Eco-roads: safe and sound for people and nature

Roads and nature in Europe and more specific in The Netherlands

Hans de Vries

Hans Bekker, Hein van Bohemen, Ruud Cuperus, Peter-Jan Keizer, Annette Piepers, Geesje Veenbaas

Ministry of Transport and Public Works
Road and Hydraulic Engineering Institute
Delft, Netherlands

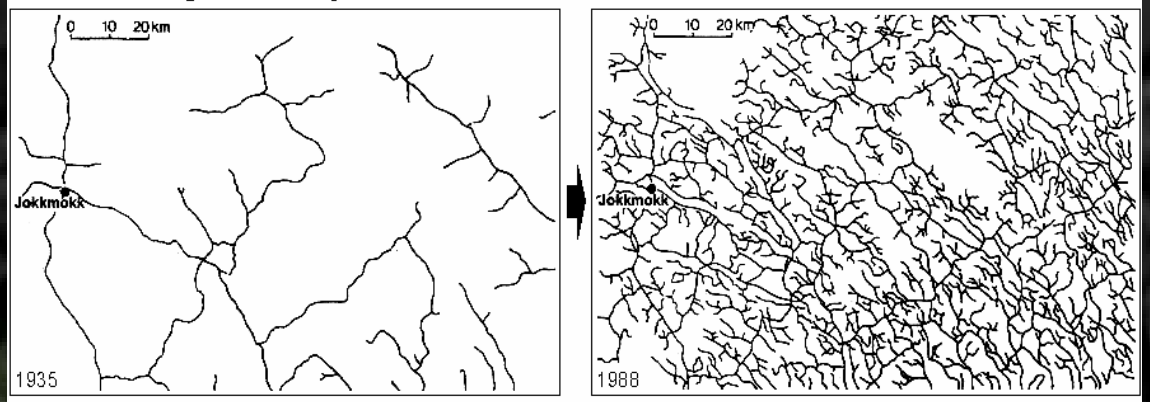
Topics

- *basic principles of landscape ecology*
- *effects of roads and traffic, habitat fragmentation*
- *‘defragmentation’*
- *road ecology*

What happens?

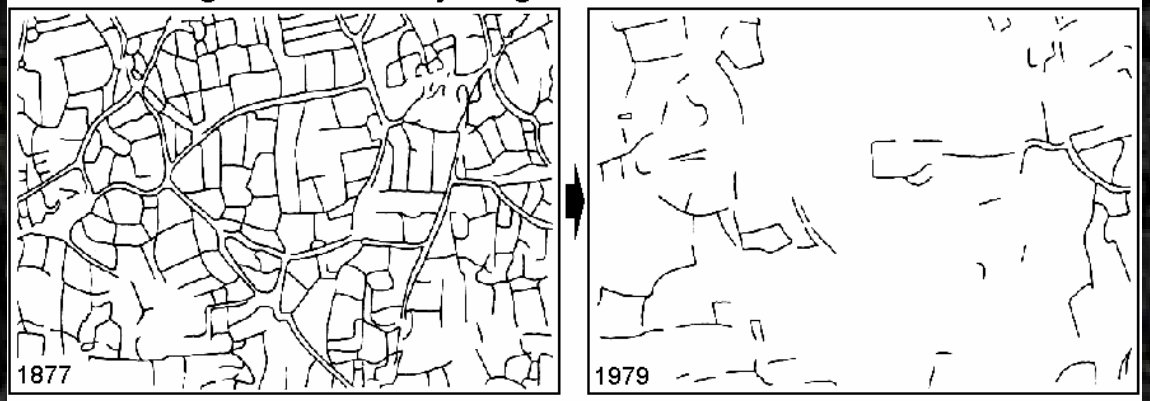
- *increase road density*
- *decrease of small scale landscape and as a result*
- *disappearance of green networks: hedgerows, wooded banks*

Increasing density of road barriers

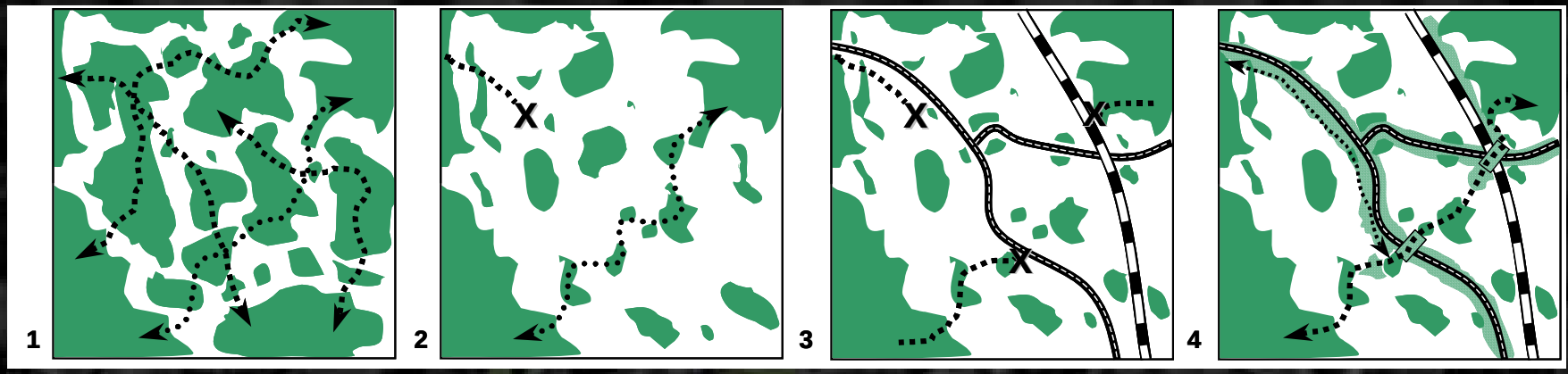


Forest roads in Northern Sweden

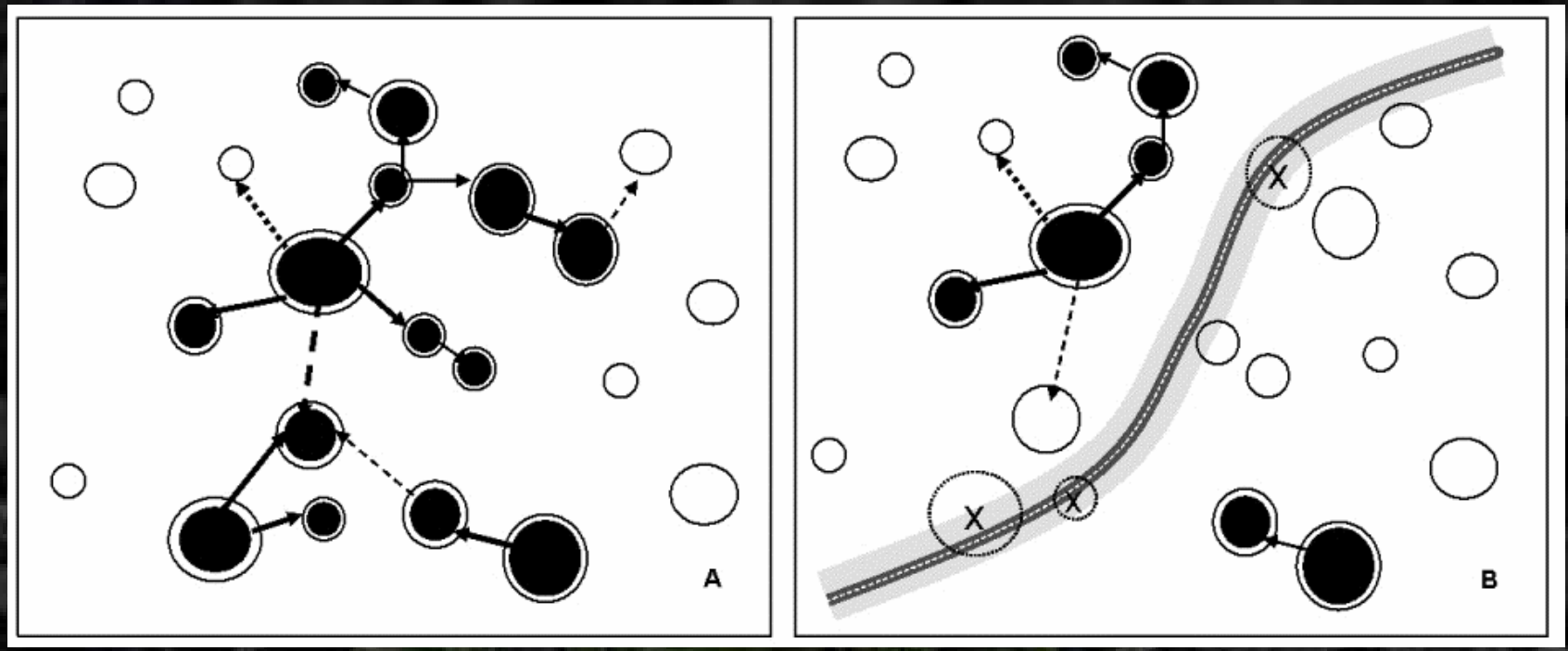
Decreasing connectivity in green network



Wooded road verges and hedgerows in northern Germany



1. *habitat fragmentation inhibits dispersal, number of suitable habitat patches decreases*
2. *connectivity still possible via ‘stepping stones’or corridors*
3. *infrastructure causing additional barrier, enforced isolation*
4. *measures such as fauna passages and ecological verge management may improve connectivty*



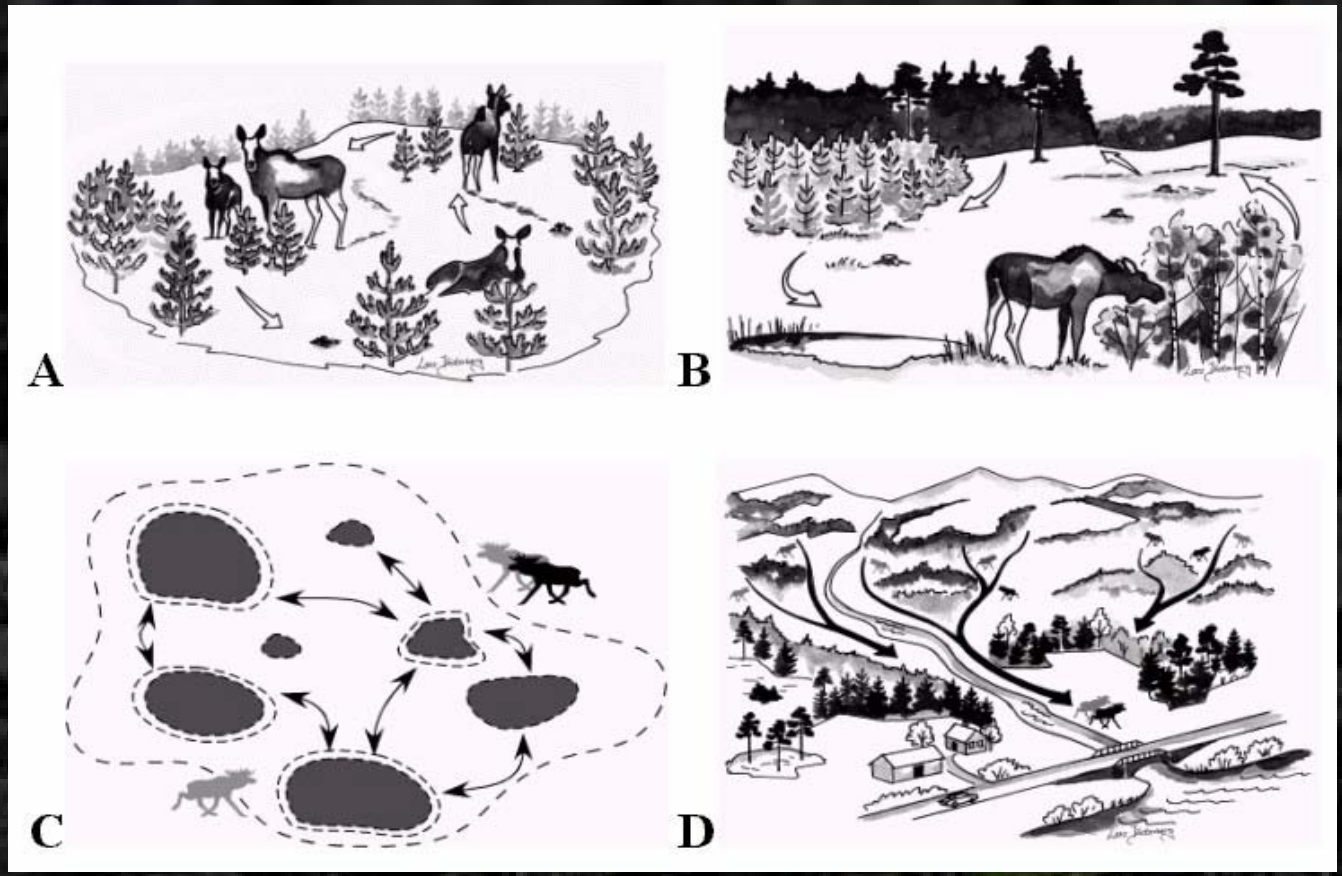
- *Metapopulation consists of a network of local (sub)populations linked through dispersal. Local extinction can be followed by re-colonisation from surrounding populations through dispersal.*
- *A road causes loss of local populations and may act as a dispersal barrier, preventing re-colonisation.*

sink, source

Sink habitats have a non-sustaining birth-death ratio and are dependent on immigration from source populations

Source habitats are areas where populations of a given species can reach a positive balance between births and deaths and thus act as a source of emigrating individuals

Road area, verges are for many animal species sub-optimal habitats => do not attract these species by road (side) maintenance (ponds, nesting trees close to traffic)



A. *foraging movement of individuals within a forest stand*
B. *commuting movements between patches within home range*
C. *dispersal movements between local populations (emigration, immigration)*
D. *seasonal migration by local populations*

Habitat fragmentation due to infrastructure:

"Dissection and reduction of the habitat area available to a given species - caused directly by habitat loss (e.g. due to land-take) or indirectly by habitat isolation (e.g. due to barriers increasing distances between neighbouring habitat patches)."

Dispersal of plant species via cars (e.g. seeds on tires) or road side animals.

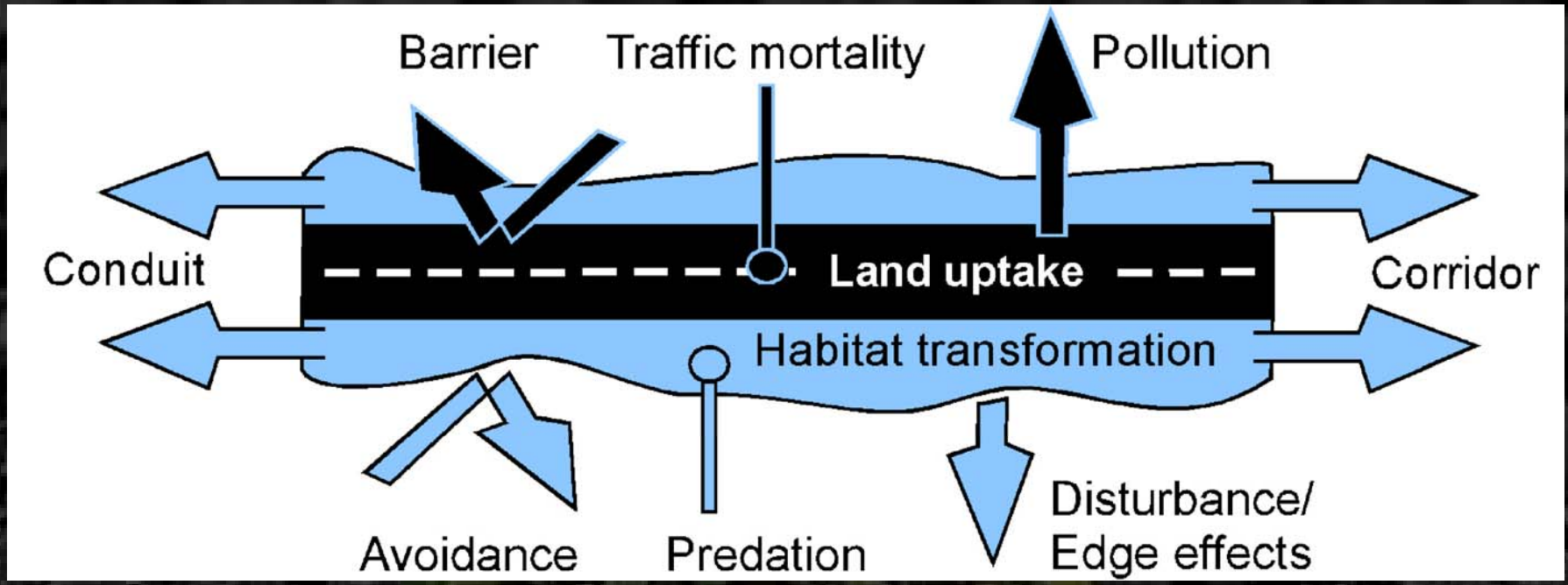
Habitat fragmentation as such not always negative

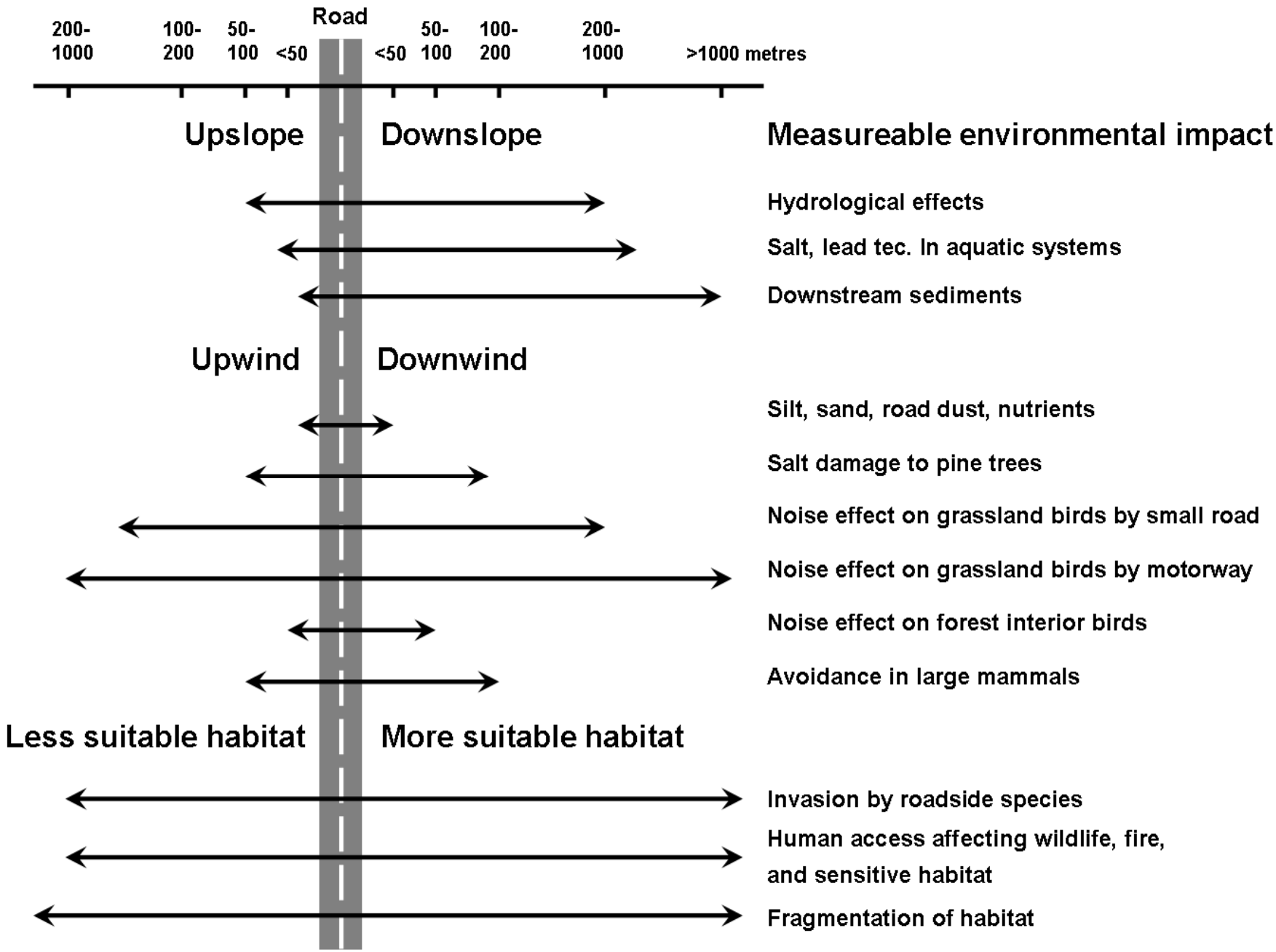
- *natural isolation*
- *small scale landscape*

Important definitions:

(1) **connectedness** *and (2)* **connectivity***:*
(1) The state of structural landscape features being connected, (2) enabling certain species to move between places via a continuous route of passage.
(1) = landscape based, (2) = species based

Knowledge of scale and hierarchy are important for understanding ecological patterns en processes within the landscape => necessary condition in order to successfully counteract habitat fragmentation, e.g. scale of landscape <=> scale of road network


Barrier
Traffic mortality
Pollution
Conduit
Land uptake
Corridor
Habitat transformation
Avoidance
Predation
Disturbance/
Edge effects


Road
200-1000
100-200
50-100
<50
<50
50-100
100-200
200-1000
>1000 metres
Upslope
Downslope
Measureable environmental impact
Hydrological effects
Salt, lead tec. In aquatic systems
Downstream sediments
Upwind
Downwind
Silt, sand, road dust, nutrients
Salt damage to pine trees
Noise effect on grassland birds by small road
Noise effect on grassland birds by motorway
Noise effect on forest interior birds
Avoidance in large mammals
Less suitable habitat
More suitable habitat
Invasion by roadside species
Human access affecting wildlife, fire, and sensitive habitat
Fragmentation of habitat


Loss of habitat

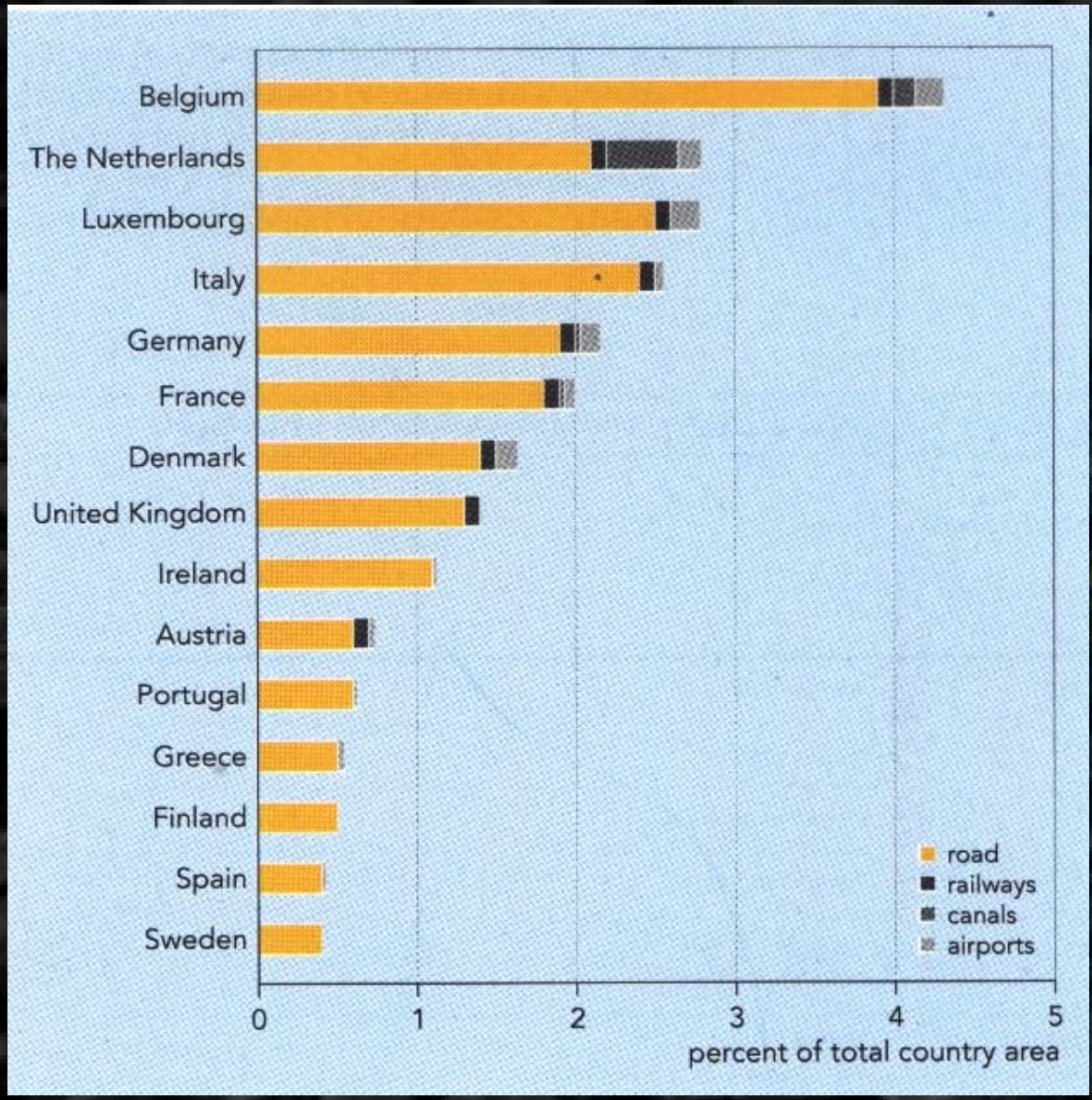
Land take by transport mode

Mode	Type	Width (m)	Size (ha/km)
railway	*conventional*	*26*	*2,6*
	HSR upgrade	*32*	*3,2*
	HSR new	*35*	*3,5*
road (# lanes)	*2x1*	*32*	*3,2*
	2x2	*54*	*5,4*
	2x3	*60*	*6,0*
	2x4	*72*	*7,2*

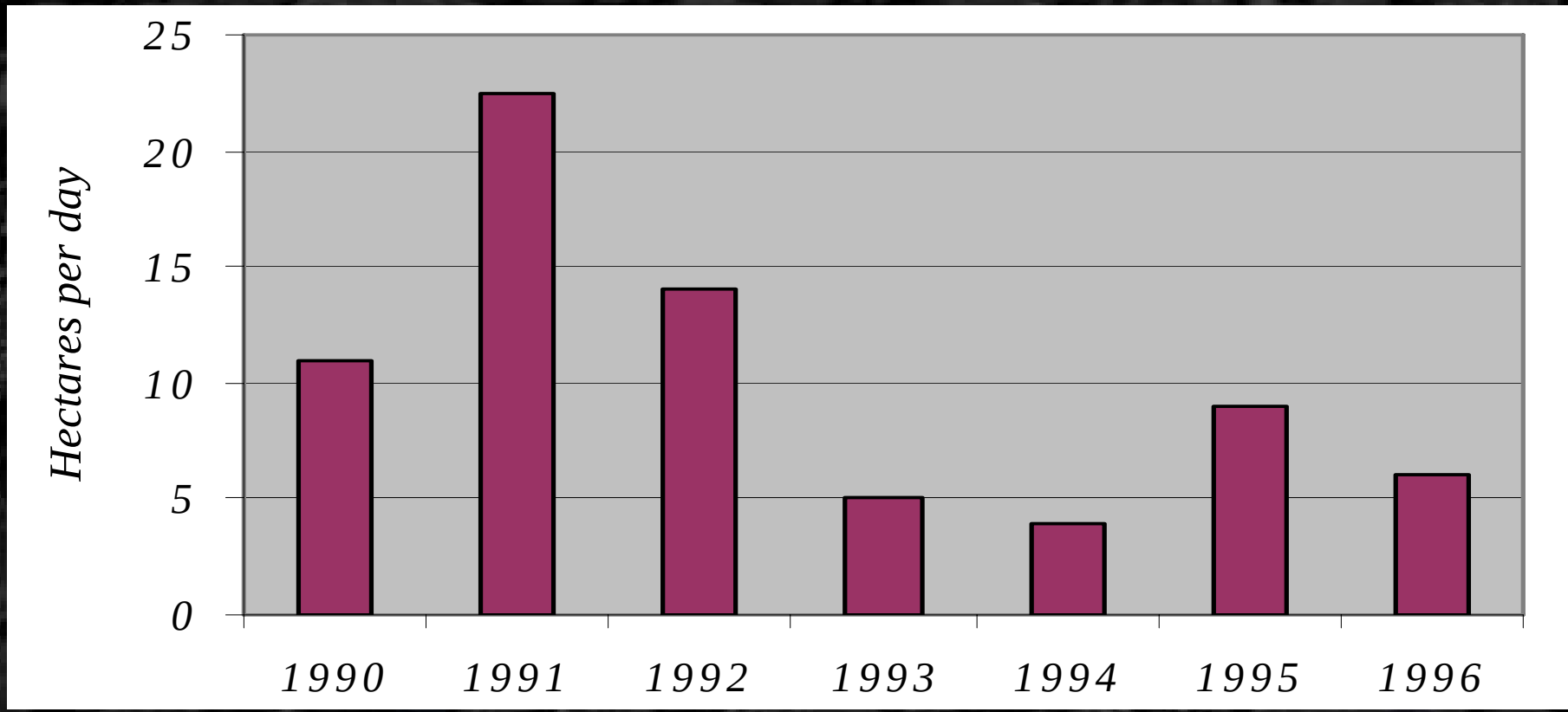
Netherlands (NL)
125.000 km road

- *rural 68.000 km*
- *urban 57.000 km*
- *motorways 2.300 km*
- *unpaved roads 11.000 km*
- *55.000 ha road verge = 2% NL, nature area = 4% NL*
- *15.000 ha motorway verges*

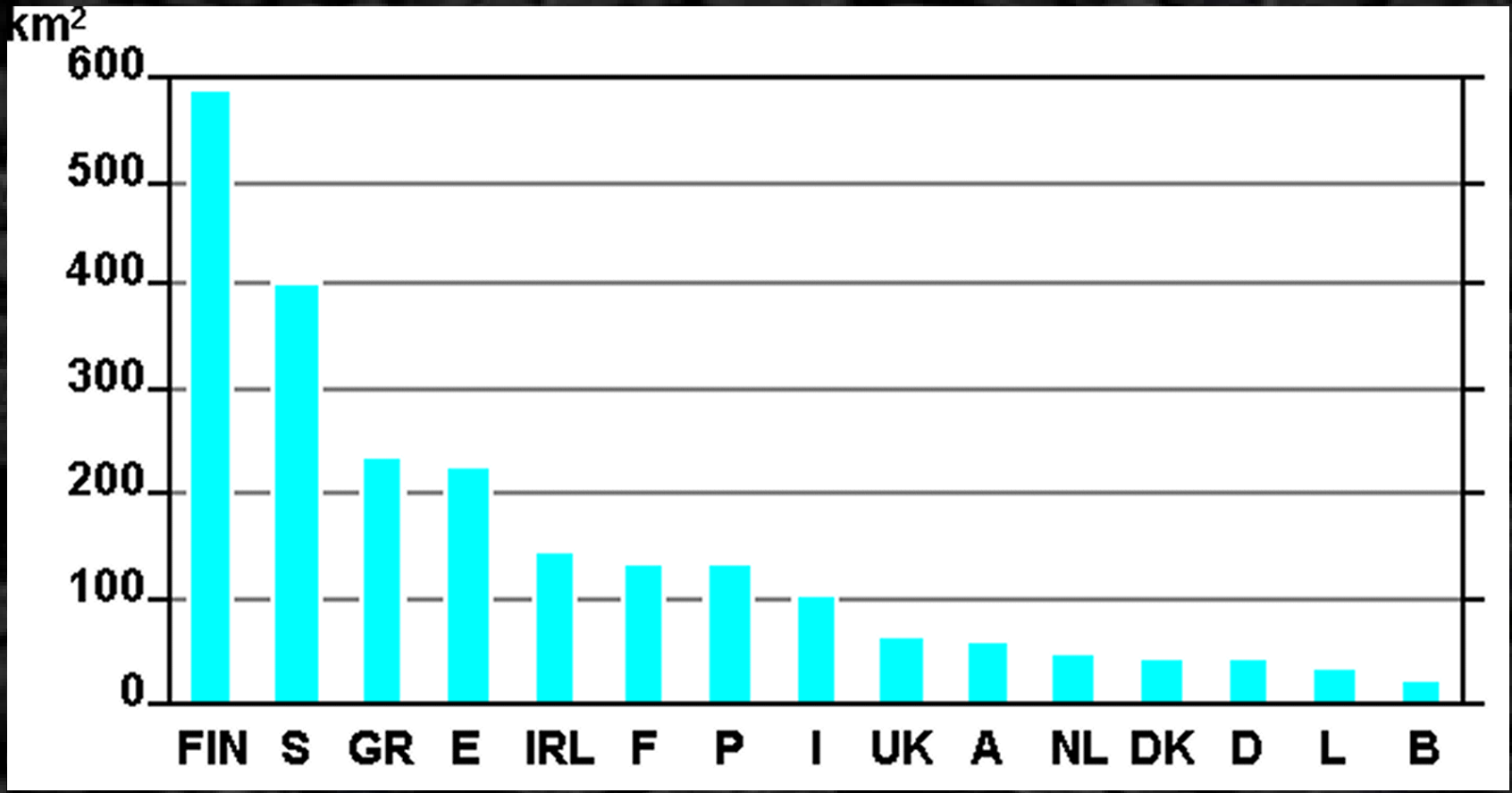
Land take, % of total country area



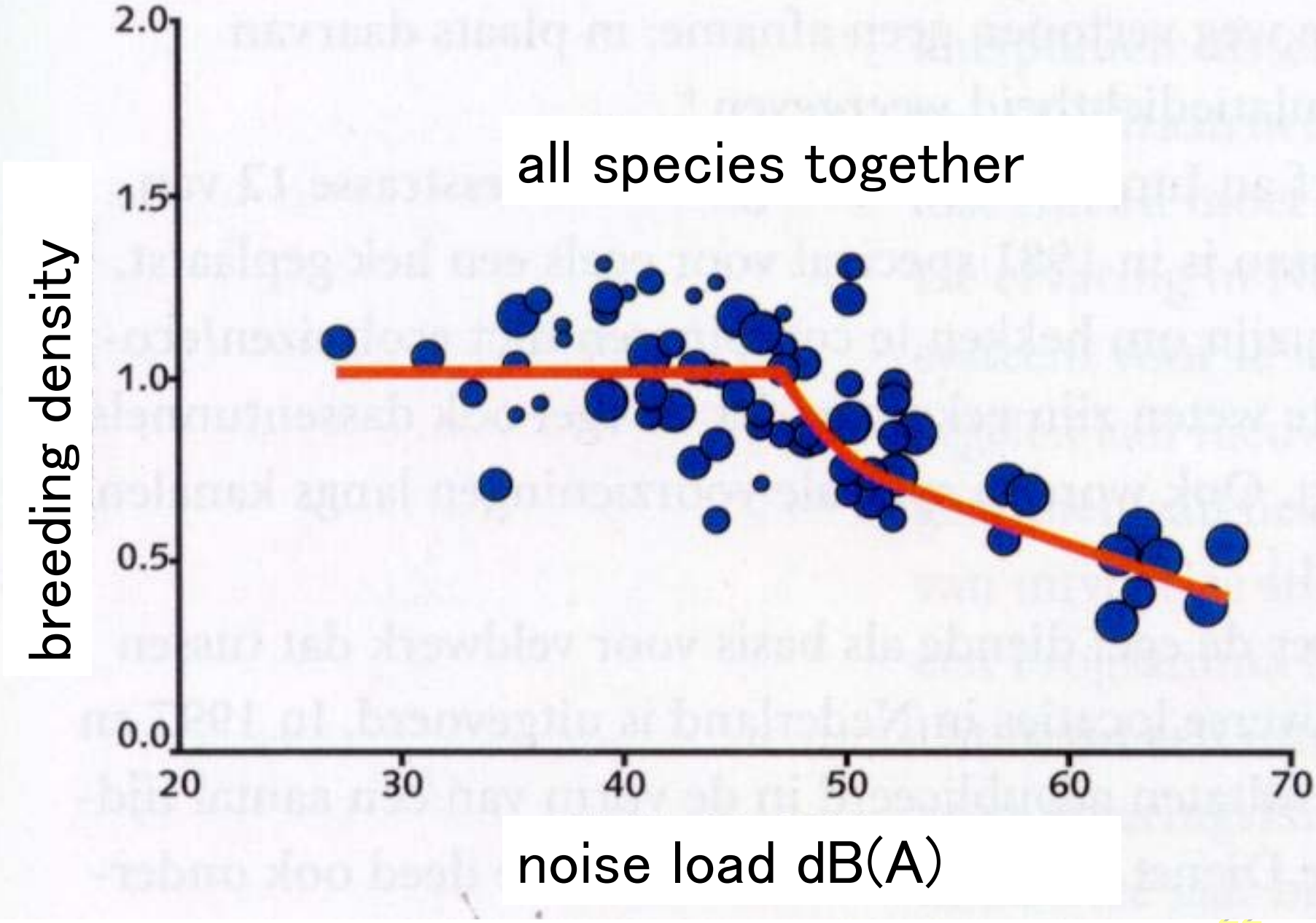
Average daily land taken by new motorways in the EU (hectares per day)



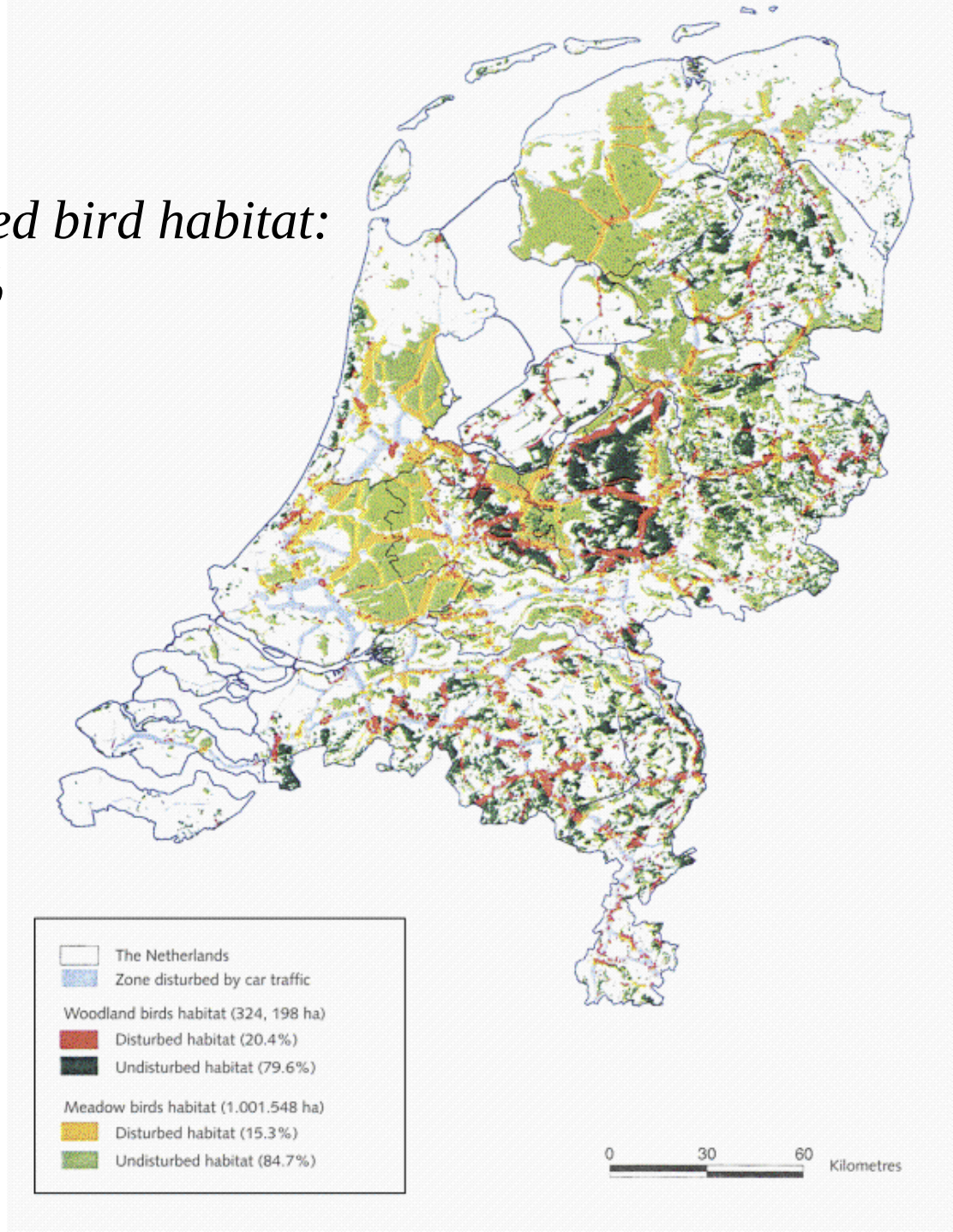
Average size of land parcels not fragmented by motorways



disturbance

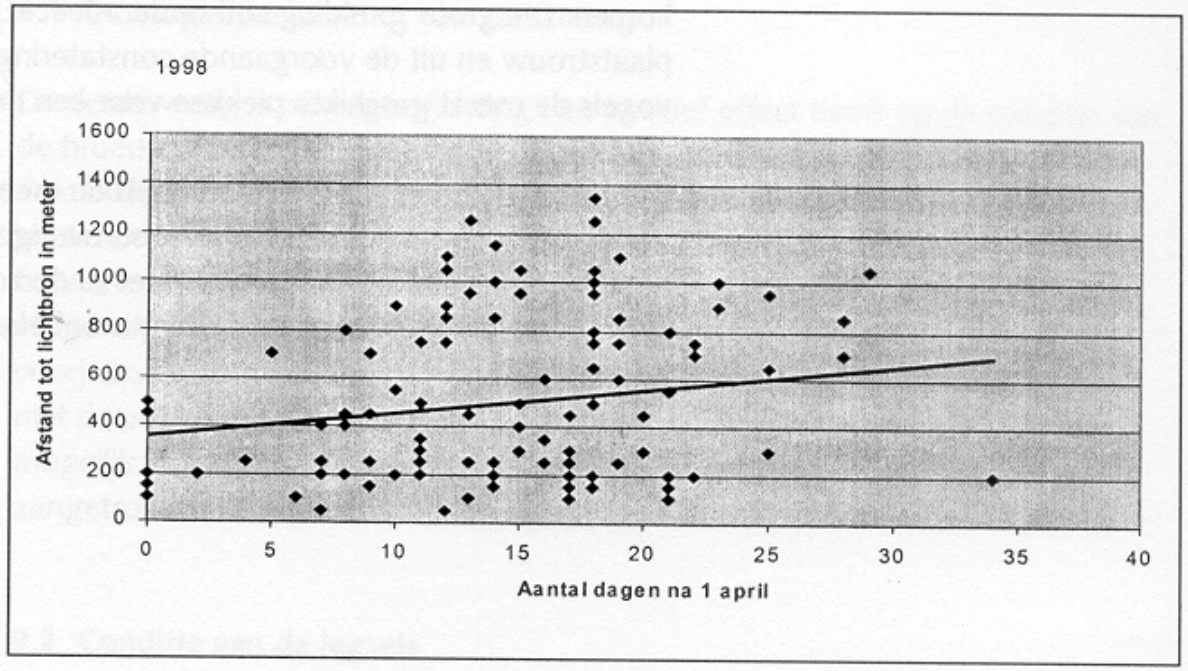

all species together
breeding density
2.0
1.5
1.0
0.5
0.0
20
30
40
50
60
70
noise load dB(A)

disturbed bird habitat:
15-20%

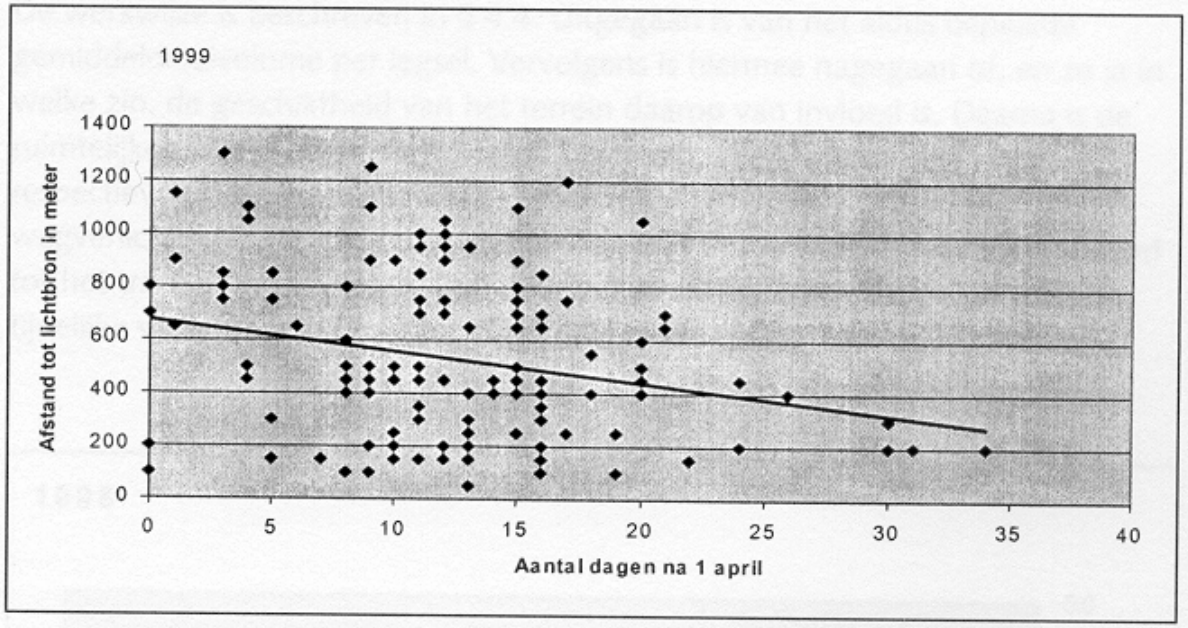


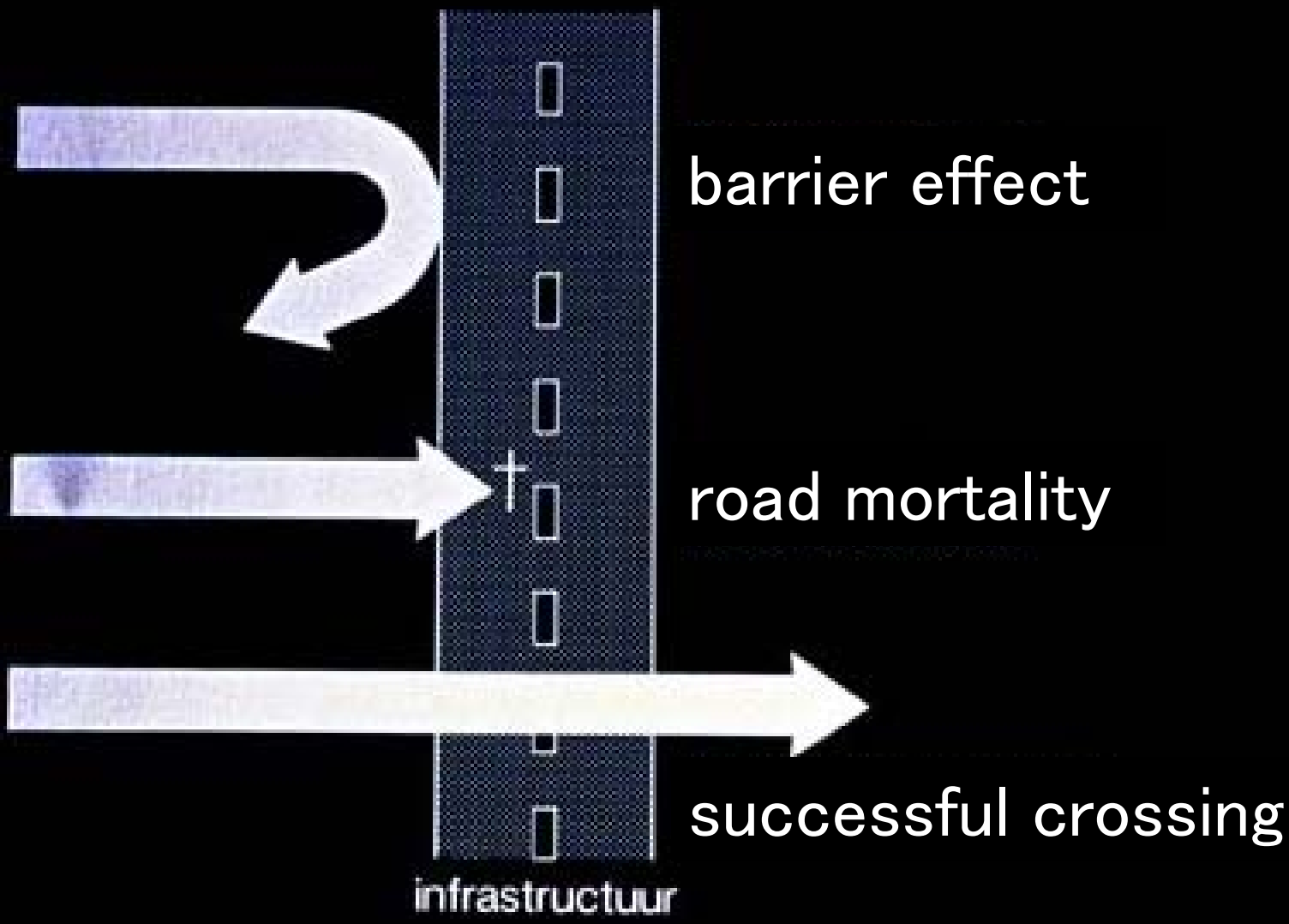
Effect of road illumination on black-tailed godwit (Limosa limosa)

- *breeding density*
- *nest choice*
- *breeding period*
- *breeding success*



disturbance breeding behaviour godwits by road lighting




barrier effect
road mortality
successful crossing
infrastructuur


traffic
mortality

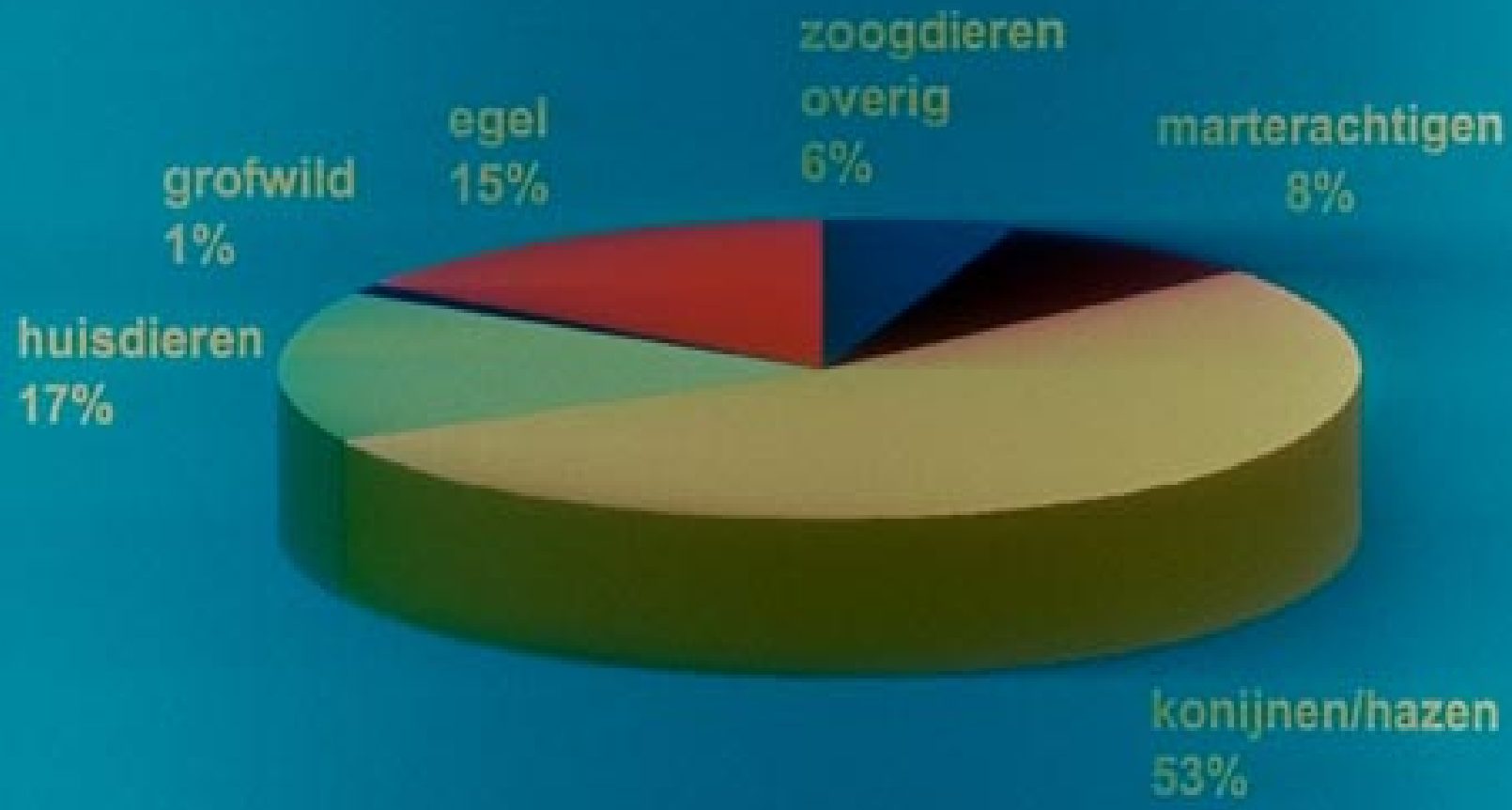
Road casualties most visable, annual toll in The Netherlands:

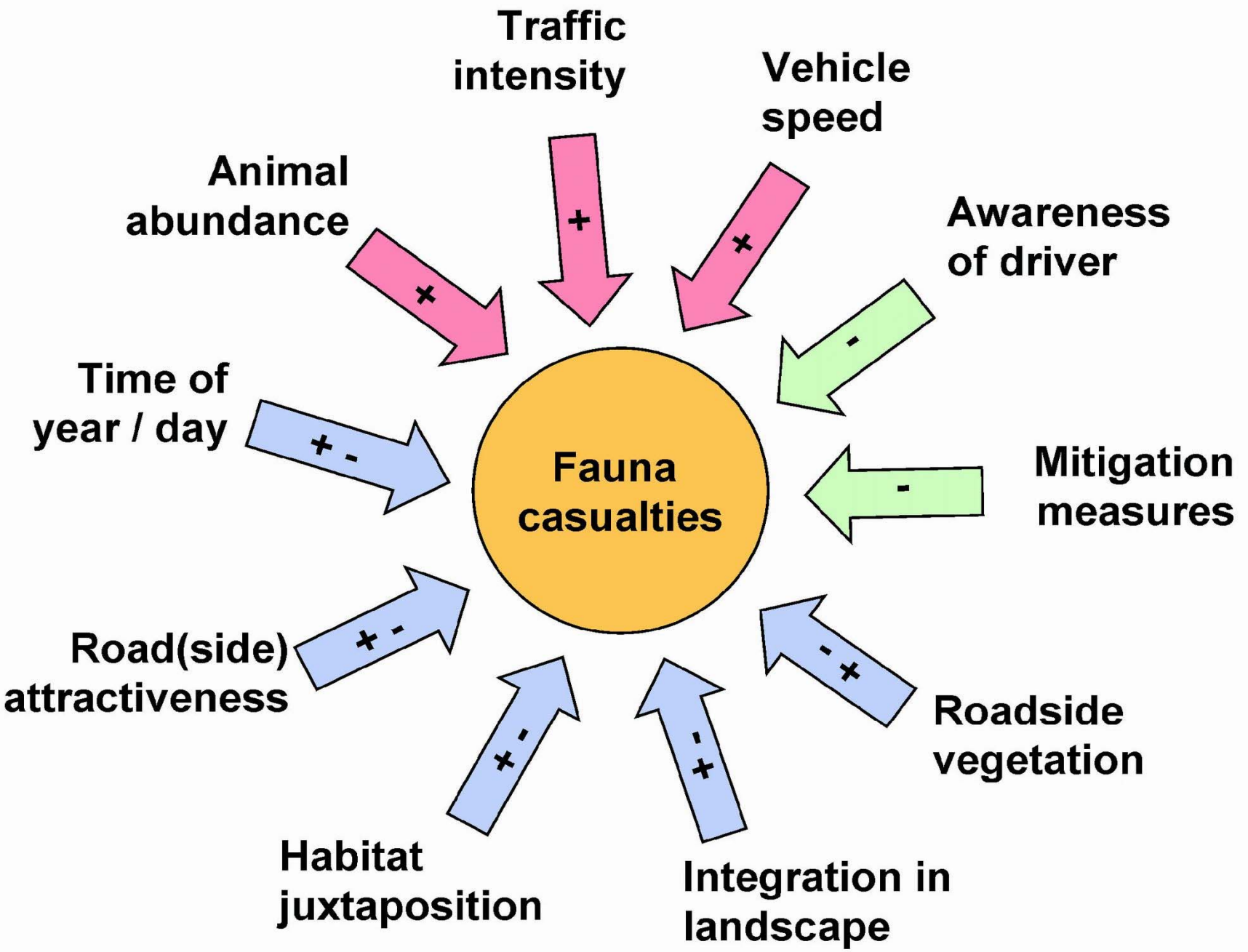
- *2-10 million birds*
- *0,5 - 1 million rabbits and hare*
- *0,3 - 0,5 million hedgehogs*
- *500 – 800 badgers*

estimated 5 – 10 million vertebrates

(= approx. 3 casualties / week / km[1] road)

mammals


zoogdieren overig 6%
egel 15%
marterachtigen 8%
grofwild 1%
huisdieren 17%
konijnen/hazen 53%

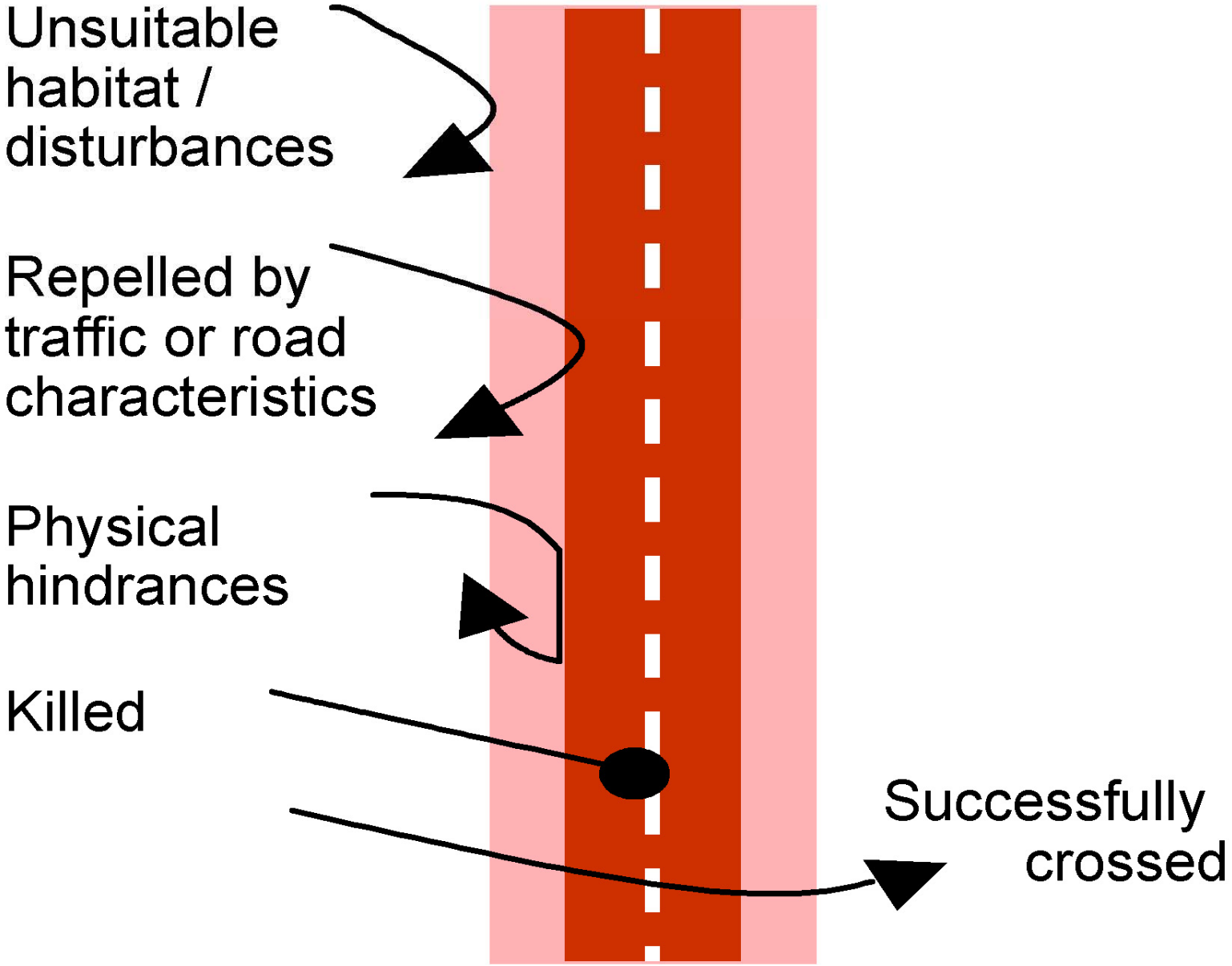

Traffic intensity
Vehicle speed
Animal abundance
Awareness of driver
Time of year / day
Fauna casualties
Mitigation measures
Road(side) attractiveness
Roadside vegetation
Habitat juxtaposition
Integration in landscape
+
+
+
-
+ -
-
+ -
- +
+ -
- +

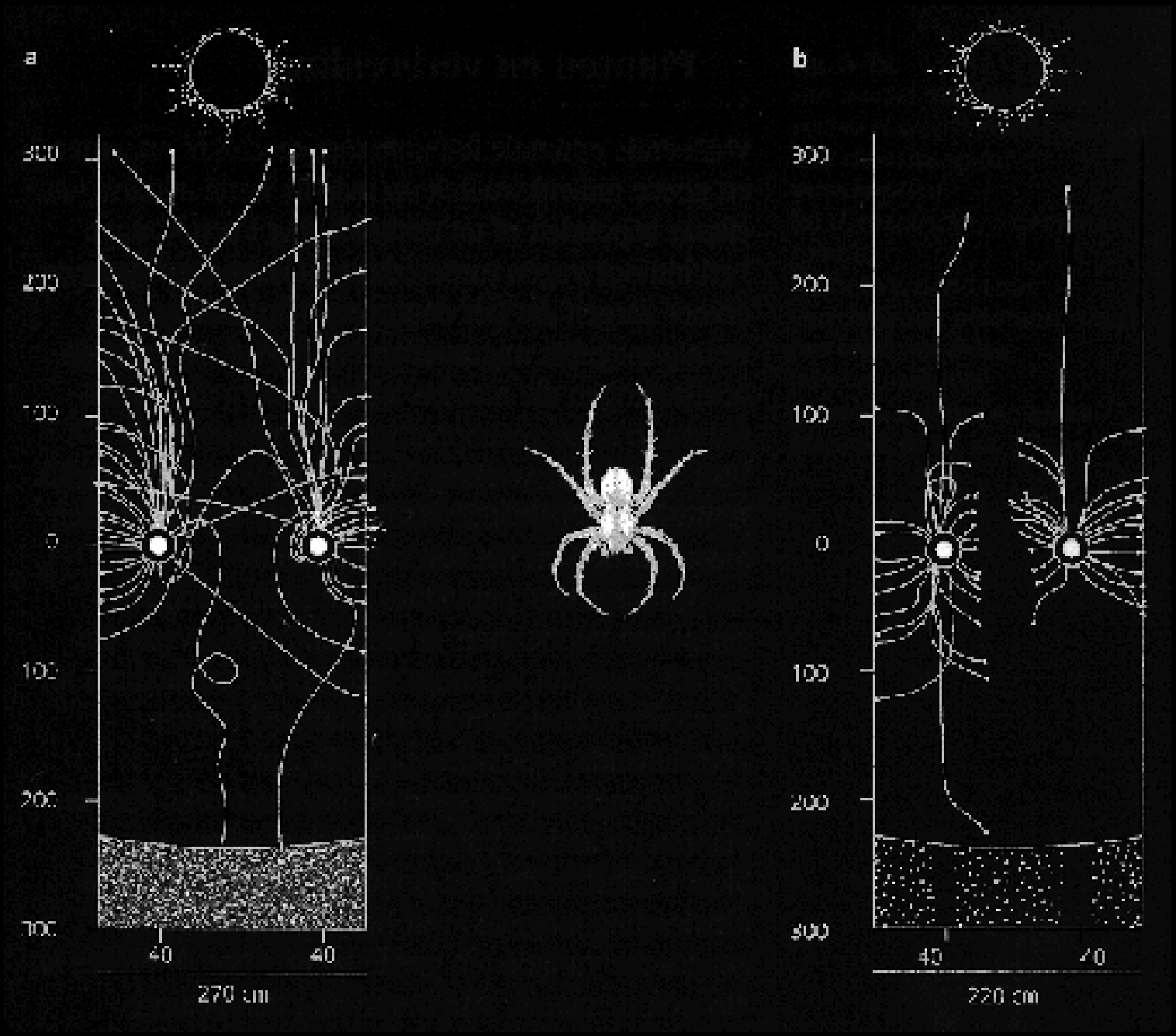
Hedgehog research (6 years)

- *6 – 9 % of the population killed by traffic*
- *2 - 3 times more males killed than females*
- *peak in july*
- *high risk spots: wooded banks, forest edges, etc. crossing roads*

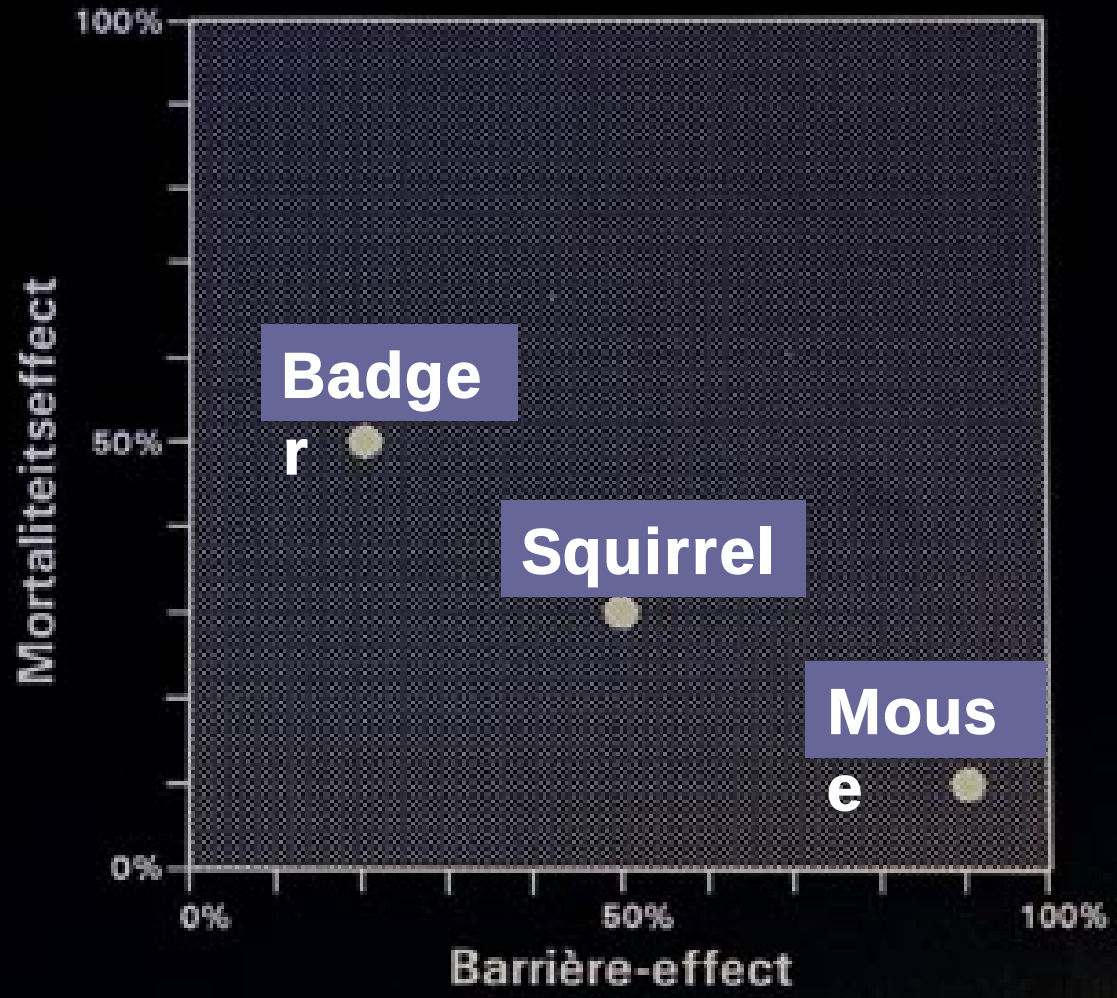

0
100
200
300
400
jan
feb
mrt
apr
mei
jun
jul
aug
sep
okt
nov
dec

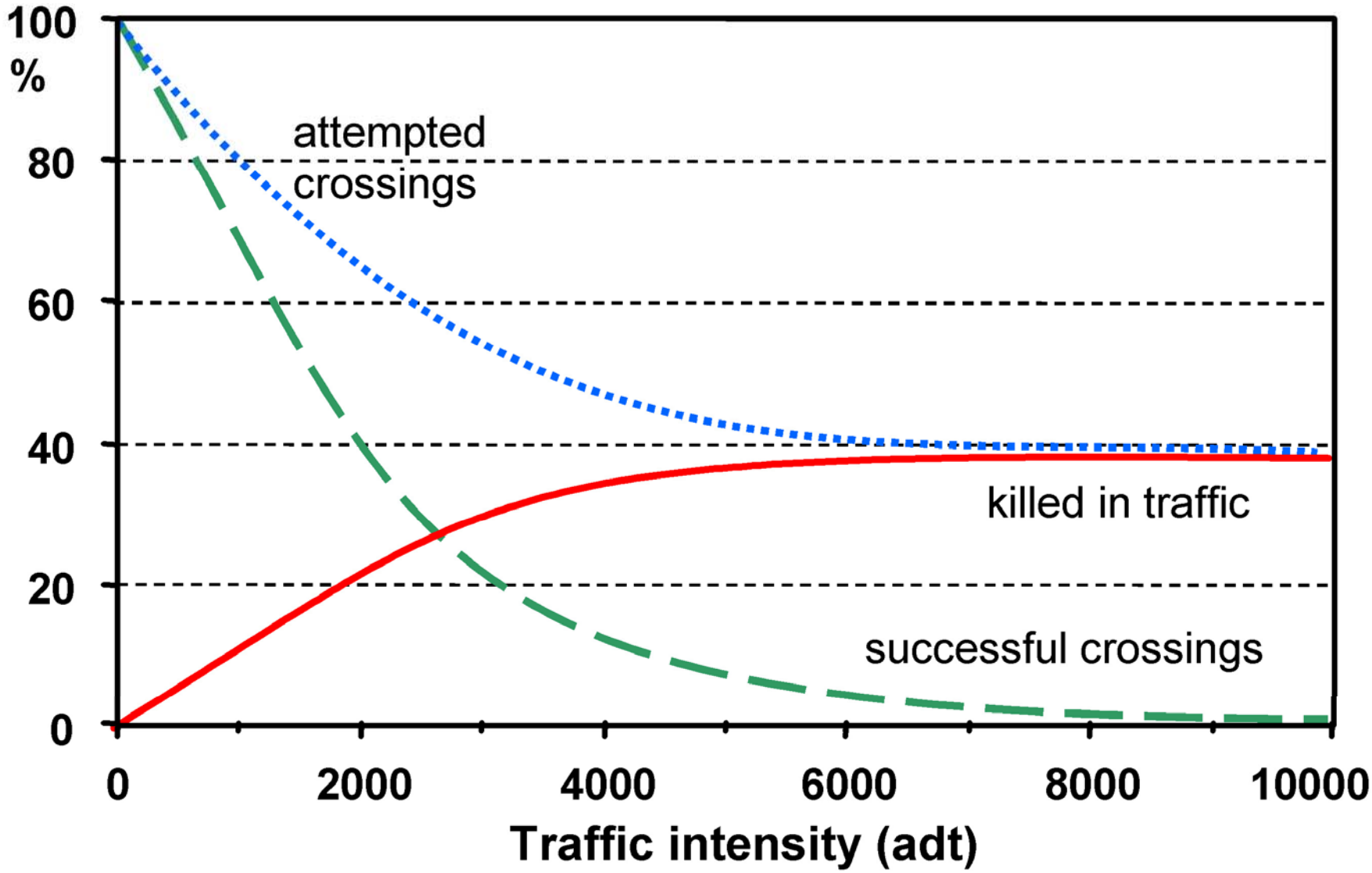
barrier effect


Unsuitable habitat / disturbances
Repelled by traffic or road characteristics
Physical hindrances
Killed
Successfully crossed

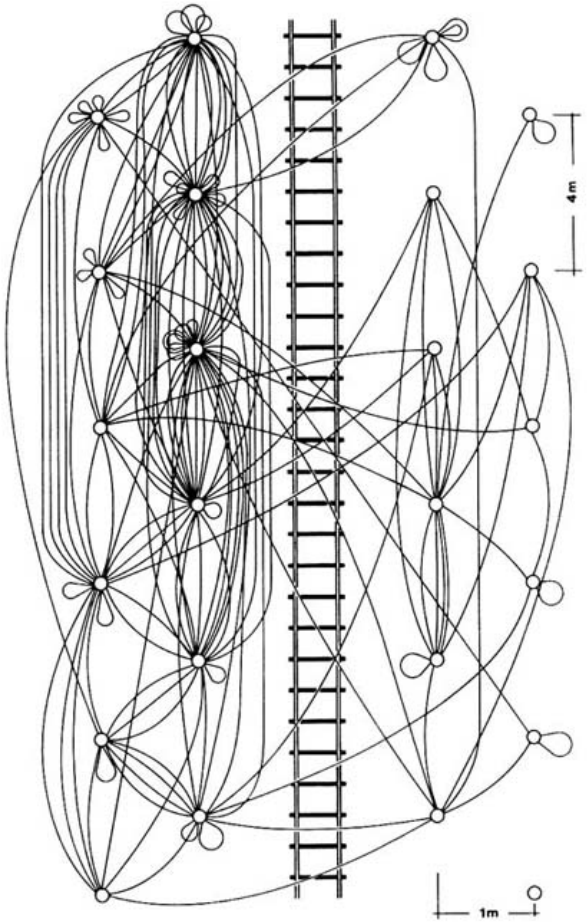

a
b
40
40
270 cm
40
220 cm

Effects species dependant




100
%
80
60
40
20
0
attempted
crossings
killed in traffic
successful crossings
0
2000
4000
6000
8000
10000
Traffic intensity (adt)

RAILWAY

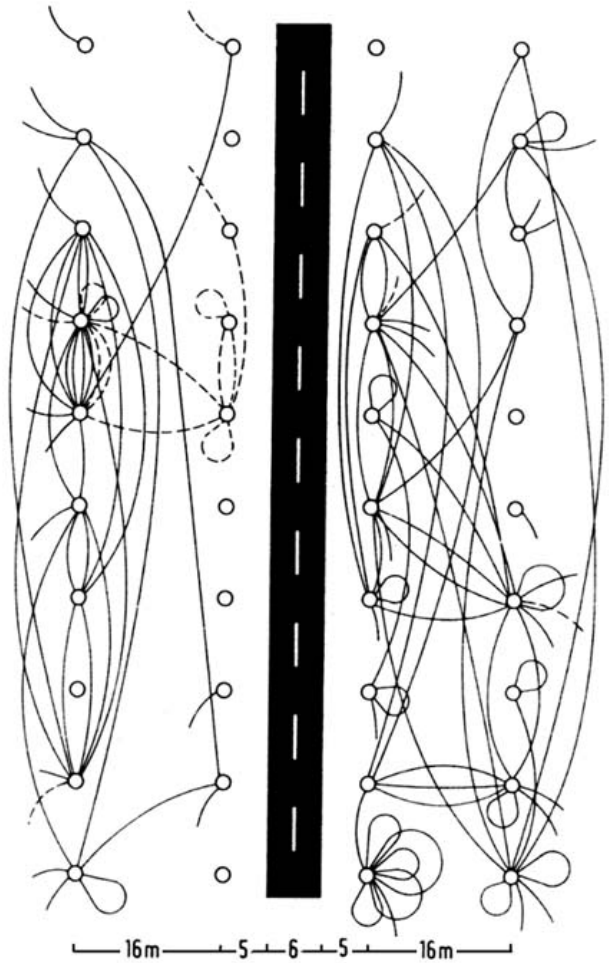


CARABID BEETLES

Pterostichus melanarius.
Amara spp.

from Mader et al. 1990

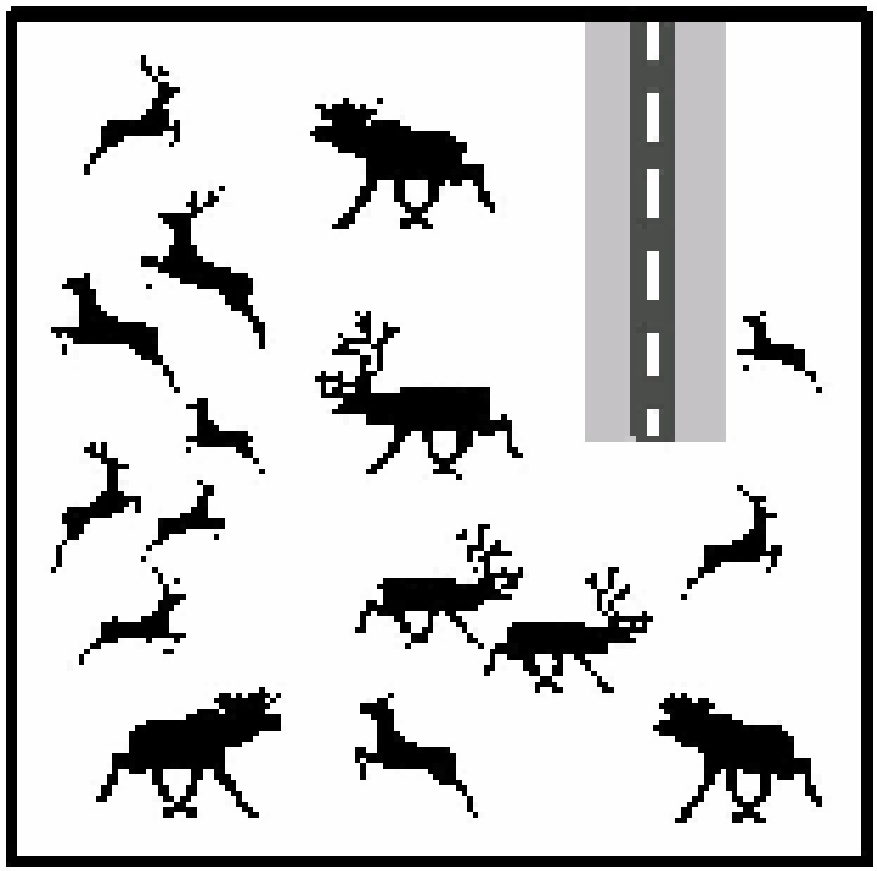
HIGHWAY



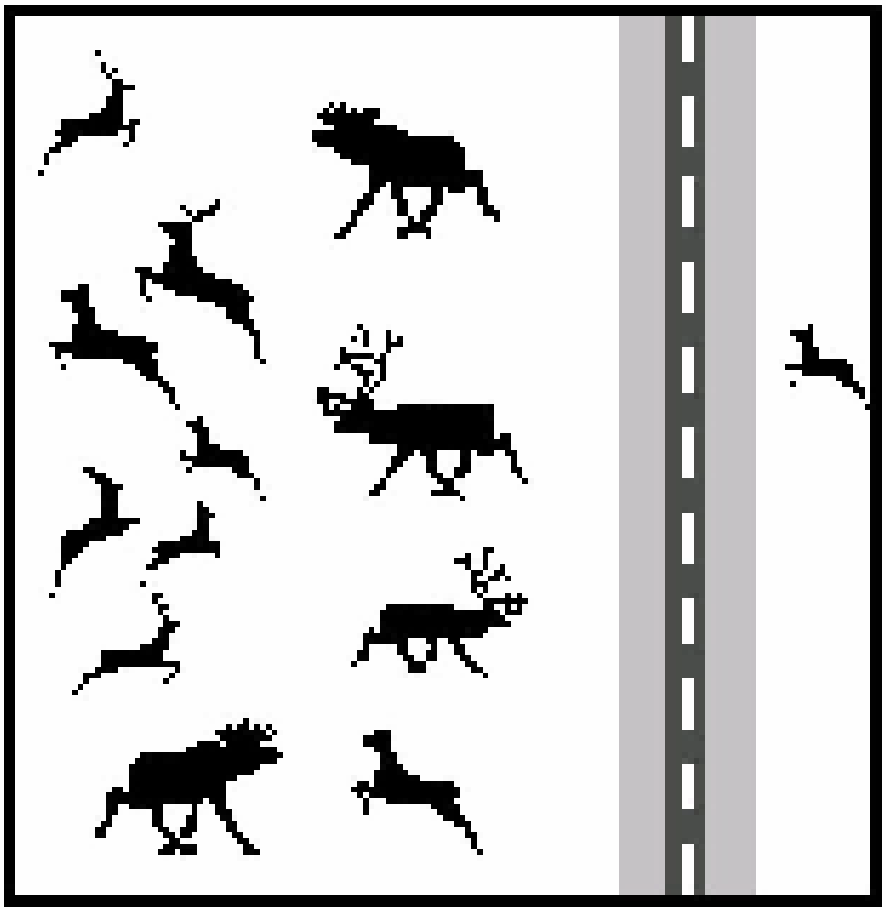
SMALL MAMMALS

Apodemus flavicollis ——
Clethrionomys glareolus – – –

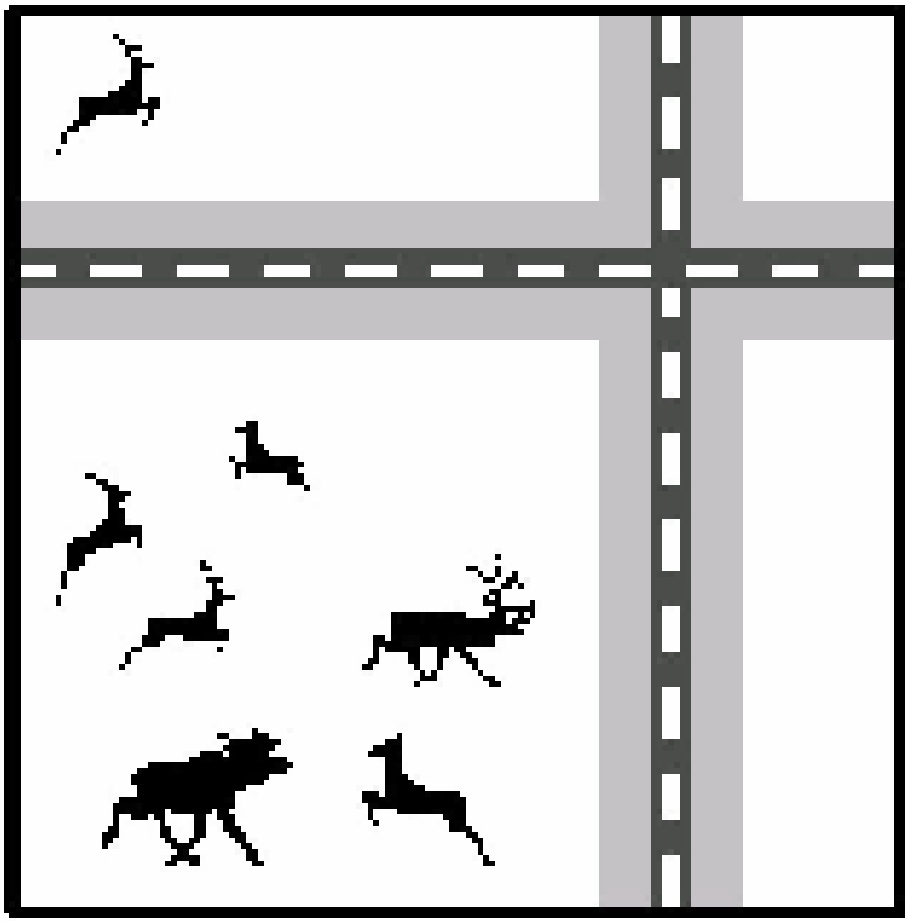
from Mader 1984



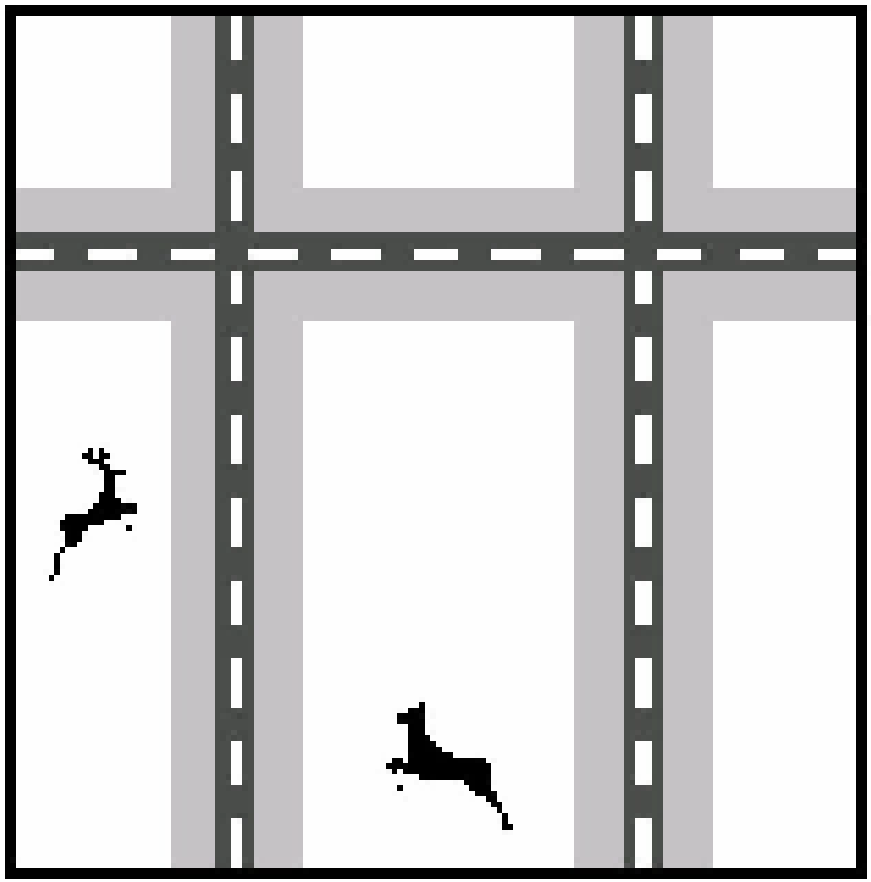
Road density 0.5



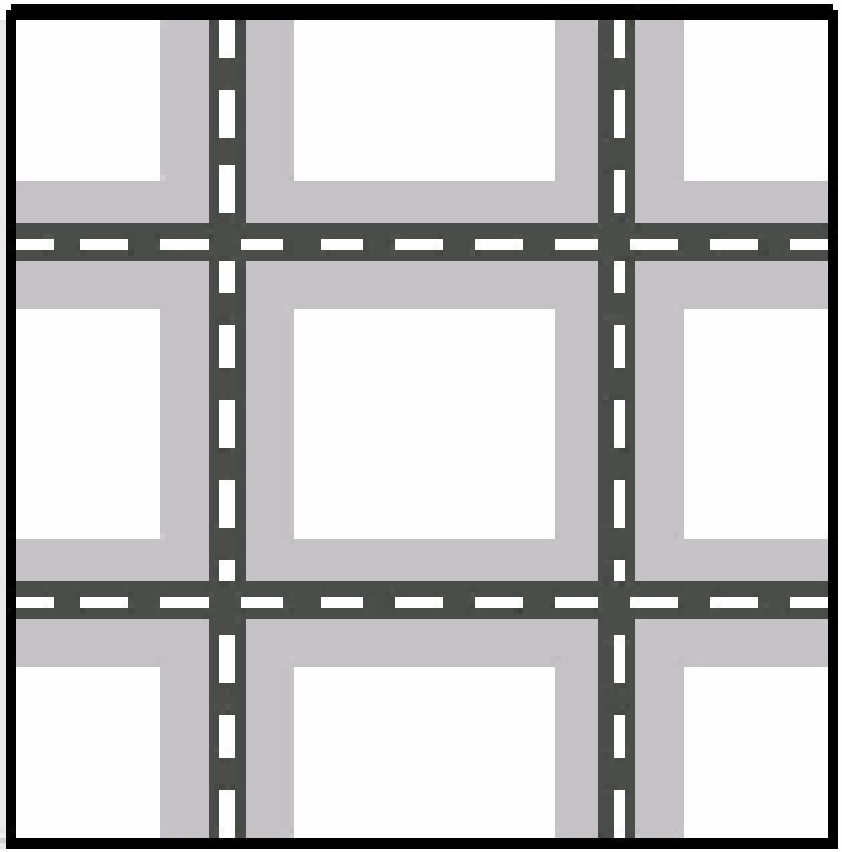
1.0



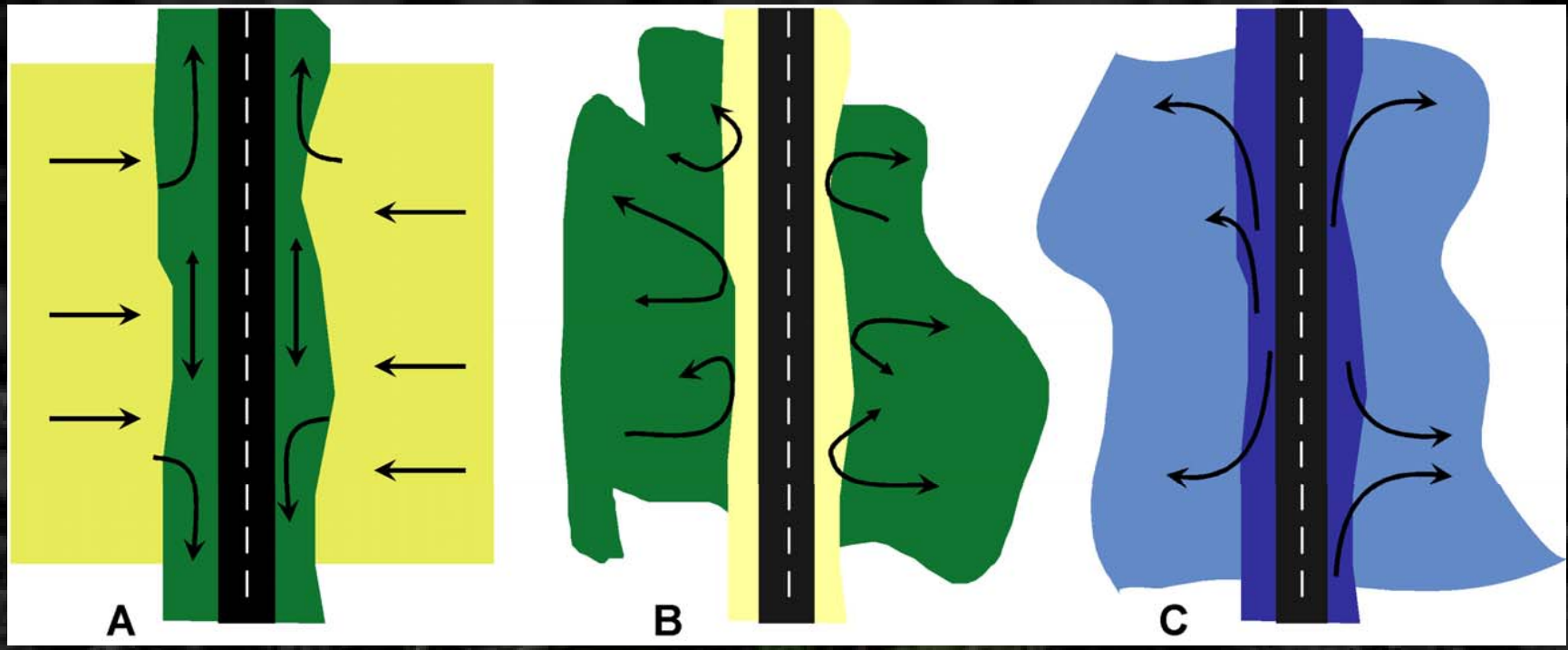
2.0



3.0



4.0 (km/km^2)



A agricultural landscape: verges relatively rich, source

B nature area, forest: verges relatively poor, add. barrier, sink

C ± similar habitats, verges may act as conduit or source

“Defragmentation” in the Netherlands

1990 - defragmentation policy made official by government

1993 - ‘no net loss’ principle adopted

- start defragmentation program at existing motorways

2003 - approx. 500 fauna measures at motorways

5 ecoducts, 280 badger - & 175 small fauna tunnels, 4 large fauna tunnels, 170 modified engineering structures

- long range defragmentation program for national and provincial roads, railroads and waterways

Ecological Main Structure EMS

- *EMS important concept for counteracting fragmentation*
- *national plan, regional elaboration by provinces*
- *example function on a local scale*

Principles of EMS:

- *core areas (<500 ha)*
- *ecological corridors*
- *network consisting of:*
  - *‘arteries’ (national)*
  - *‘veins’ (regional)*
  - *‘capillaries’ (local)*

connection zones:

- *20 year (2000-2018)*
- *5000 km*
- *25.000 ha*
- *100 million $*

Defragmentation strategy

avoidance -> mitigation -> compensation ->

optimisation of maintenance

Avoiding habitat fragmentation by:

- *no road construction (alternatives)*
- *choice of route / least impact corridor*
- *tunnel construction*
- *closing down / removal of roads*

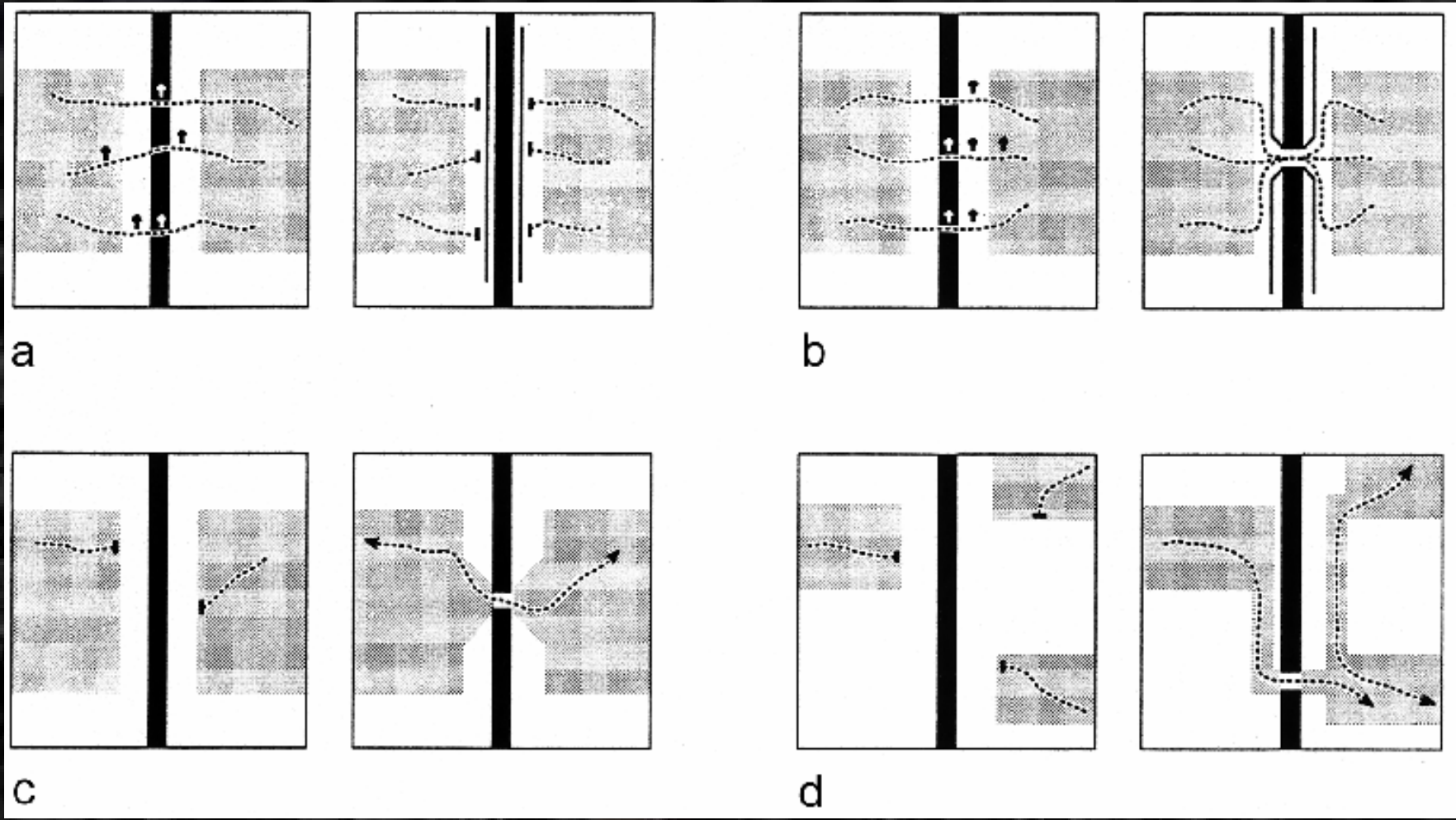

Legenda
bureau waardenburg bv
1

Mitigating measures:

- *Separating / shielding the road*
- *Fauna passages*
  - *ecoducts*
  - *fauna tunnels*
  - *modification of existing constructions (bridges etc.)*
- *Traffic measures*
  - *wildlife detection, speed limitations*
- *Adaptation of surroundings (configuration of the landscape)*


PAUL KERBIJN

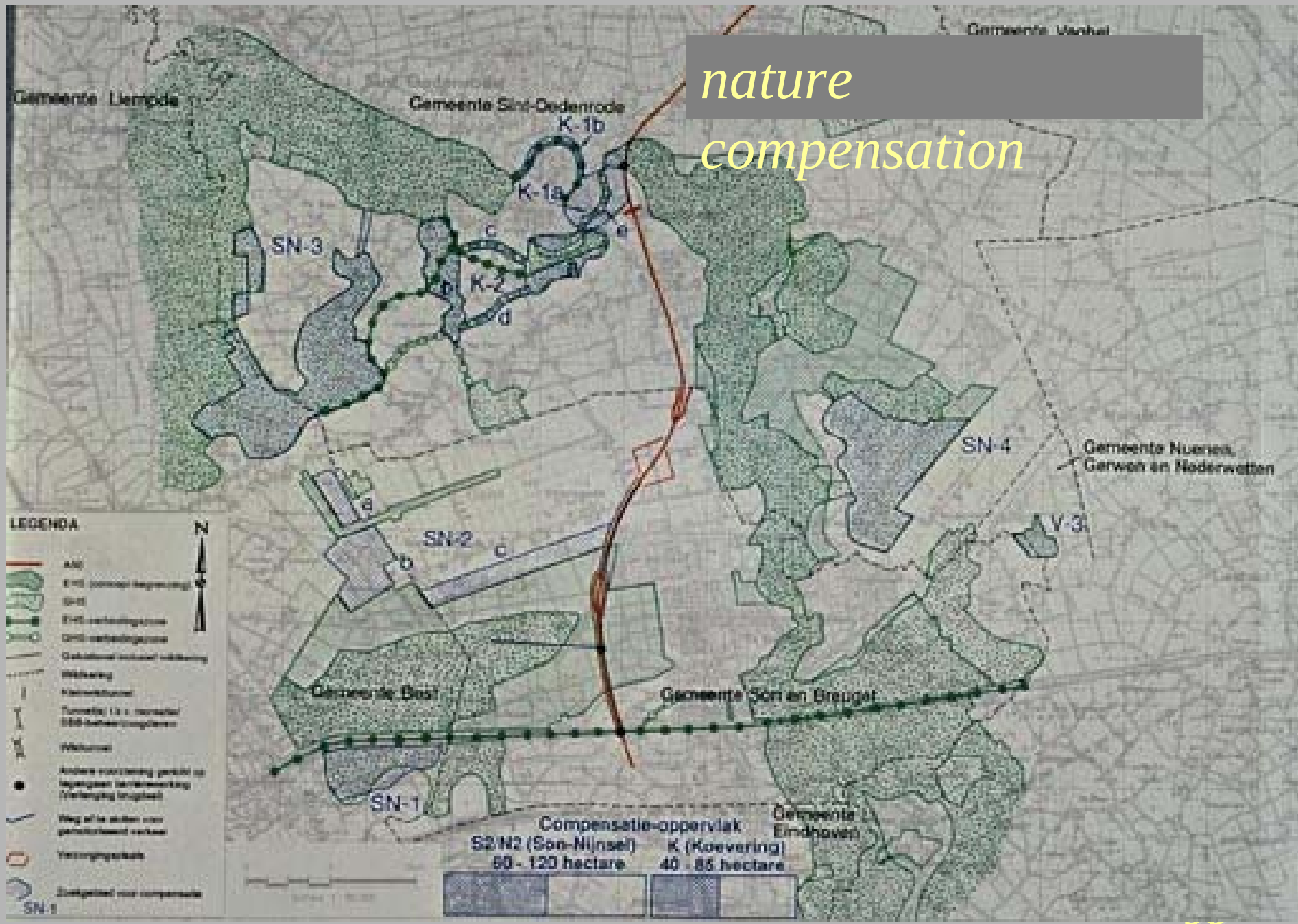
decrease disturbance

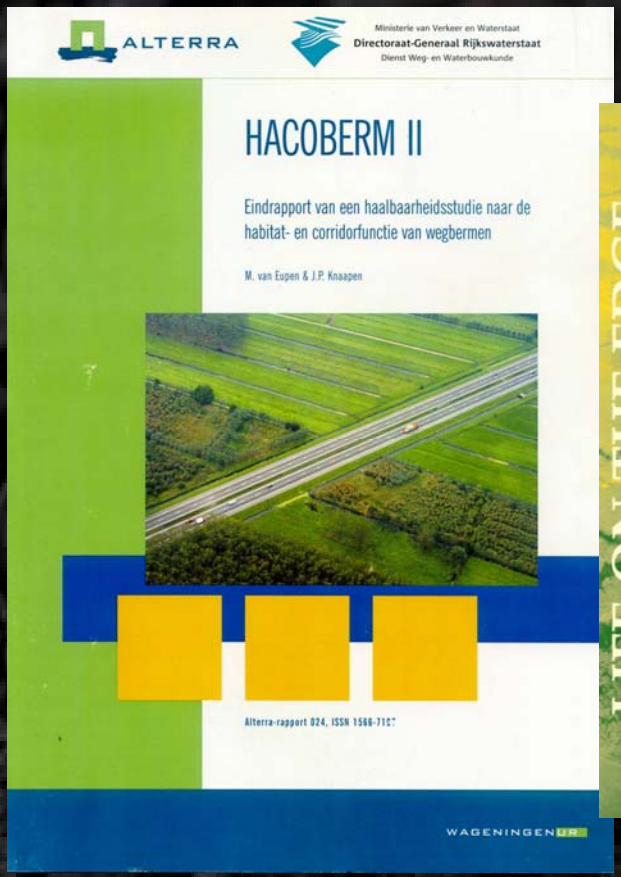


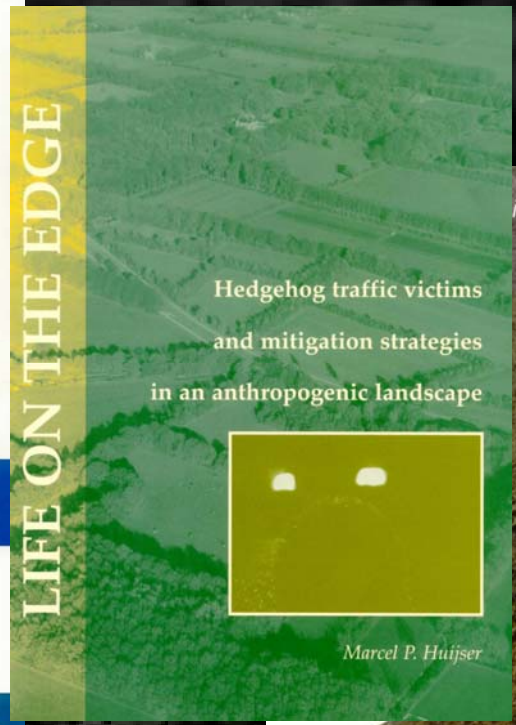
a/b reduction traffic mortality by fencing + crossing facilities
c/d elimination of barrier effect linking isolated habitats


padden trek


50
km/h


nature
compensation
Gemeente Liempde
Gemeente Sint-Oedenrode
K-1b
K-1a
SN-3
K-2
SN-4
Gemeente Nuenen, Gerwen en Nederwetten
V-3
SN-2
Gemeente Best
Gemeente Son en Breugel
SN-1
Gemeente Eindhoven
Compensatie-oppervlak
S2 N2 (Son-Nijnsel)
60 - 120 hectare
K (Koevering)
40 - 85 hectare
LEGENDA
N





20 years of research:

- *impact studies roads, traffic*
- *construction and maintenance*
- *effectiveness of measures*

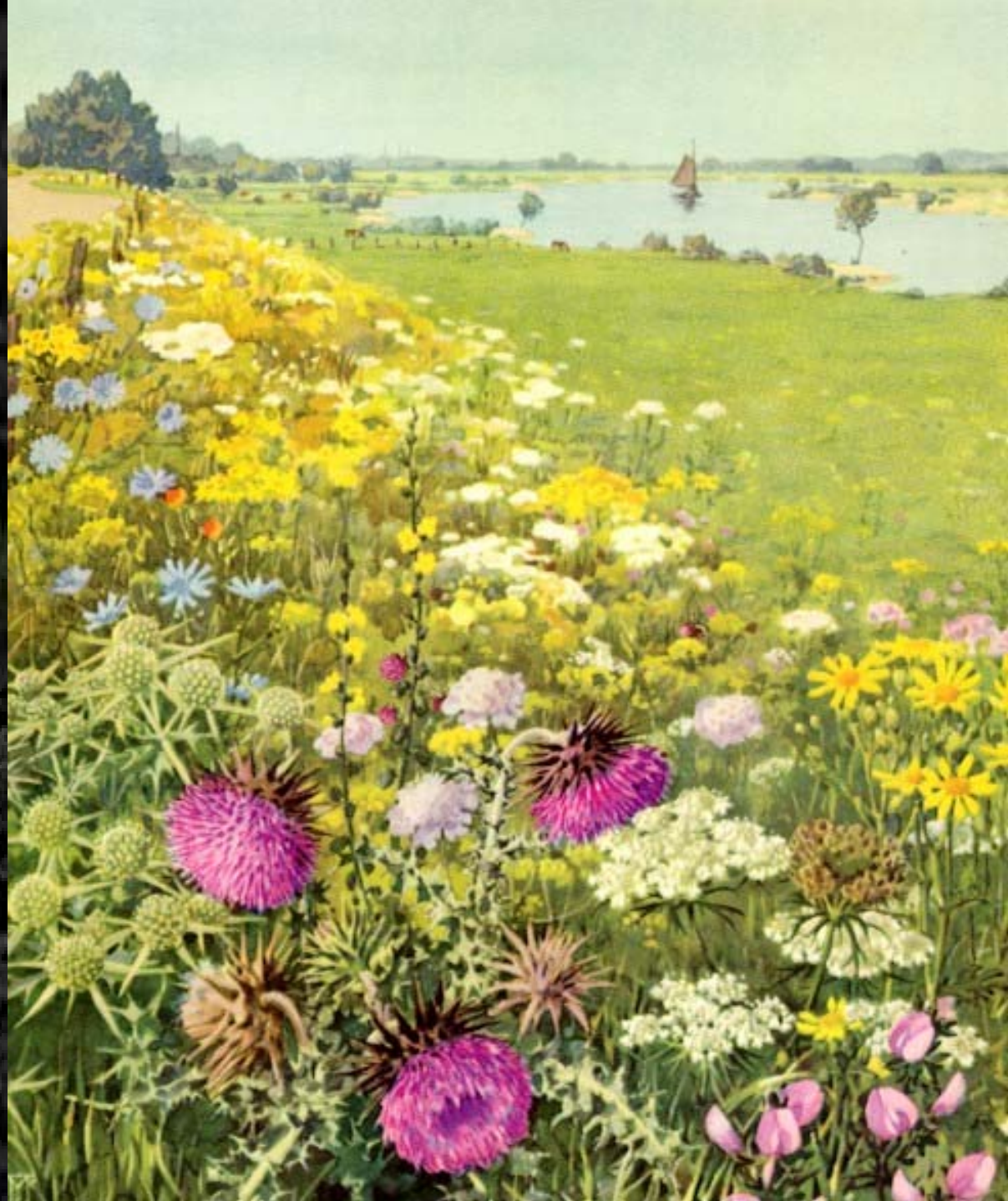

the road as a habitat

Road maintenance, verges, fauna measures

- *3.143 km national roads*
- *cost of road maintenance: 500 million $ / year*
  = 160.000 $ / km
- *road-side maintenance 35 million $ = 7% of budget*
- *12.000 ha of road verges = 29.000 $ / ha*
- *fauna measures on existing roads: 1% of budget*

1930:
dikes and verges:
rich in species

2000:
(semi-) natural grasslands:
3000 ha = 0.5%
of all grasslands



1950-1970:

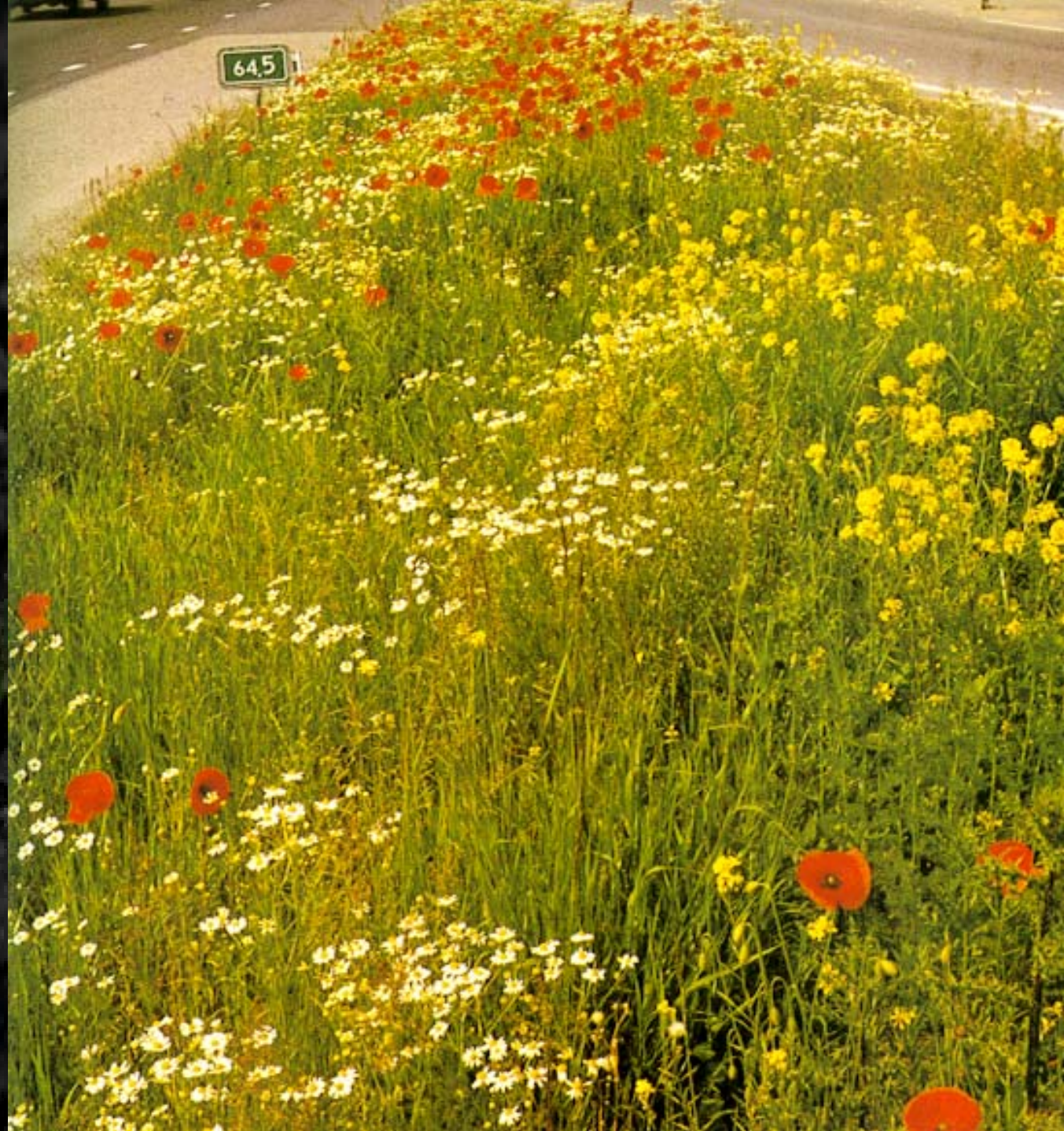
- *mowing (mulching) 6-10 times / year*
- *herbicides/pesticides*
- *fertiliser*
- *nutrient-rich soil*
- *low ecological values*

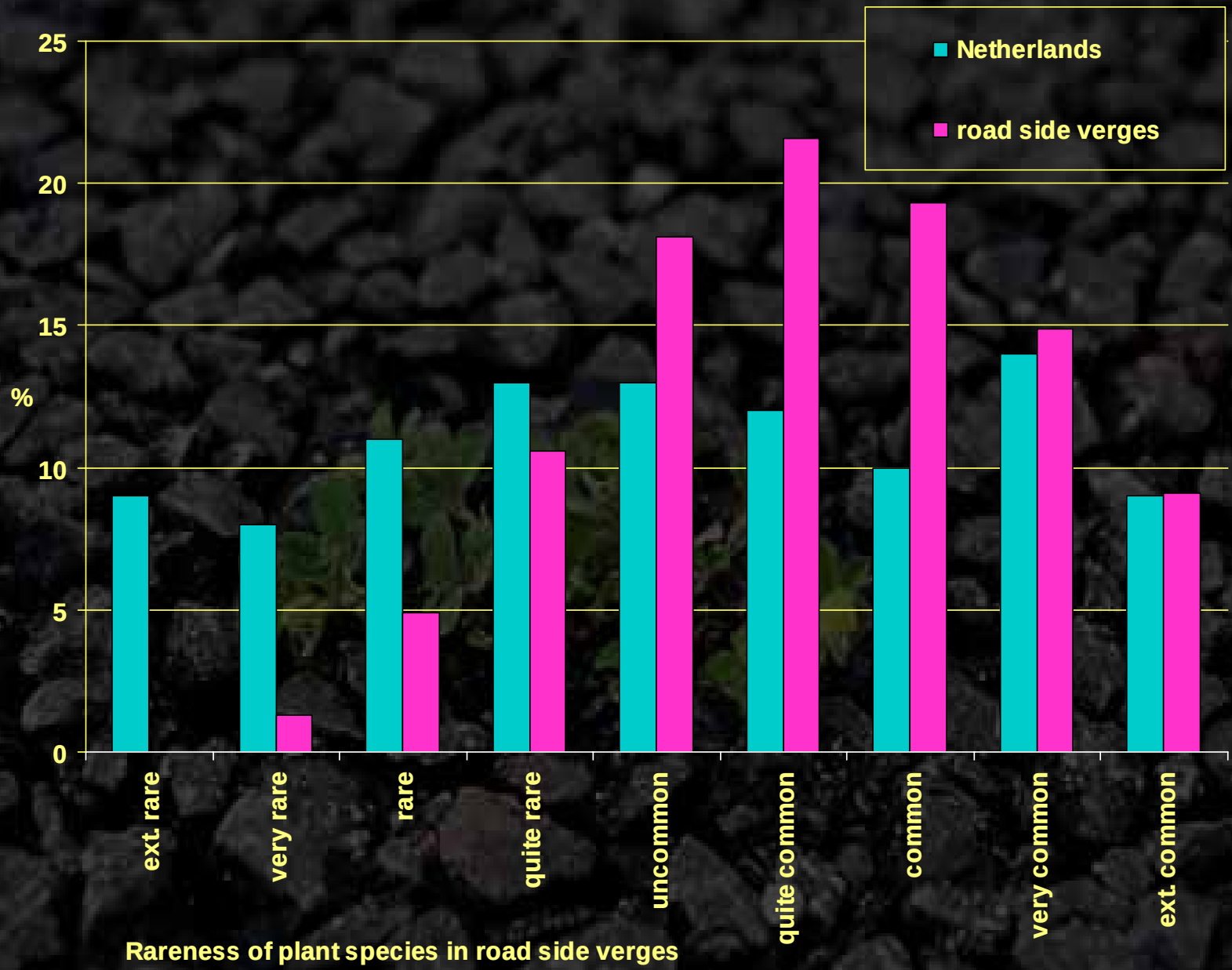
1970-1980:

- *changing management,*
- *more ecology*
- *mowing (cutting) 1-3 times / year*
- *removal of the hay*
- *no fertilisers*
- *no herbicides/ pesticides*

Netherlands: 1600 plant species

Road verges: 780 plant species





Rareness of plant species in road side verges

Significance of verges as habitat / corridor species dependant

group of species	*significance (under conditions)*	*effect*
Mustelidae	*part of habitat, corridor*	--
large mammals	*minimal*	--
hare/rabbit/hedgehog	*part. habitat*	-
mice/voles	*full habitat, part. habitat, corridor*	++/-
bats	*part. habitat, corridor*	-/+
birds	*part. habitat*	--/-
reptiles/amfibians	*part. habitat, corridor?*	-/+
invertebrates	*full habitat, part. habitat, corridor*	++/-
plants	*habitat, corridor??*	++/-

Conclusion:

Verges are most important for plants (mushrooms included), some groups small mammals, invertebrates.

Less important / suitable for other species.

Arrhenaterion most common type of vegetation

Relatively dry, nutrient-poor soil

Arrhenaterion

Heathland and poor sandy grassland vegetation

poor sandy grassland vegetation

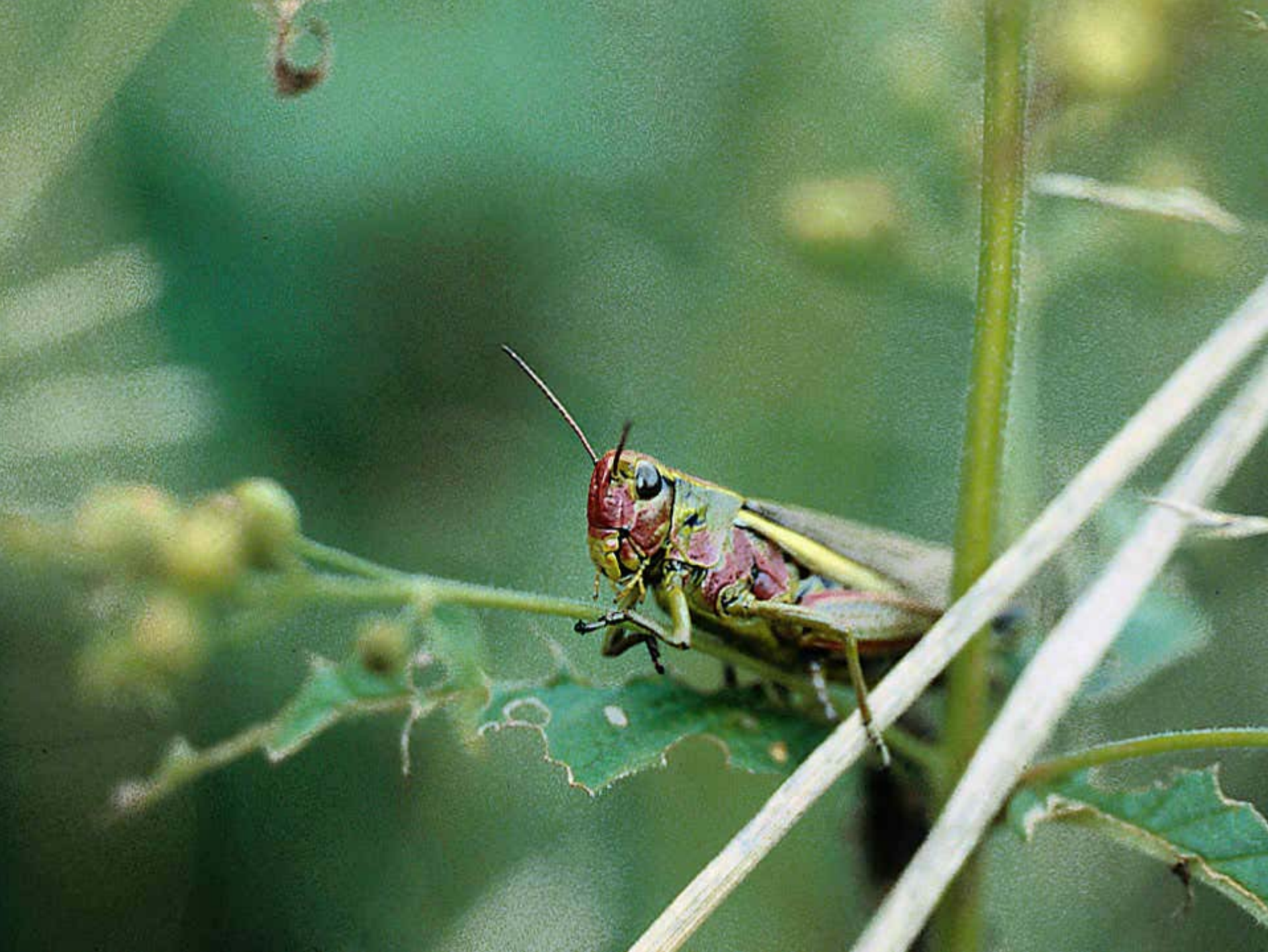
Ericaceous communities

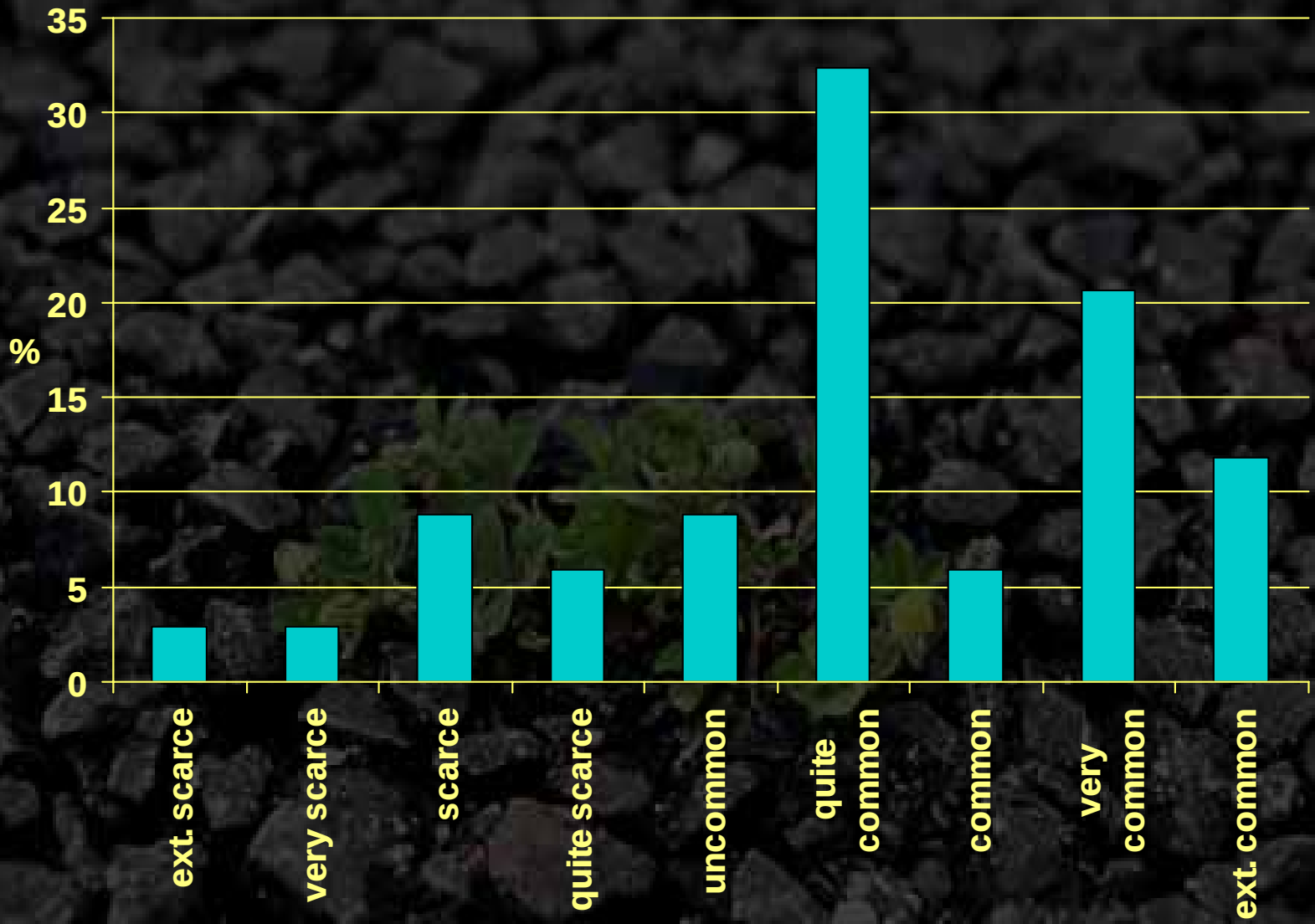
Underwood vegetation of nutrient-rich soil

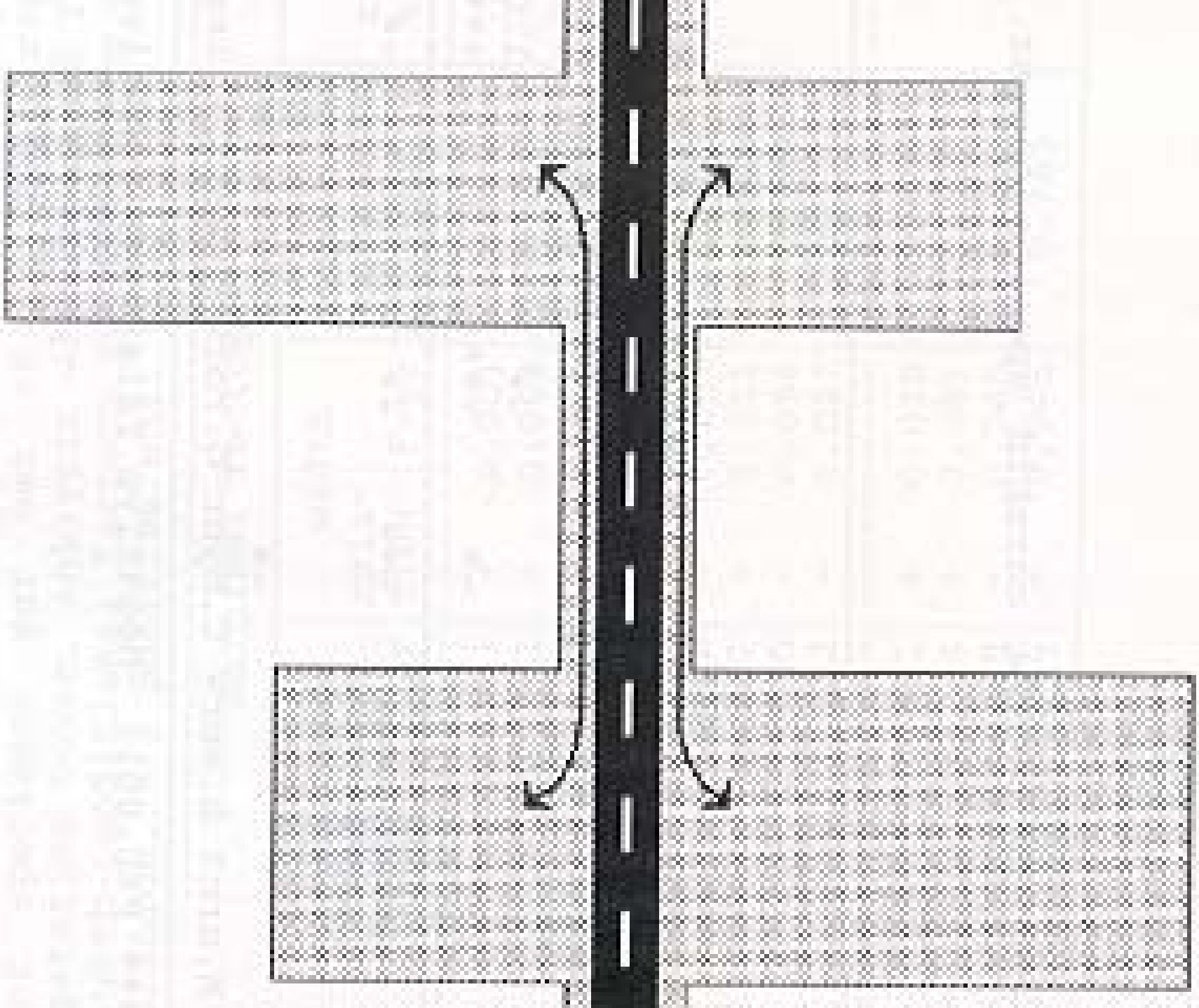
Anthriscus and Rumex

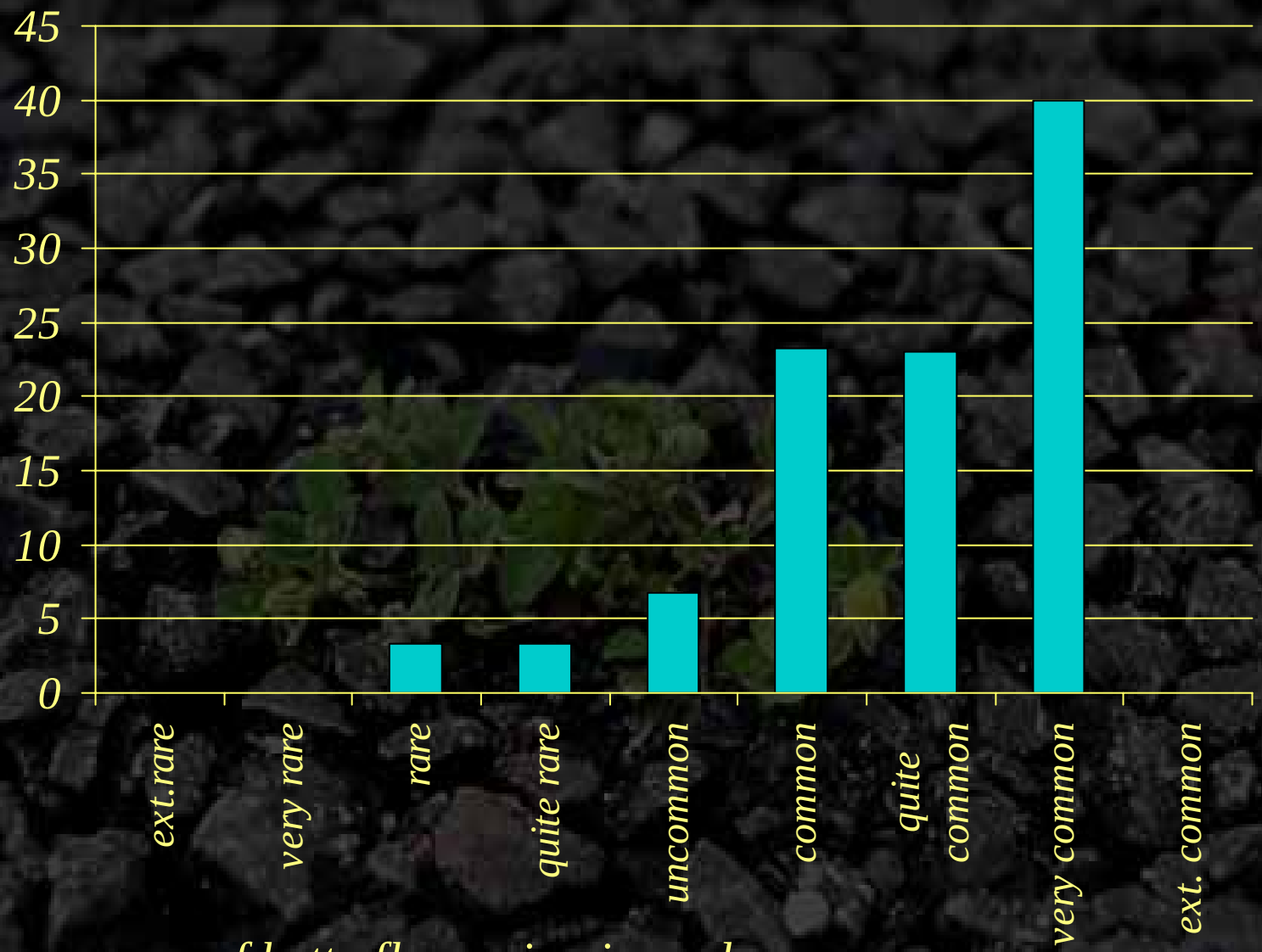
Aegopodium community

road sides / verges can act as corridors e.g. saline vegetation spreads along roads due to use of de-icing salt

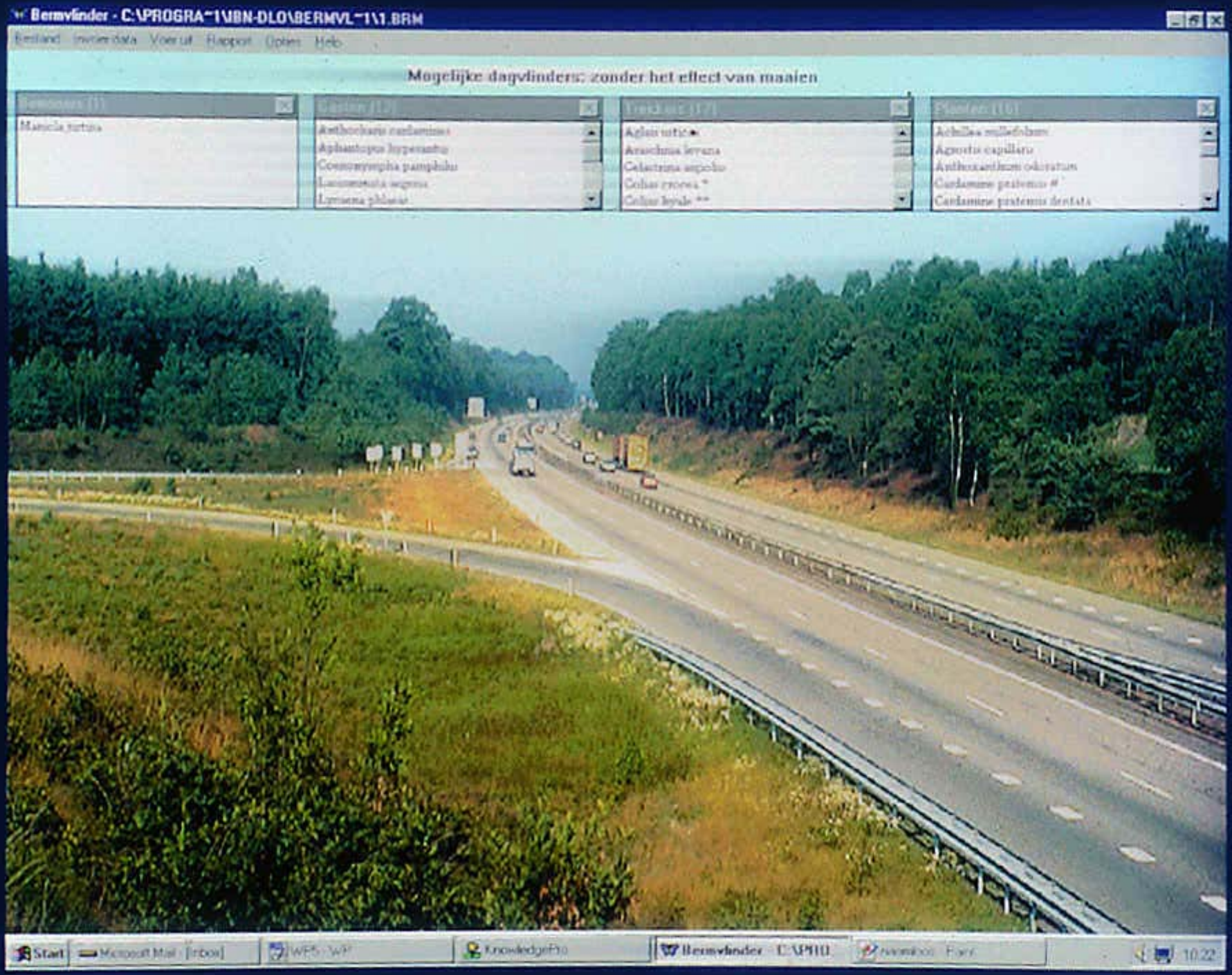



35
30
25
20
%
15
10
5
0
ext. scarce
very scarce
scarce
quite scarce
uncommon
quite common
common
very common
ext. common
rareness of grasshopper species in road verges





rareness of butterfly species in road verges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Bestand Invoer data Voer uit Rapport Opties Help
Mogelijke dagvlinders: zonder het effect van maaien
Start
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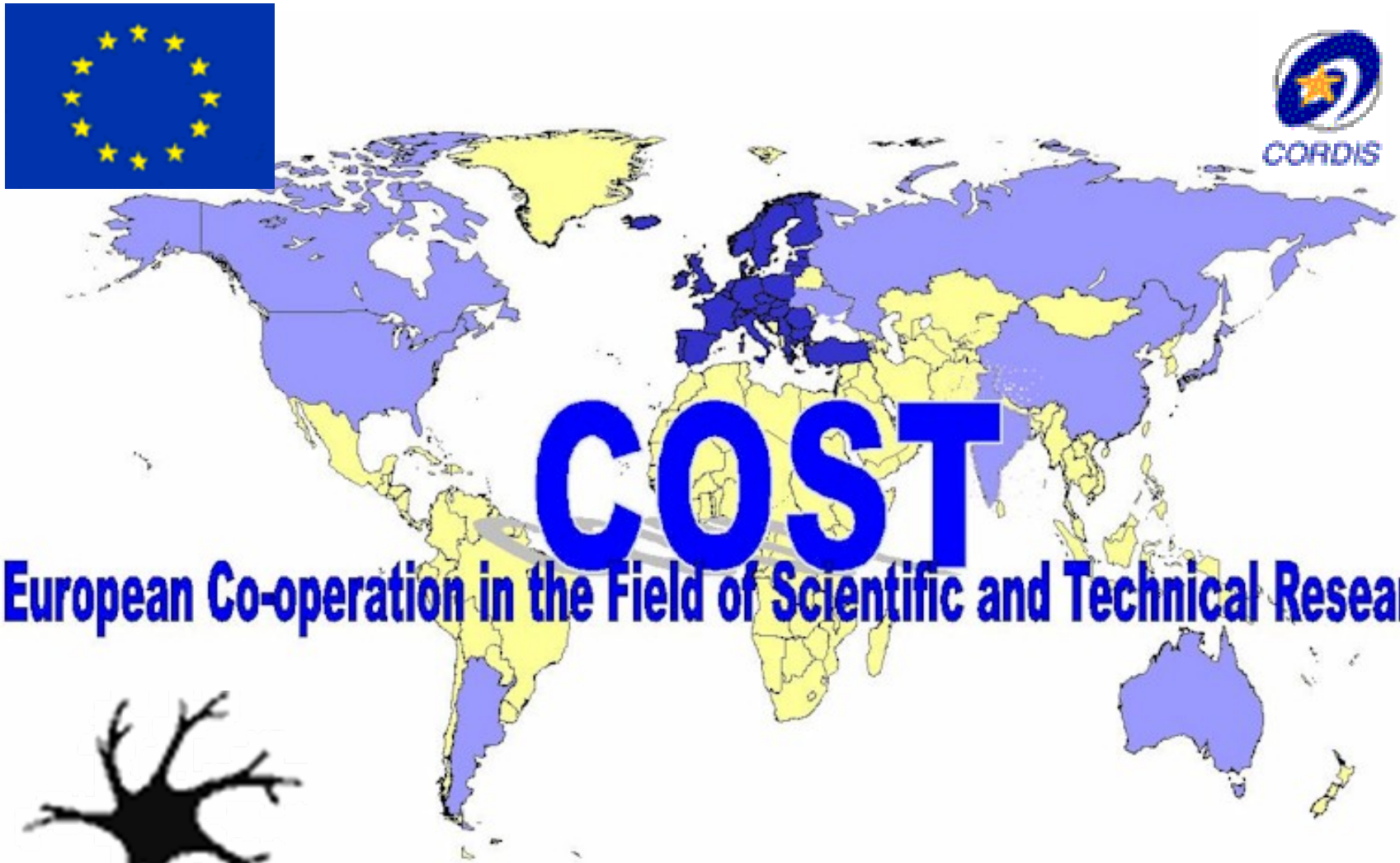
GEHLEN



Infra Eco Network Europe