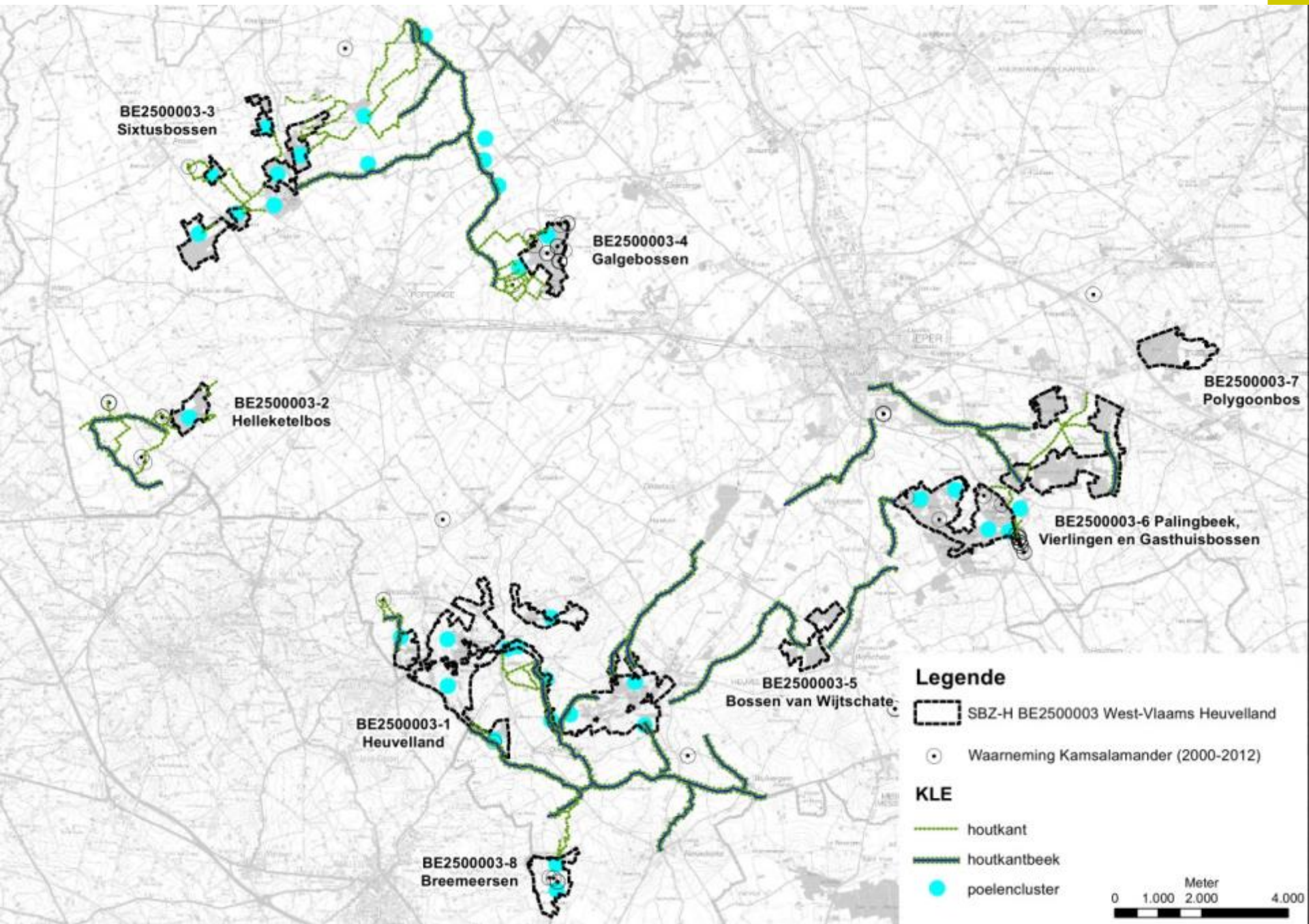
Santiago Saura[1]*, Örjan Bodin[2] and Marie-Josée Fortin[3]

[1]ETSI Montes, Universidad Politécnica de Madrid, Ciudad Universitaria s/n, 28040 Madrid, Spain; [2]Stockholm Resilience Centre, Stockholm University, Stockholm 106 91, Sweden; and [3]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON M5S 3G5, Canada

Natura 2000 and climate change

Saura et al. 2014:

- The loss of intermediate and sufficiently large stepping stone habitat patches causes a sharp decline in the distance that can be traversed by species
- Species-specific
- Stepping stones with scarce or poor habitat resources are useless in promoting long-distance dispersal


BE2500003-3
Sixtusbossen
BE2500003-4
Galgebossen
BE2500003-2
Helleketelbos
BE2500003-7
Polygoonbos
BE2500003-6 Palingbeek,
Vierlingen en Gasthuisbossen
BE2500003-5
Bossen van Wijtschate
BE2500003-1
Heuvelland
BE2500003-8
Breemeersen
Legende
SBZ-H BE2500003 West-Vlaams Heuvelland
Waarneming Kamsalamander (2000-2012)
KLE
houtkant
houtkantbeek
poelencluster
Meter
0
1.000
2.000
4.000

Crested newt in West-Vlaamse Heuvelland: which connections?

"Handboek Robuuste Verbindingen" Alterra 2001:

Connection for GCN:

c. 50 km connections

Corridor: 250-500 m wide

Every 2 km "fuelling station" of 5 ha

Single connection of 12 km: 110 ha of land use

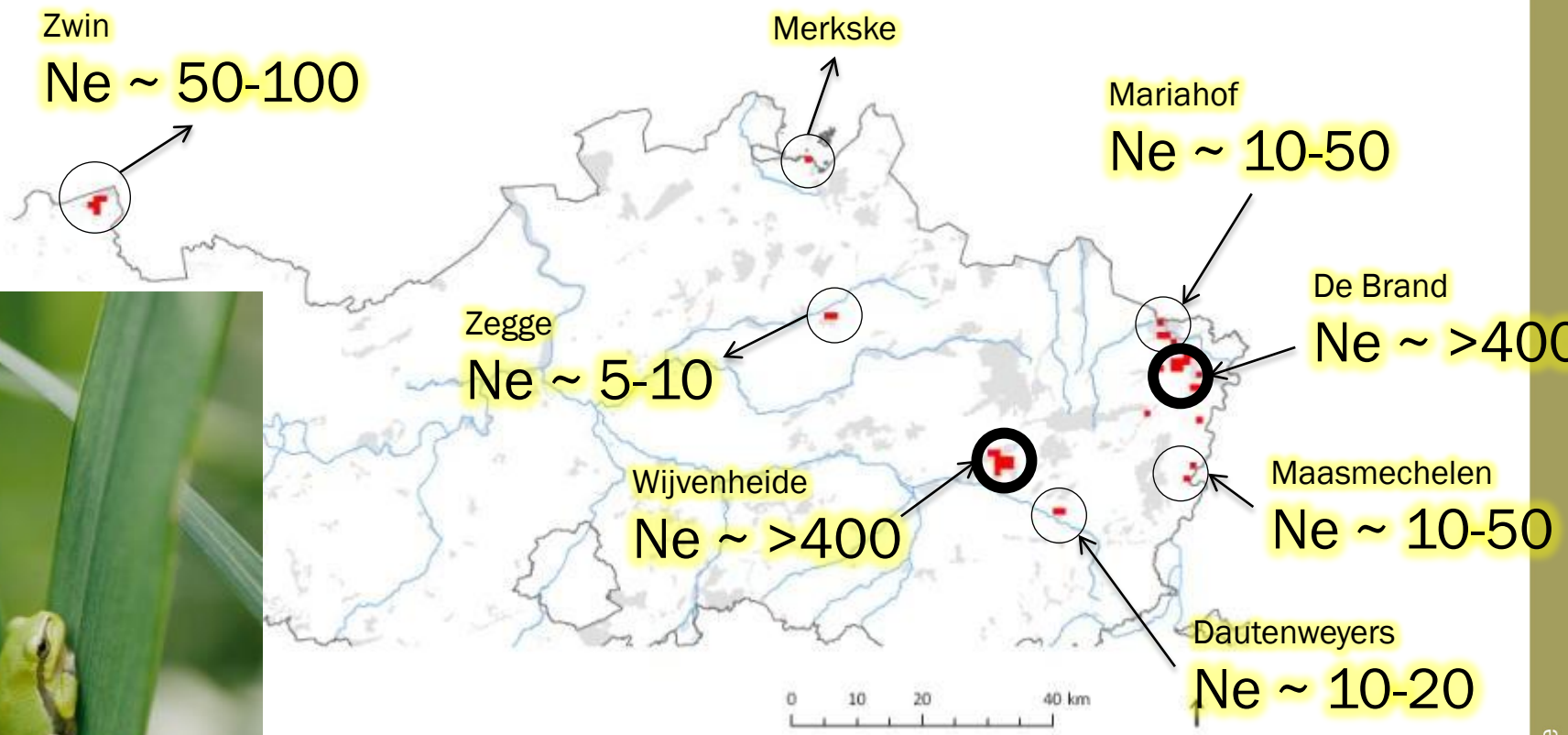
Requirements for Ne95 metapopulation: 15 ha

...

Tree frogs in Belgium: which connections?

Common tree frog, Hyla arborea. $N_{e,95}$ = 244

Current estimates (guesses) of N_e



Tree frog in Belgium

Common tree frog, Hyla arborea. $N_{e,95} = 244$

Majority of current “metapopulations” too small

Most isolated populations or metapopulations cannot be connected functionally to other populations

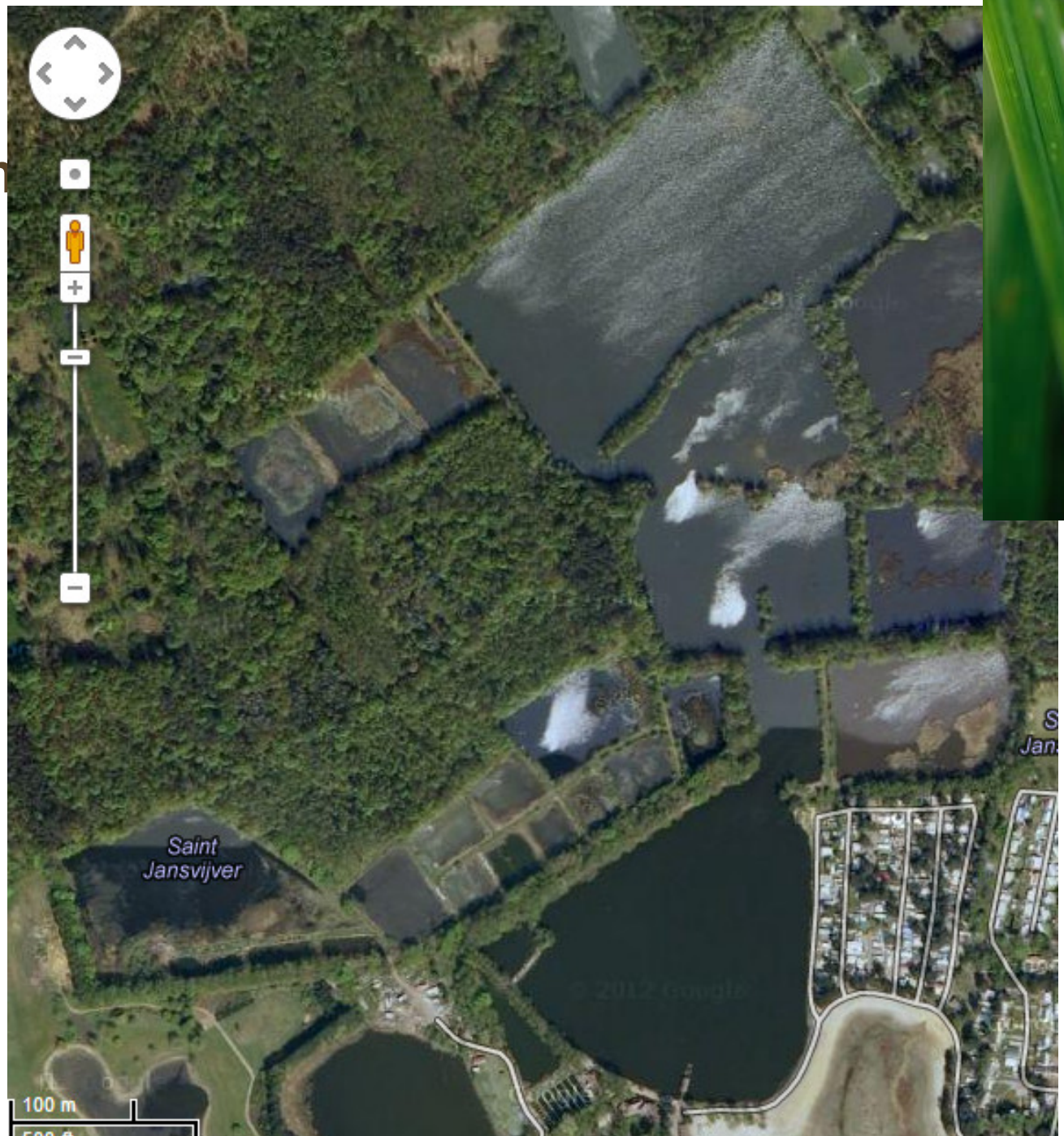
- → enlarging to Ne95 only option

Metapopulation size

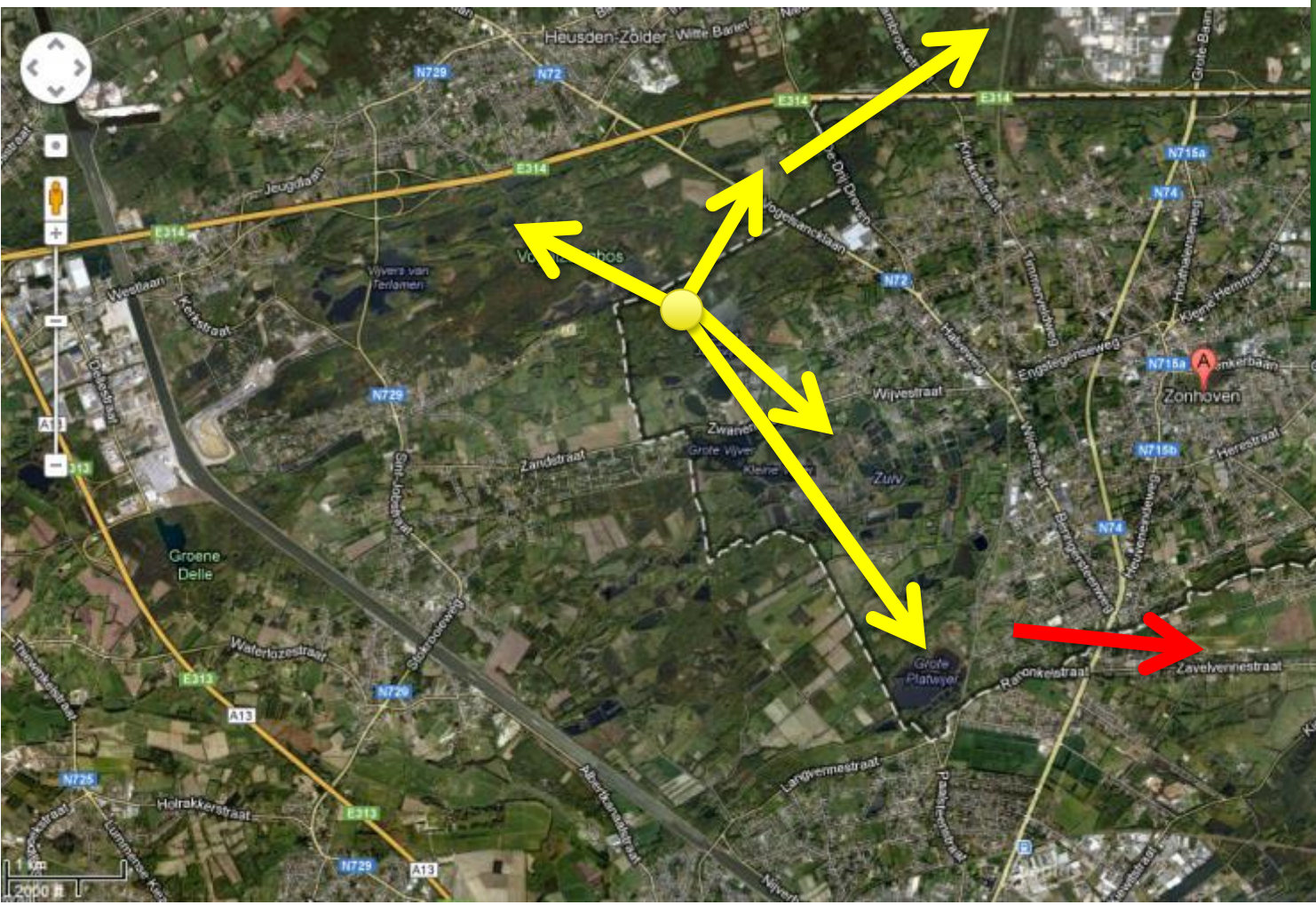
Common tree frog, Hyla arborea in Vijvergebied

- 2000: isolated small population

Comm



Tree frog in Belgium



Tree frog in Belgium

Vijvergebied Zonhoven:

2000: isolated small population

2012 “Vijvergebied”:

- Population size: c. 3000 – 4000 frogs
- Distributed over area > 100x larger

Increasing habitat quality and quantity led to increased functional connectivity

Lawton et al. 2010, Ovaskainen 2012: Enlarging (UK, NL) is top priority. Enlarging will automatically increase average connectivity.

Metapopulation size

Common tree frog, Hyla arborea in Vijvergebied

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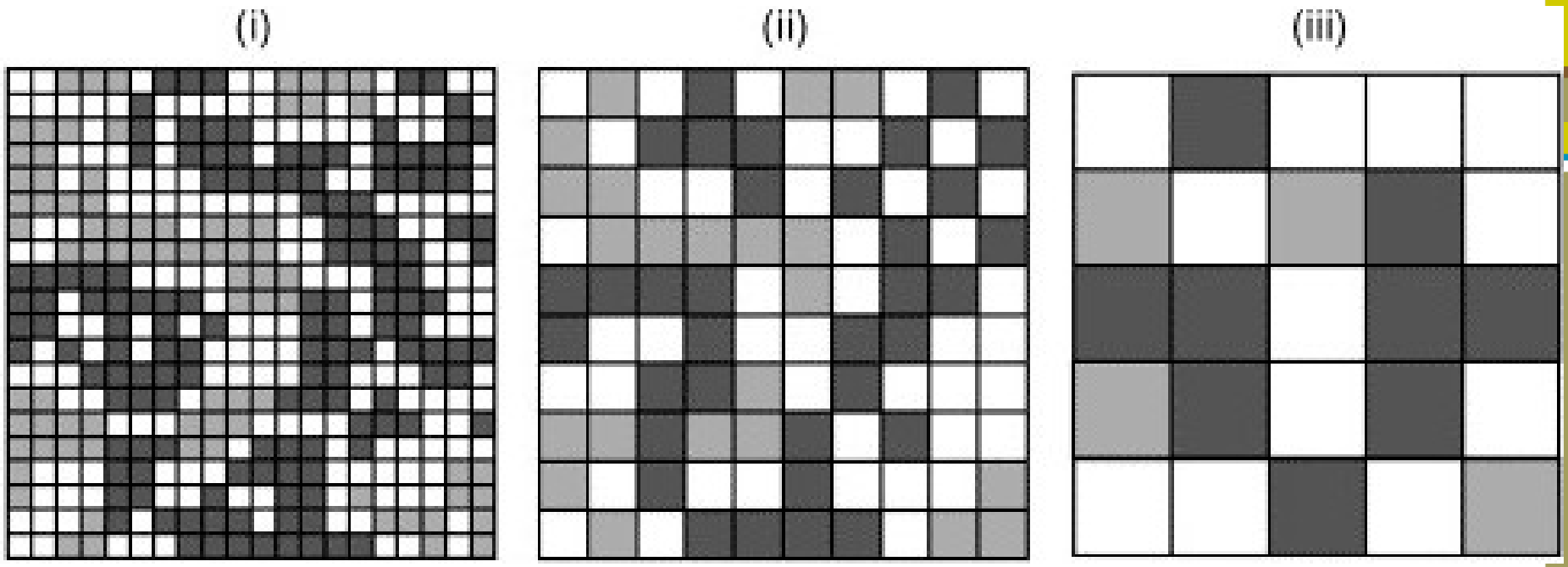
Connecting using green infrastructure

Connectivity is perceived differently by different species

Green infrastructure connects populations, not ecosystems

Misconception: green infrastructure connects ecosystems / nature reserves

Species differ in their perception of fragmentation



- Need for defragmentation varies across taxa
- Physical connection does not guarantee functional connectivity and vice-versa

Species differ in their perception of fragmentation

Species differ in their perception of connectivity (grain)

Functional connectivity is defined at the species level

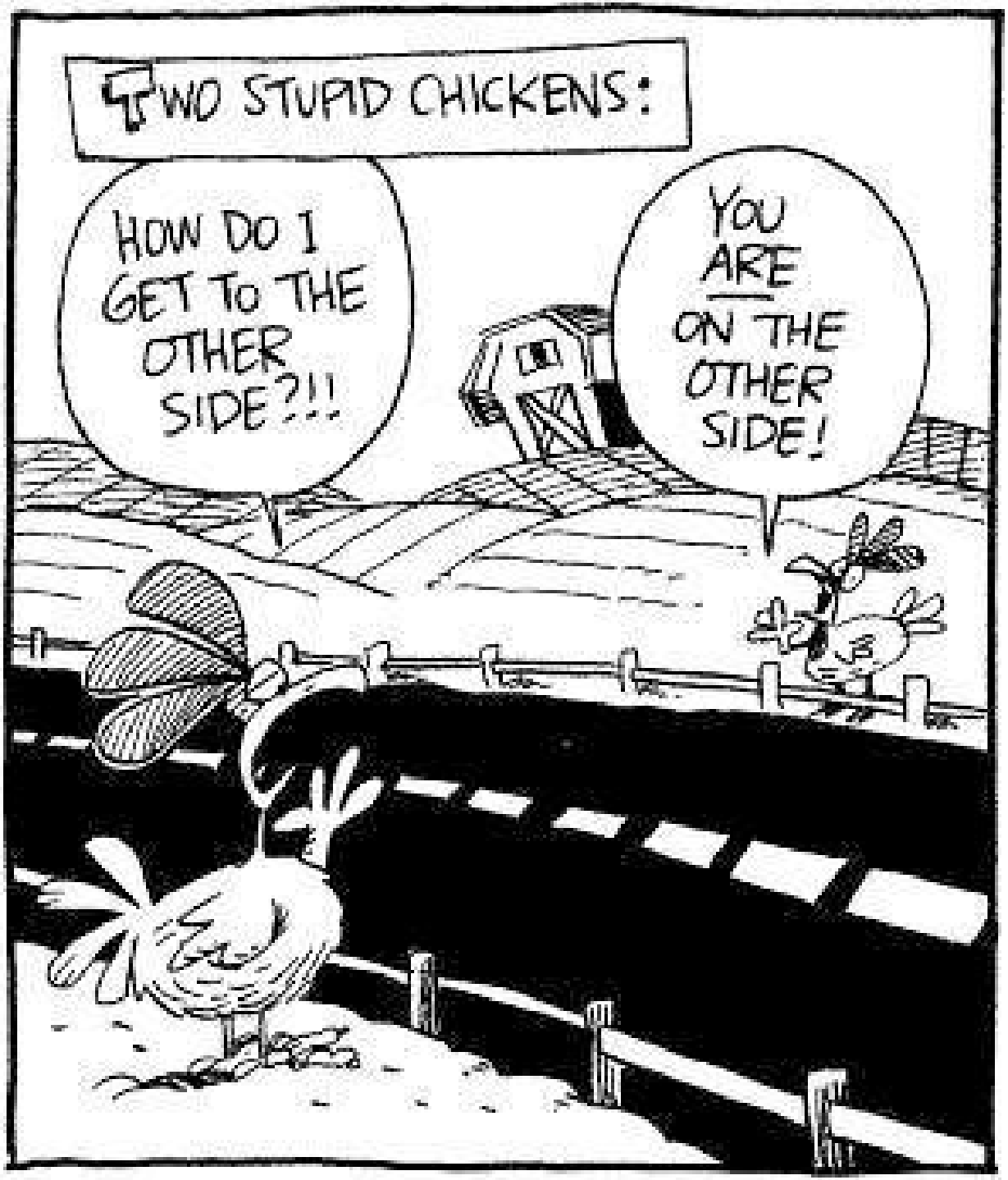
Connections should be tailored to species but are expected to have broad applications

➔ Tailor to the rate of the slowest or most demanding species

Misconception: green infrastructure connects ecosystems / nature reserves

Organisms do not actively seek connections

Anthropogenic view on connectivity


TWO STUPID CHICKENS:
HOW DO I GET TO THE OTHER SIDE?!!
YOU ARE ON THE OTHER SIDE!

Functional network is not merely rolling out green carpets between N2000 sites

Functional connectivity

Is easier to reach among **large** populations

Increasing connectivity helps, but first there needs to be high quality sites with thriving wildlife populations to connect. (Lawton et al. 2010: Defra report)

In highly fragmented landscapes enlarging more cost-efficient (Ovaskainen 2012)

Components of ecological network

Core areas ➔ Natura 2000

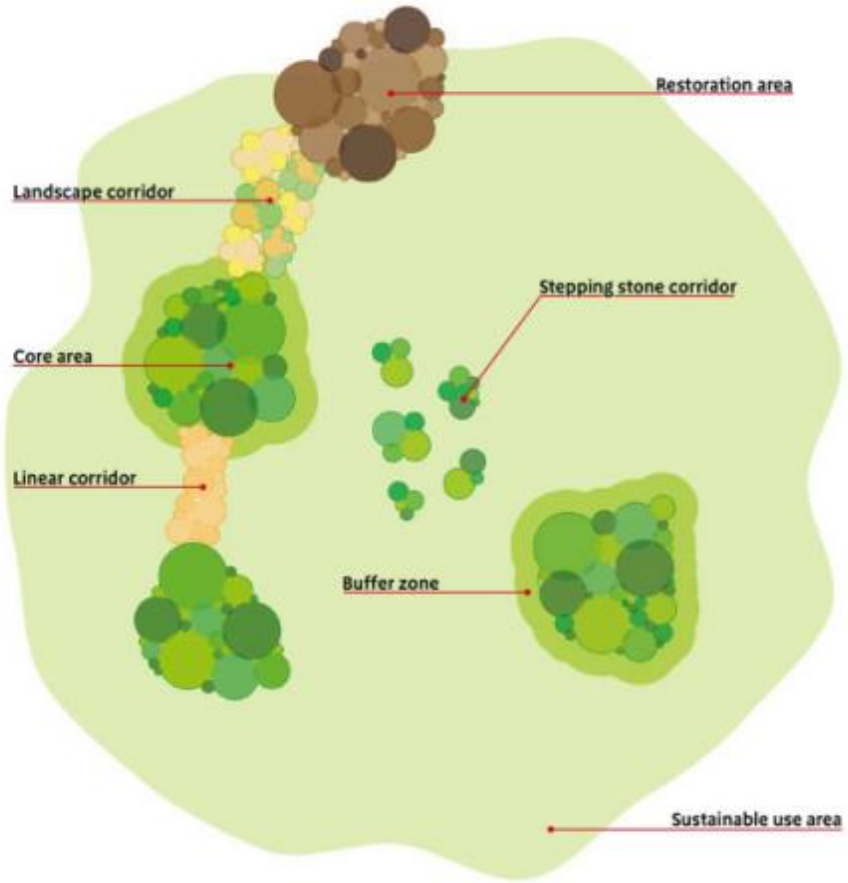
Corridors and stepping stones

Restoration areas

Buffer zones

Sustainable use areas

Lawton et al. 2010: DEFRA report



Any questions apart from the SLOSS dilemma?