Application to disease spread (in Asia)
A view on mapping exposure

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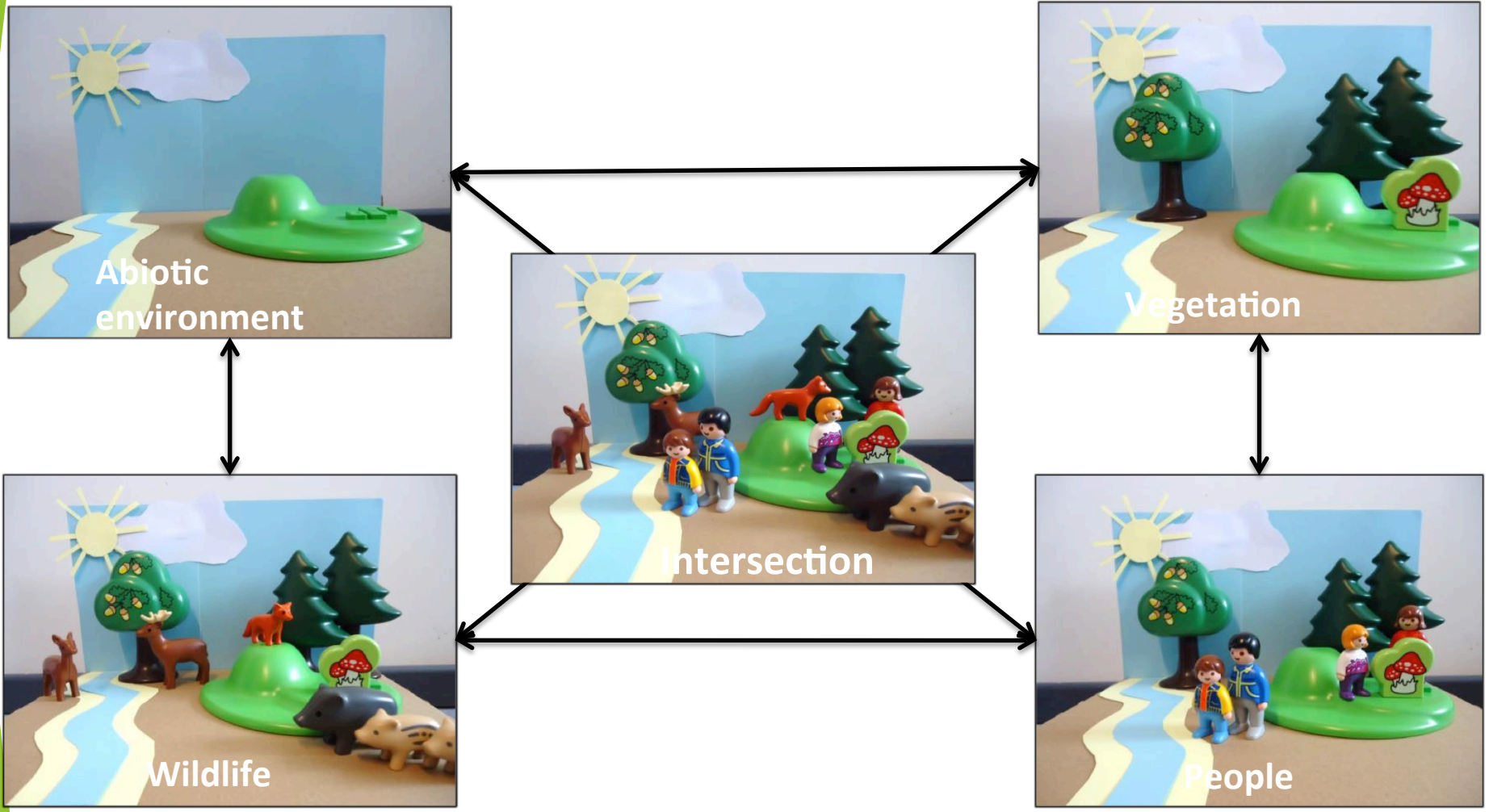
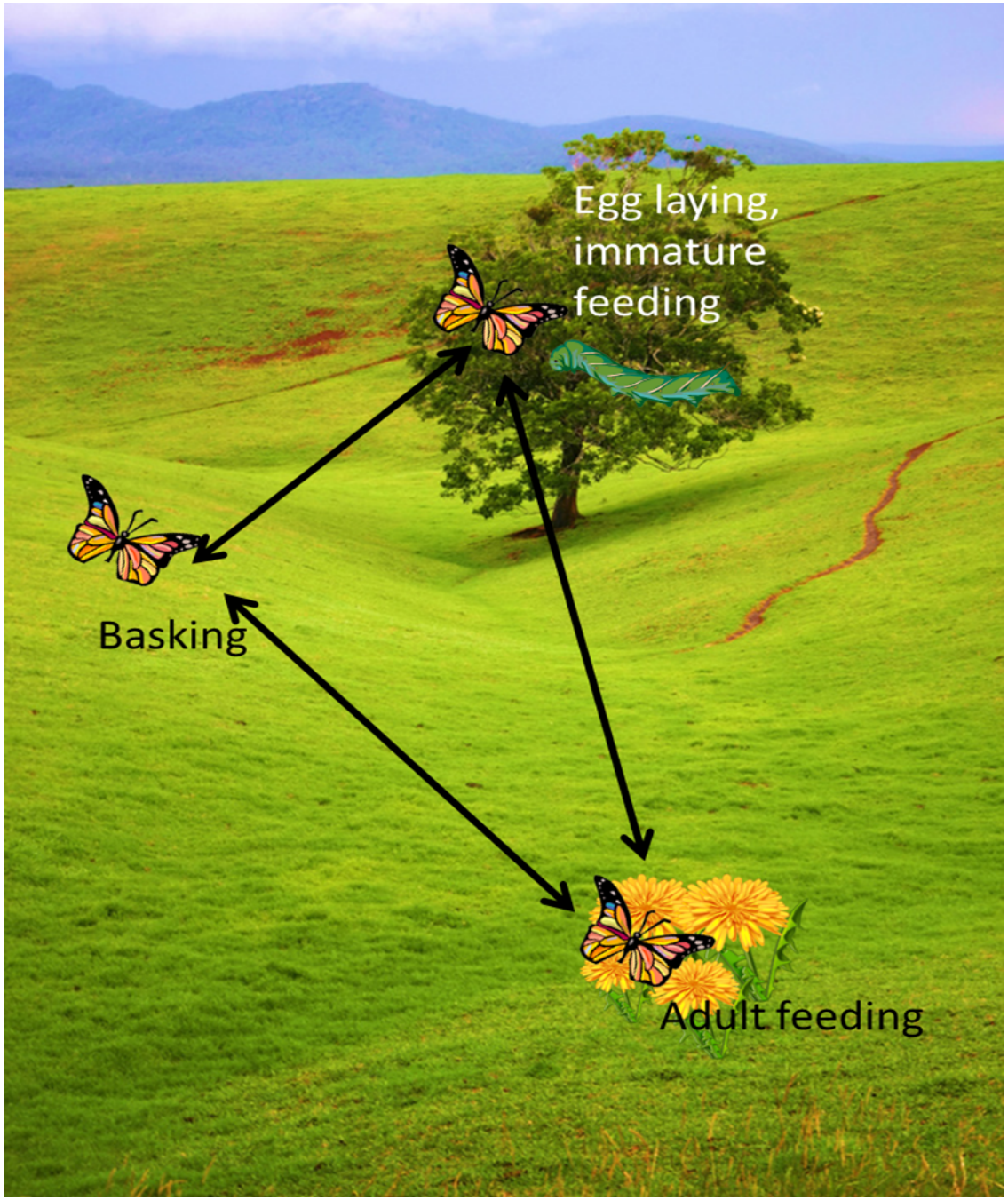
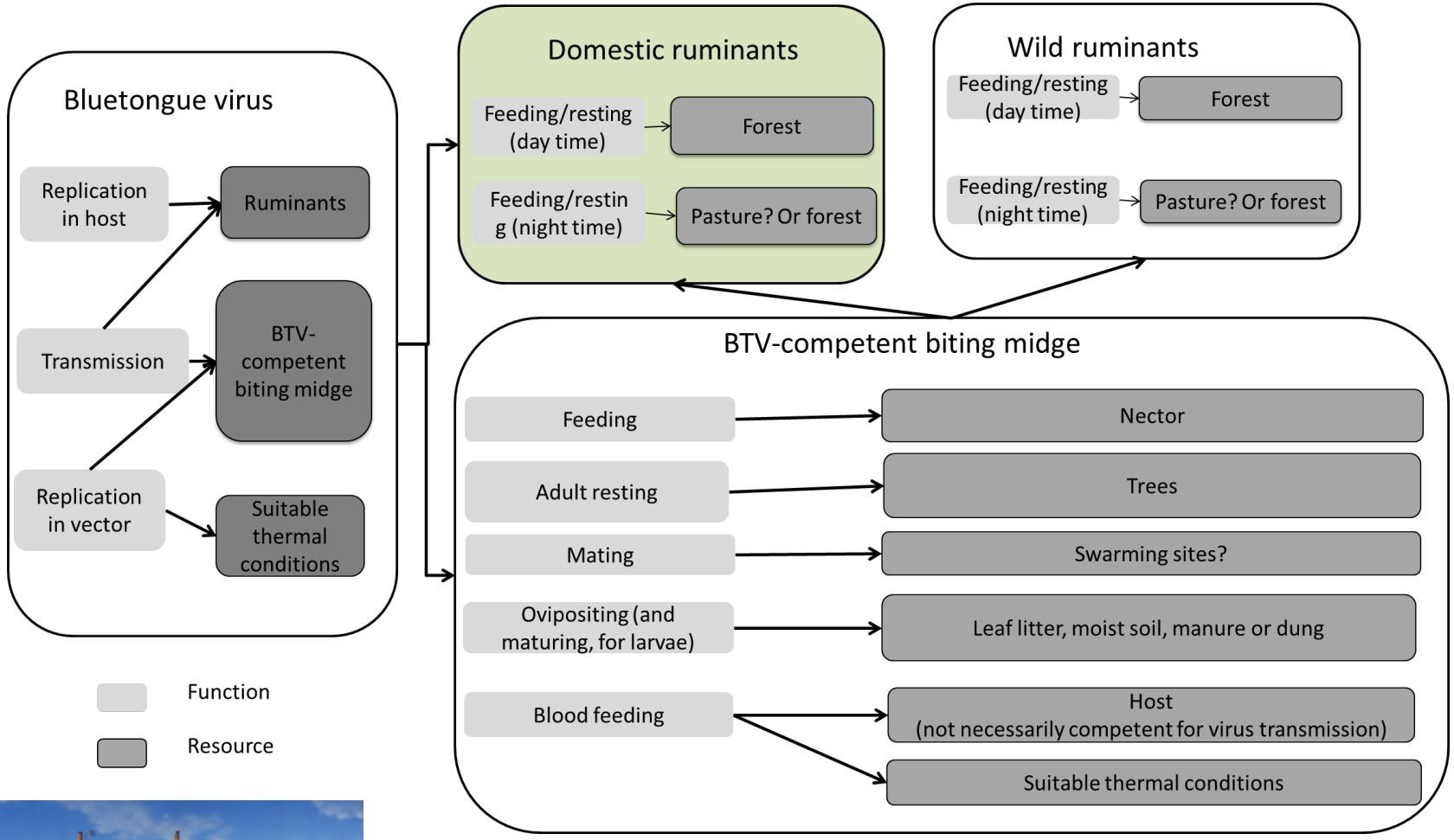

Abiotic environment
Vegetation
Intersection
Wildlife
People

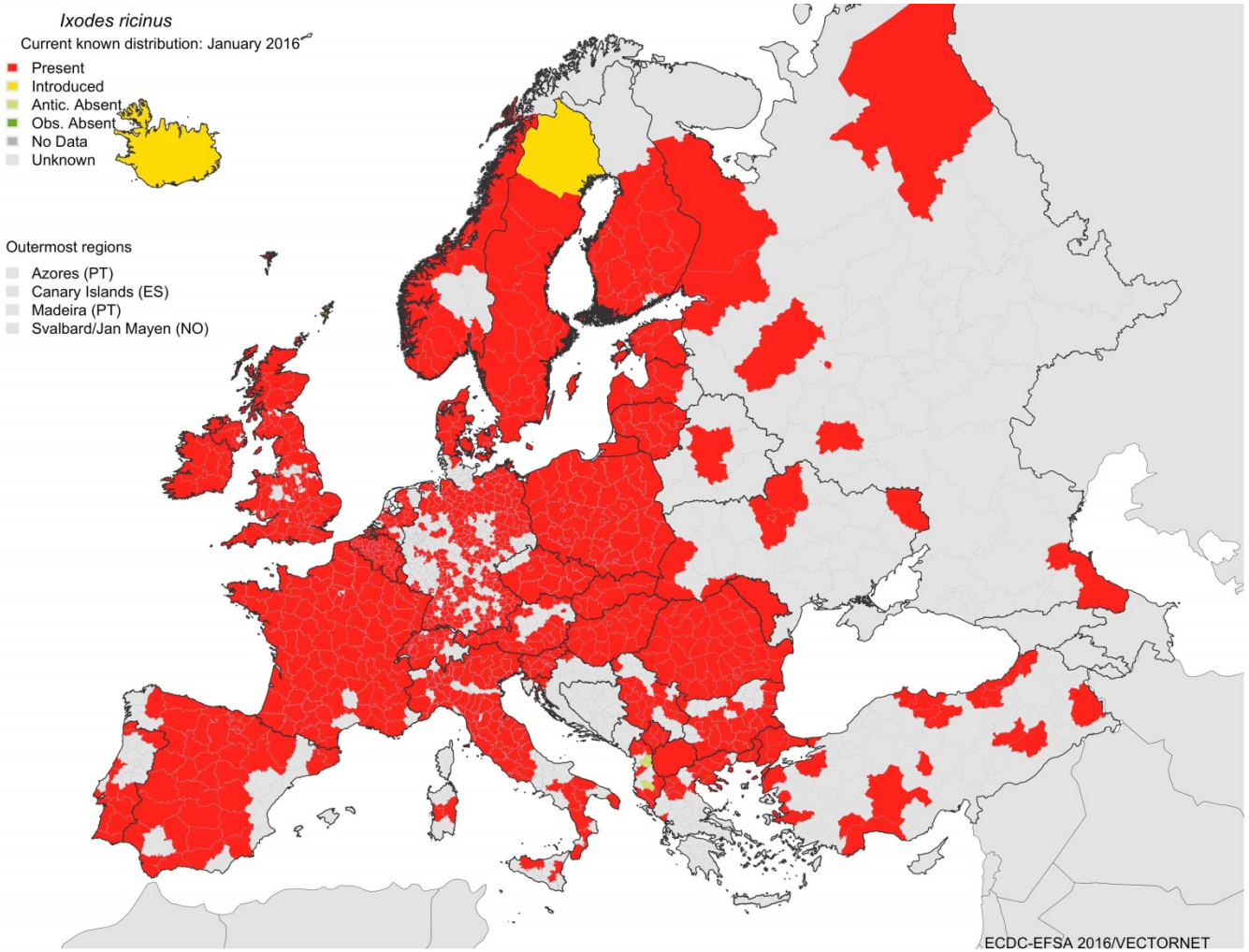

Egg laying,
immature
feeding
Basking
Adult feeding

A resource-based habitat concept for infectious diseases

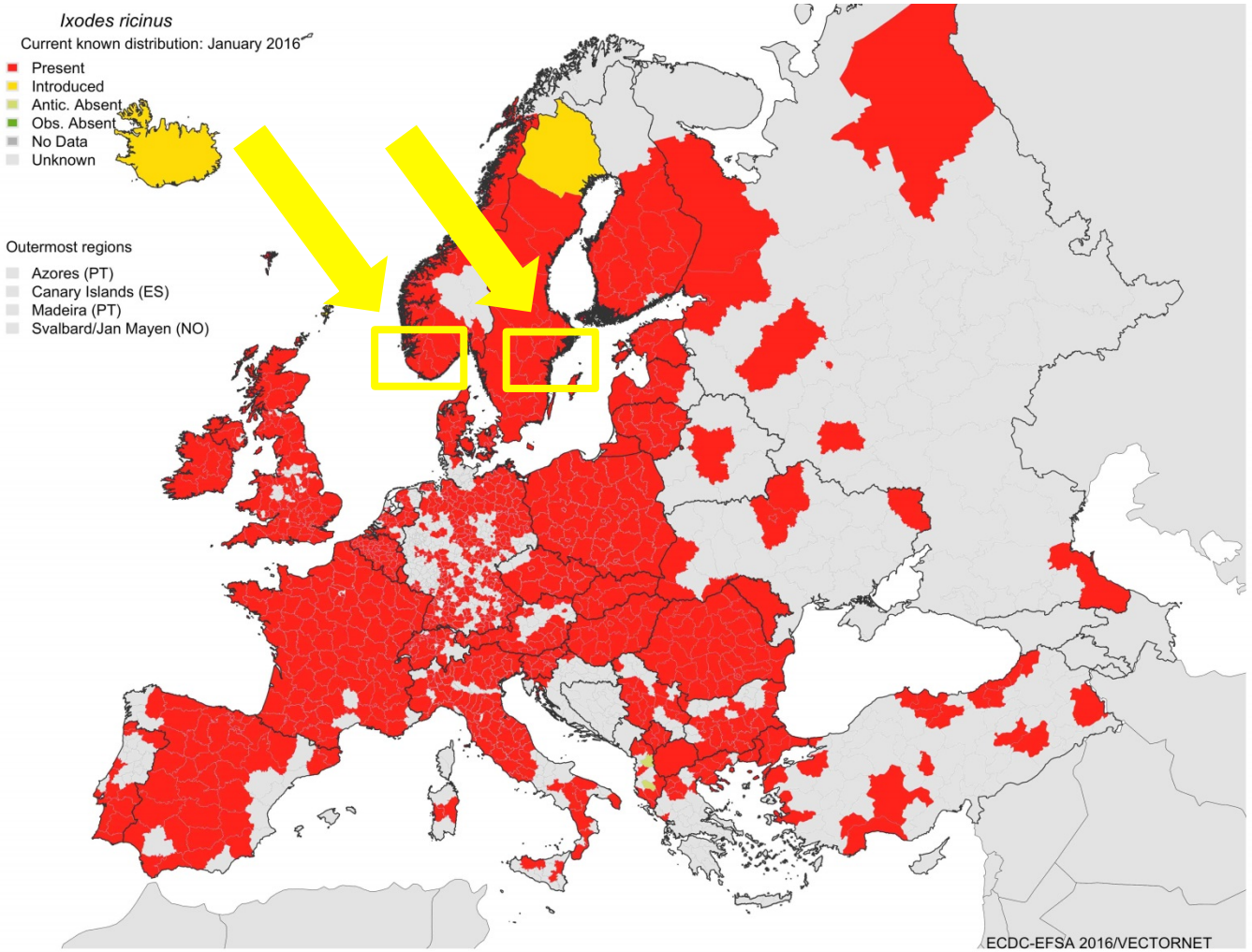


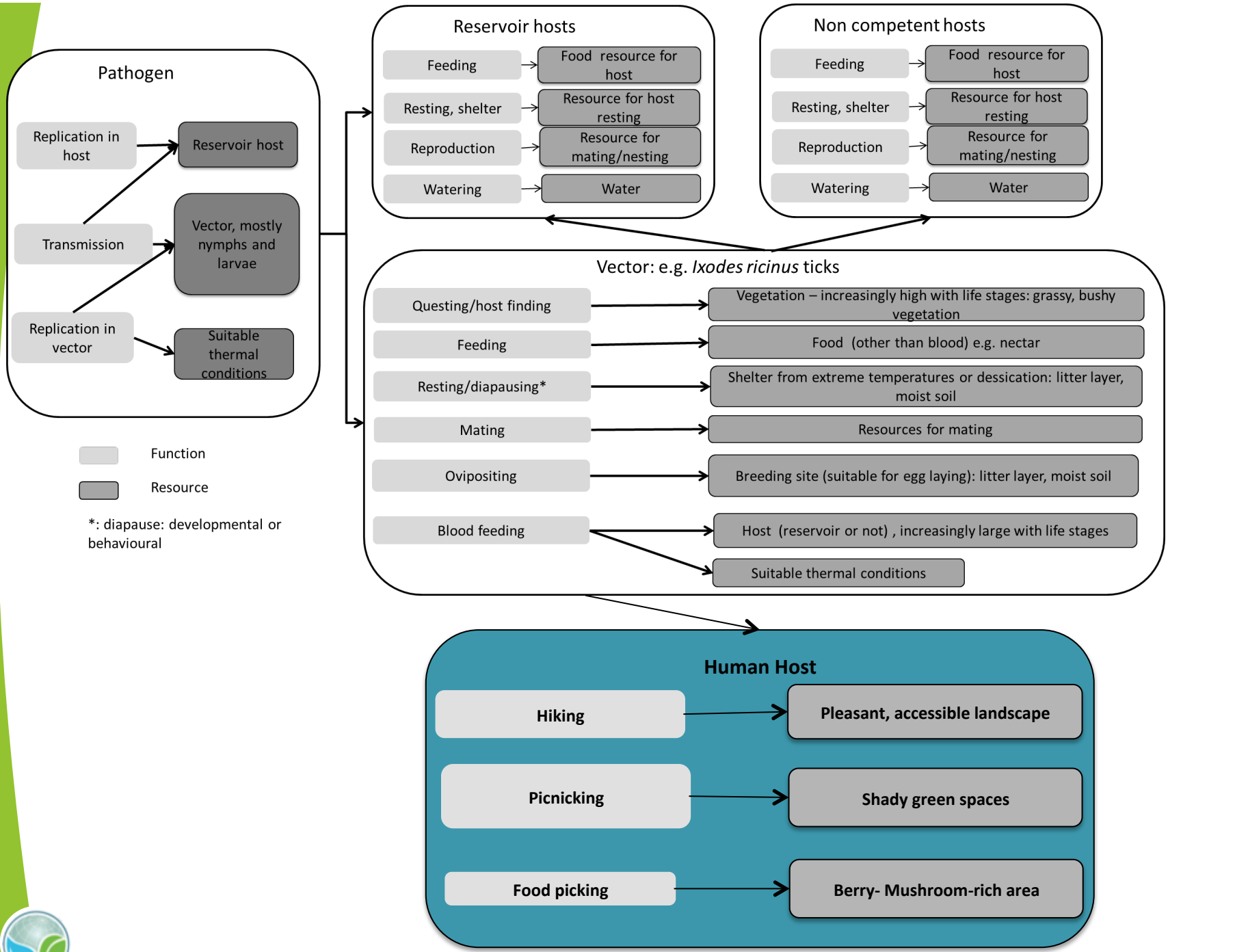
Hartemink et al., 2015

Tick-borne diseases in Europe: ticks everywhere, spatially homogenous risk?



2 examples:
Accounting for exposure in environmental covariates
Assessing exposure on its own

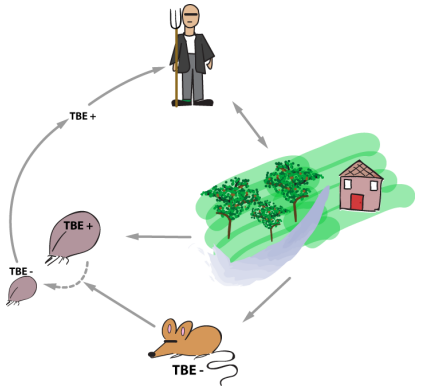



Pathogen
Replication in host
Reservoir host
Transmission
Vector, mostly nymphs and larvae
Replication in vector
Suitable thermal conditions
Function
Resource
*: diapause: developmental or behavioural
Reservoir hosts
Feeding
Food resource for host
Resting, shelter
Resource for host resting
Reproduction
Resource for mating/nesting
Watering
Water
Non competent hosts
Feeding
Food resource for host
Resting, shelter
Resource for host resting
Reproduction
Resource for mating/nesting
Watering
Water
Vector: e.g. Ixodes ricinus ticks
Questing/host finding
Vegetation – increasingly high with life stages: grassy, bushy vegetation
Feeding
Food (other than blood) e.g. nectar
Resting/diapausing*
Shelter from extreme temperatures or dessication: litter layer, moist soil
Mating
Resources for mating
Ovipositing
Breeding site (suitable for egg laying): litter layer, moist soil
Blood feeding
Host (reservoir or not) , increasingly large with life stages
Suitable thermal conditions
Human Host
Hiking
Pleasant, accessible landscape
Picnicking
Shady green spaces
Food picking
Berry- Mushroom-rich area

Step 1: interpreting environmental variables in terms of hazard and exposure

Tick-borne encephalitis in Sweden

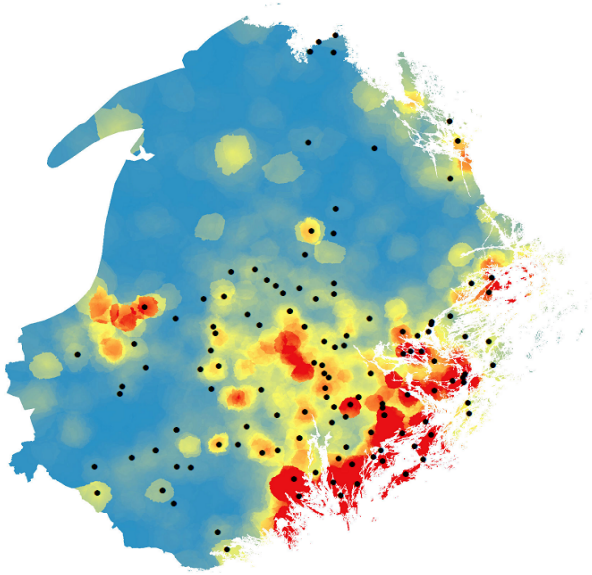
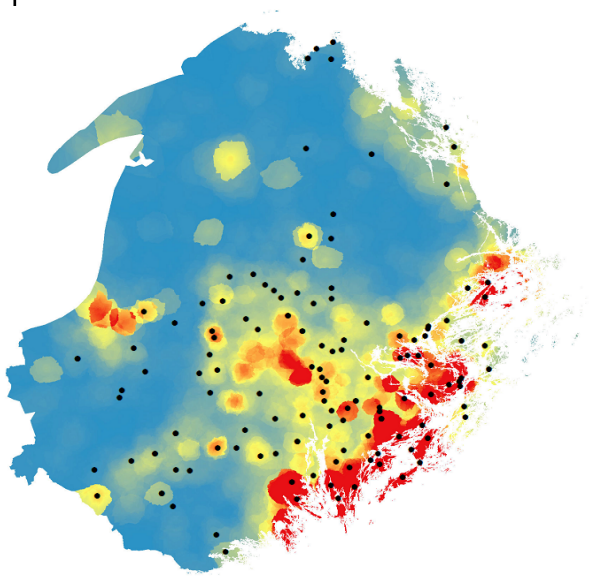
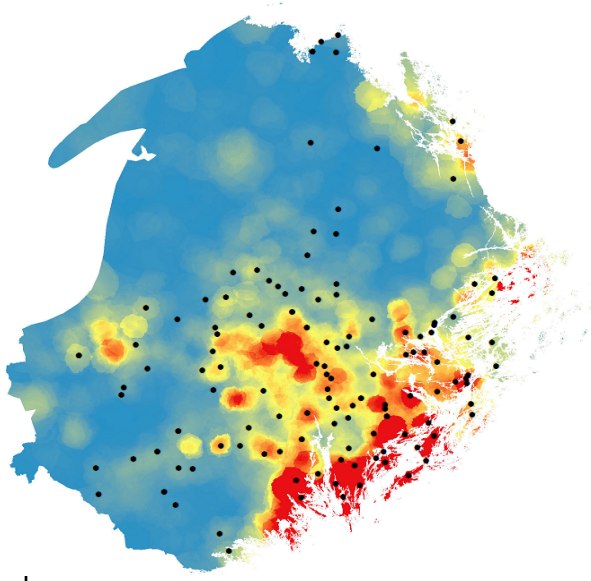
Hazard: tick suitable habitat, hosts



Exposure:
Attractivity: forest features
Accessibility: forest access

Zeimes et al., 2014 doi:10.1186/1756-3305-7-370

TBE in Sweden: integrate hazard and exposure

BRT	BRT Attractiveness	BRT Ecology
		

- TBE human infections in 2011

BRT probabilities of TBE infections between 1998 and 2007

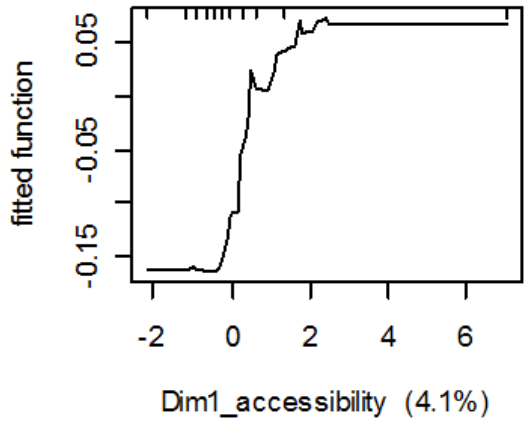
High : 0,231

Low : 0,009

Attractiveness = accessibility + beauty of the area and forest

• Accessibility

- Most of second home are near permanent home *(Pearce, 1996 ; Müller, 2006)*

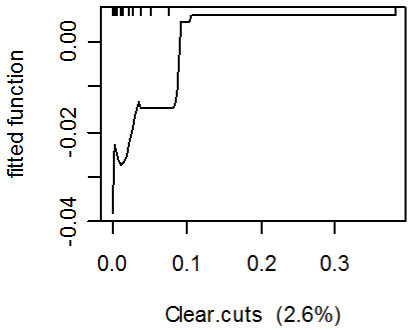


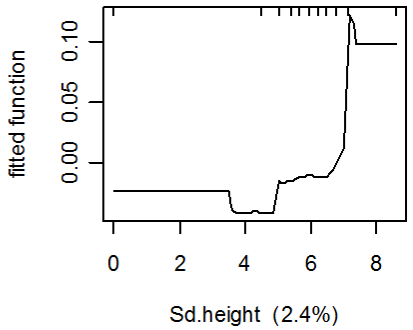
Dim1_accessibility:

+ with Population density and Roads - with Distance to Stockholm

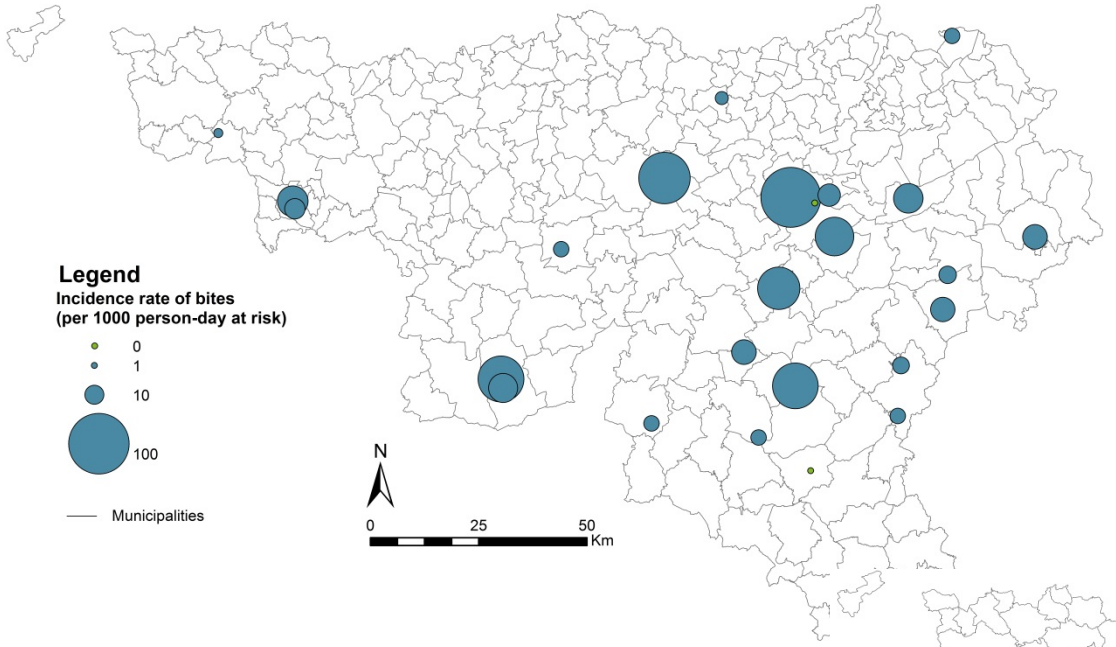
• Beauty of the forest

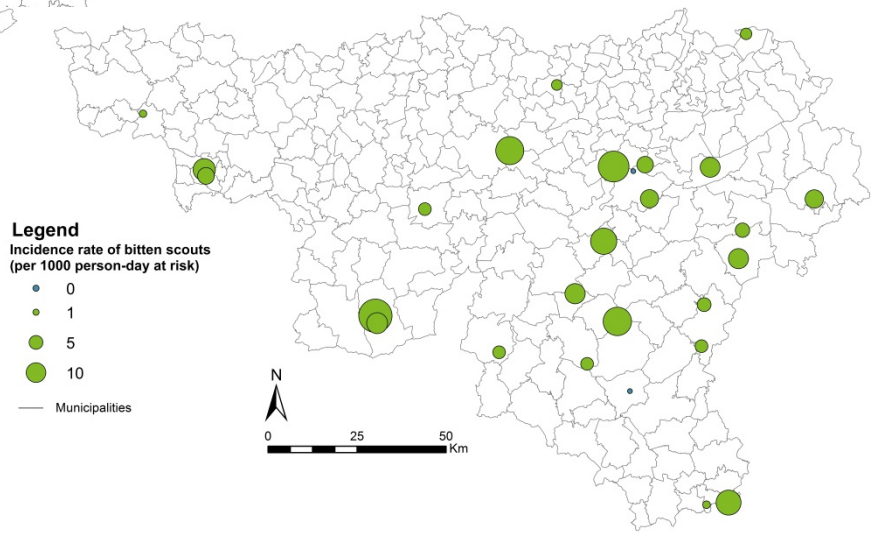
- Increasing tourism preference with
  - Number of clear-cuts (*Bostedt et al., 1995)*
  - Skewness of vegetation *(Silvennoinen et al., 2001)*





Tick bites in Scout camps

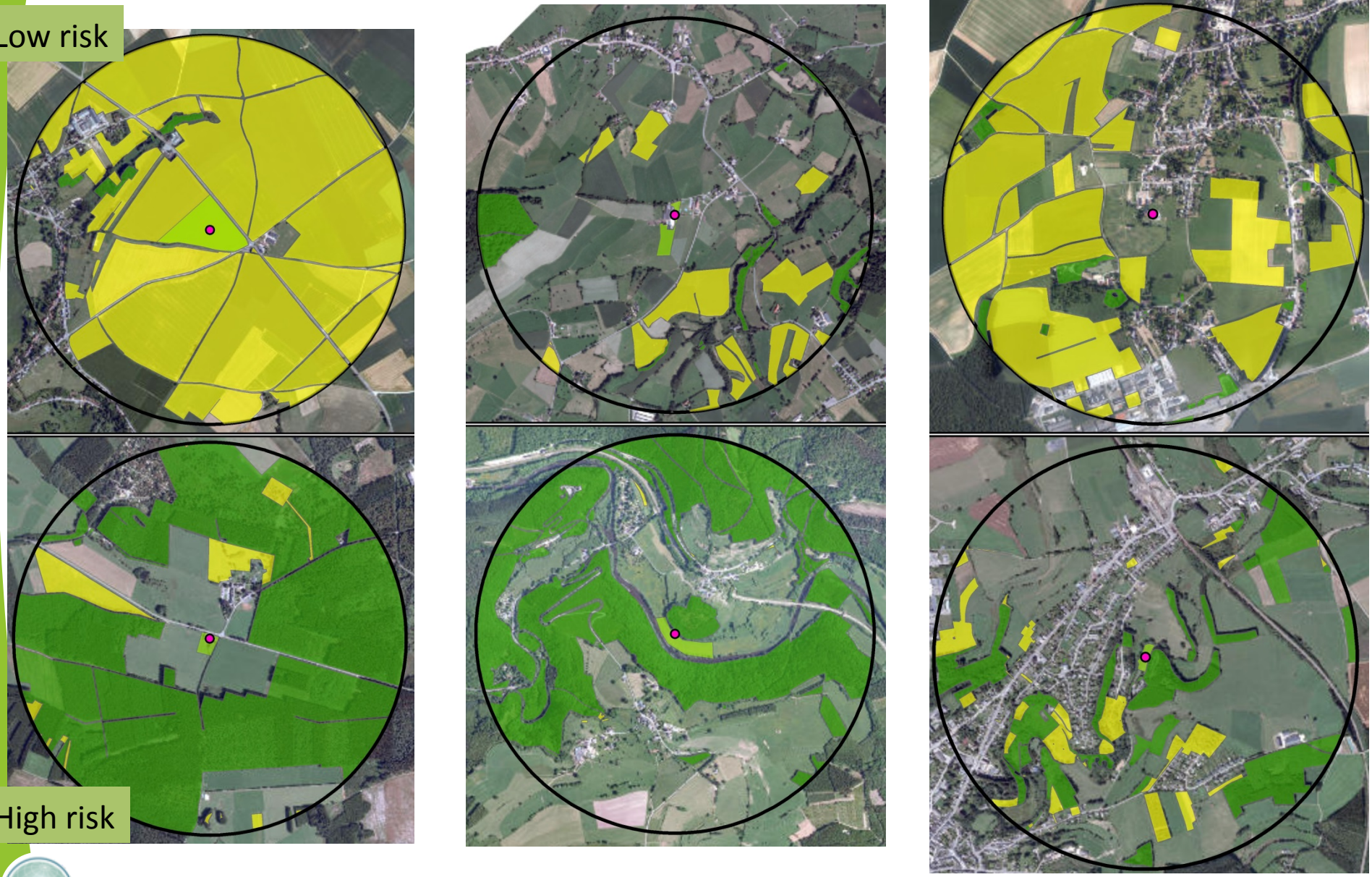




De Keukeleire et al. 2015
doi:10.1016/j.ttbdis.2015.05.008

Tick bites in Scout camps

Low risk



High risk

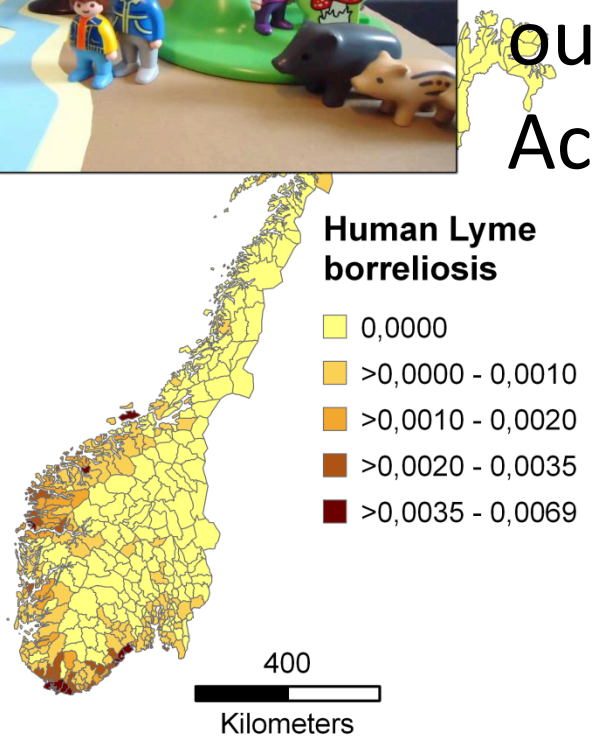
Step 2: assess exposure

Example 1: Lyme borreliosis in Norway

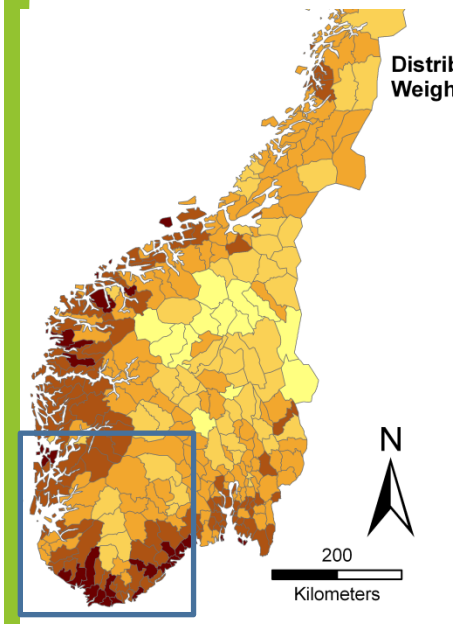
Exposure:

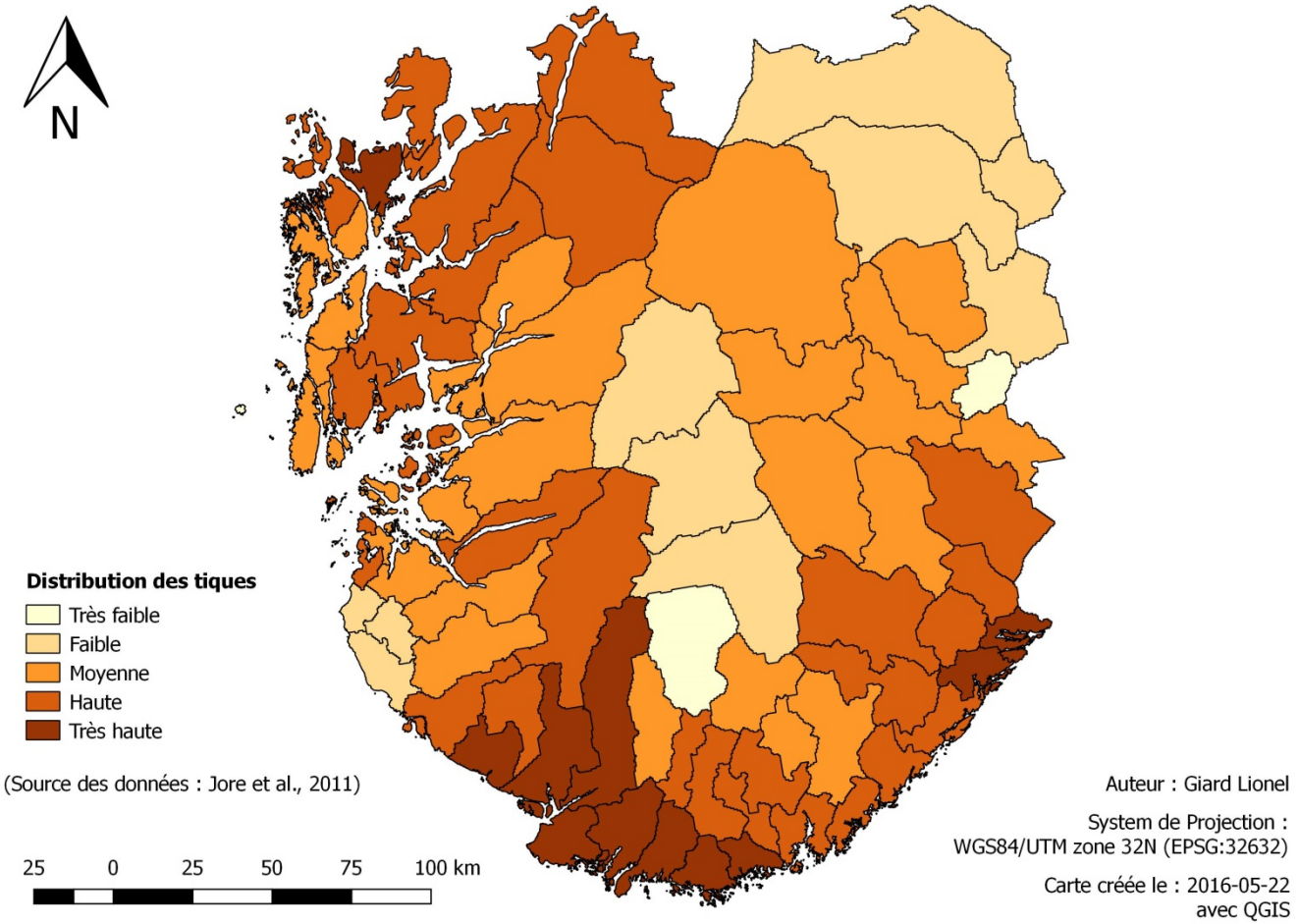
Attractivity: infrastructure for outdoor activities

Accessibility



Jore et al. 2011





Jore et al., 2011

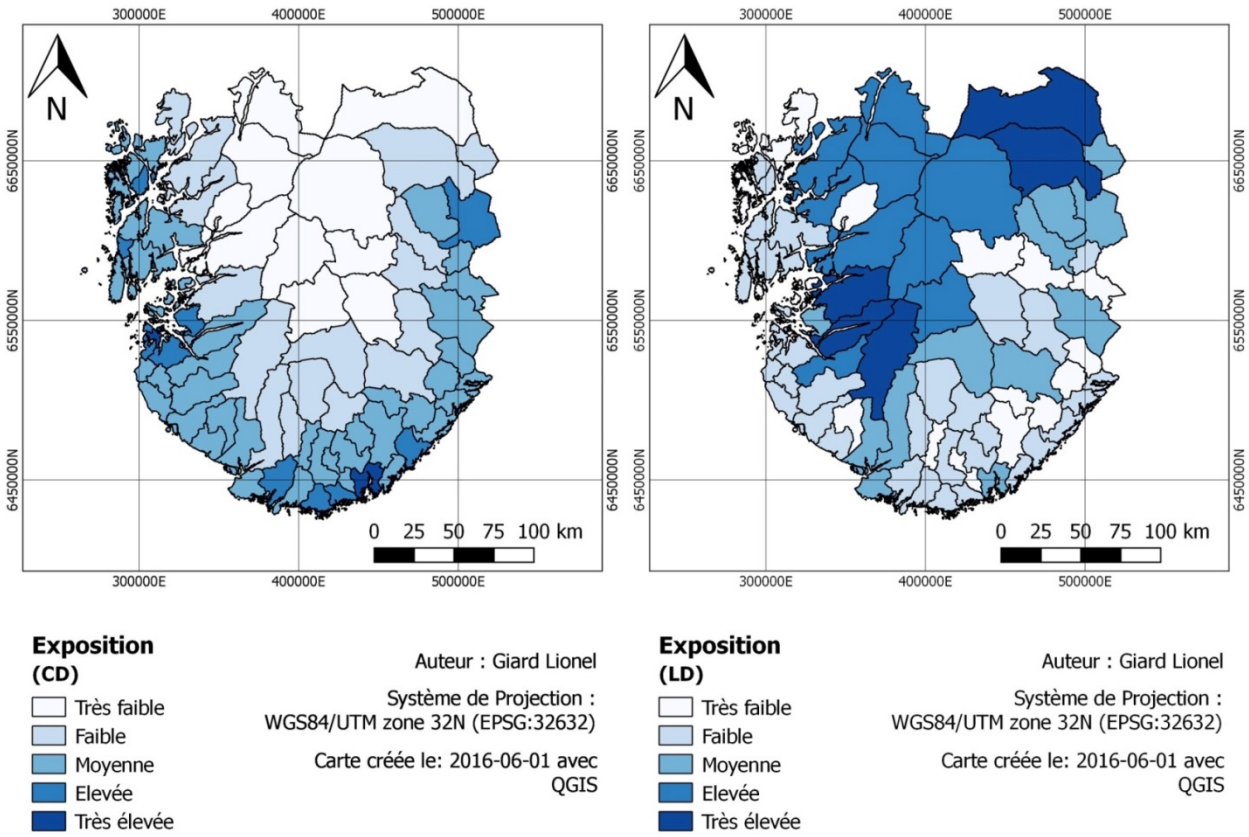
Inputs:

Roads

Hiking trails

Picnic areas

Cabins, campings



D. Oda, Star Bulletin

Dengue in Hawaii

- Sporadic outbreaks following introduction of the virus (1943, 2001)
- Vectors: *Aedes albopictus, Ae. aegypti* (controlled in the 1940s but…), both invasive
- Travel to/from Asia, Hawaii, continental US

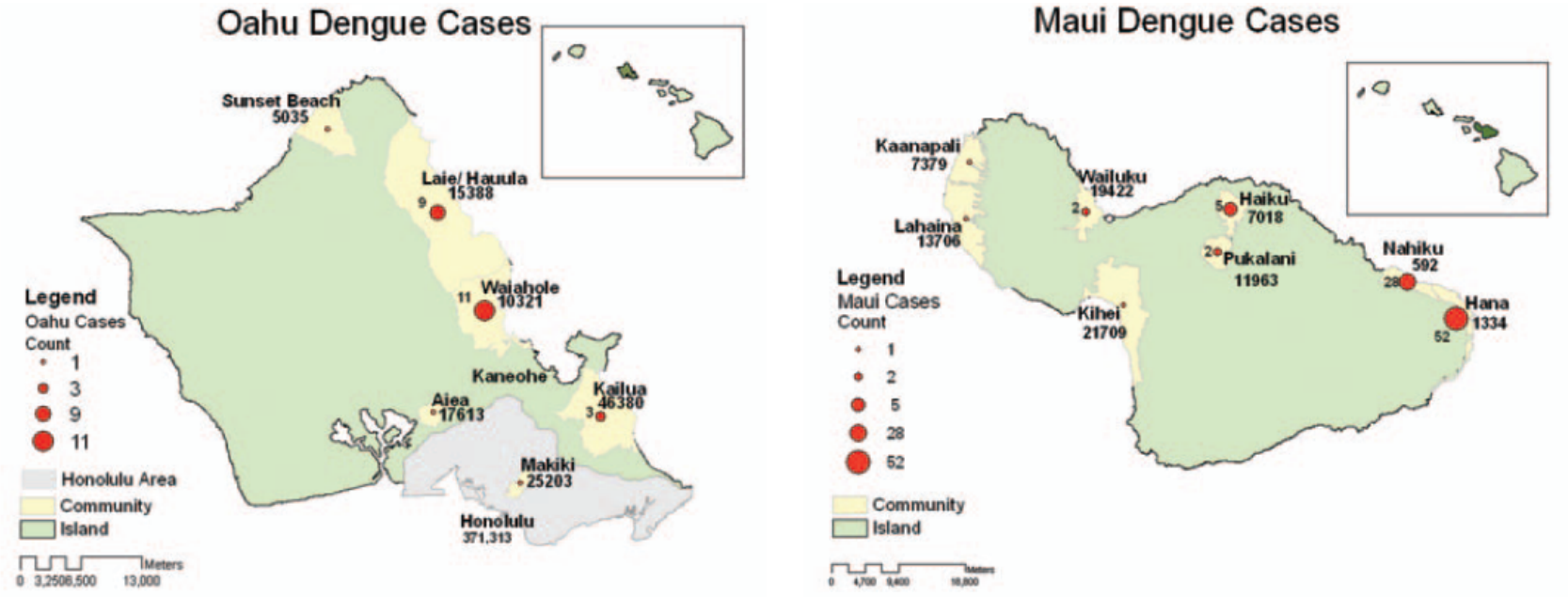
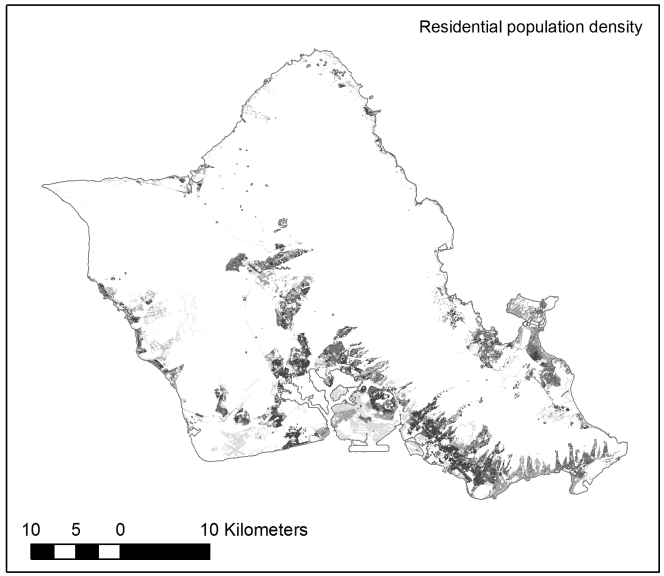


Figure 1. Autochthonous dengue infections, Maui and Oahu, Hawaii, 2001–2002.

Effler et al. 2005

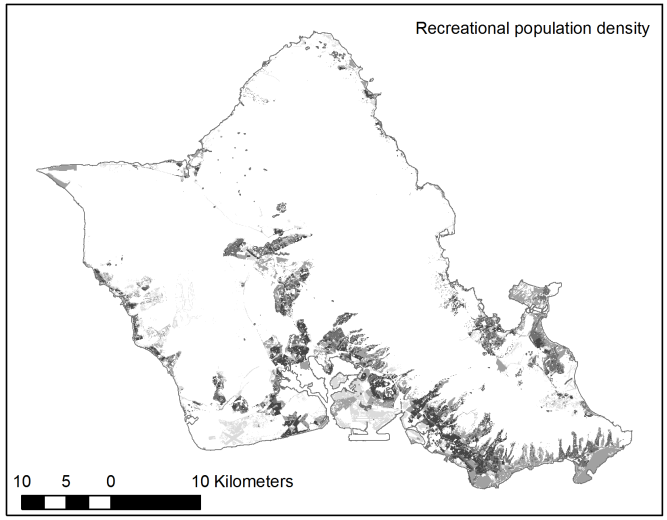
Human population density



Residential human population density Person/km2

1 051
3 148
5 246

Classification method: quantiles

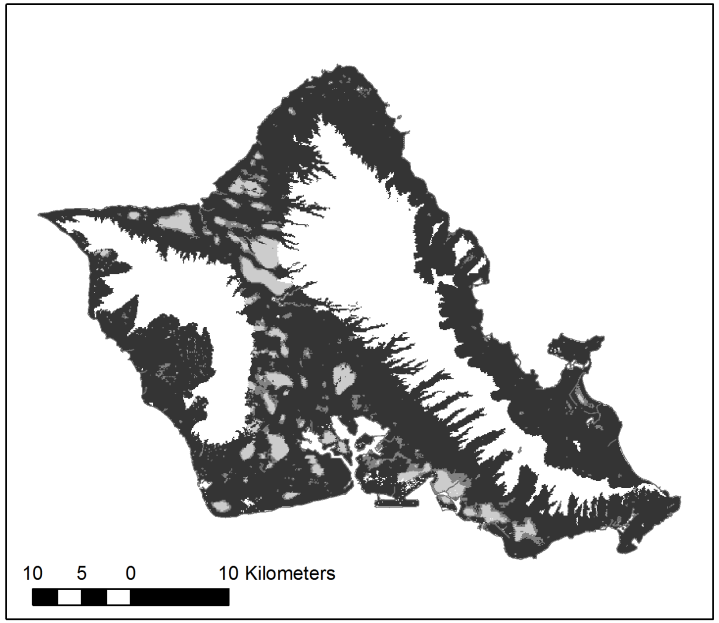


Recreational human population density Person/km2

945
2 833
4 721

Classification method: quantiles

Mosquito abundance

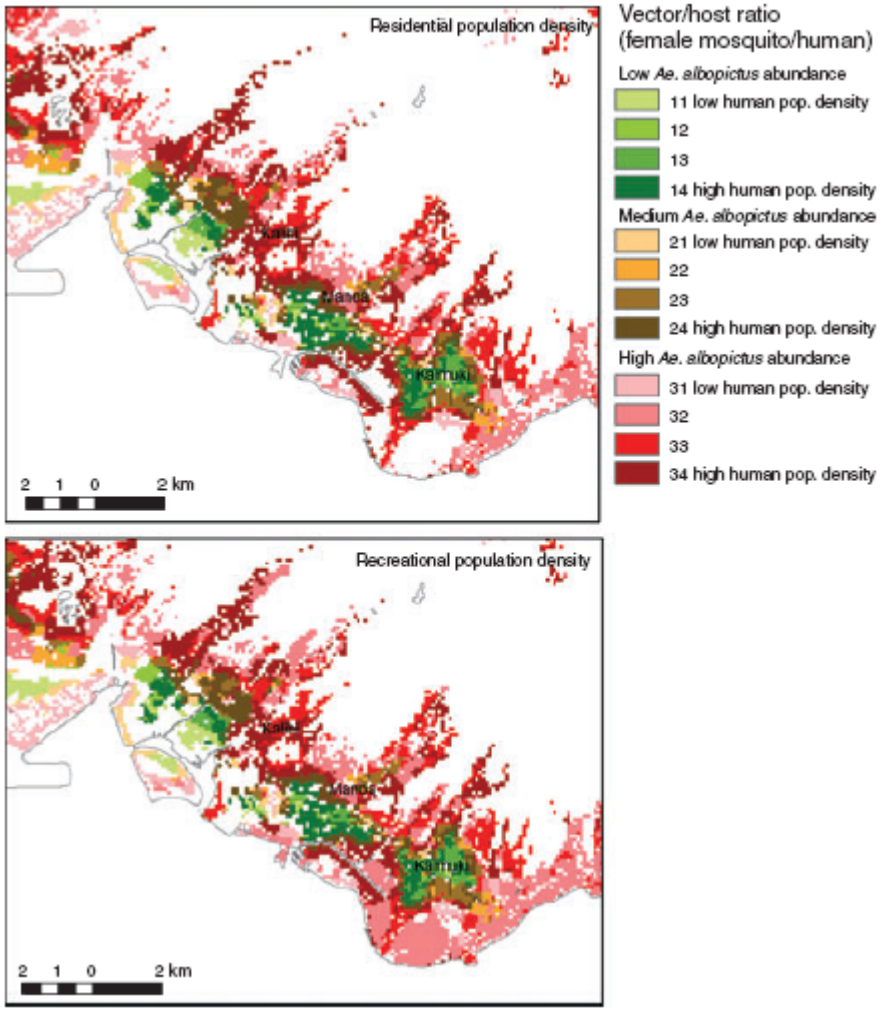


Ae. albopictus **abundance class**

Low
Medium
High

Vanwambeke et al., 2011, Tropical Medicine and International Health 16 (2)
doi: 10.1111/j.1365-3156.2010.02671.x.

Vector to host ratio



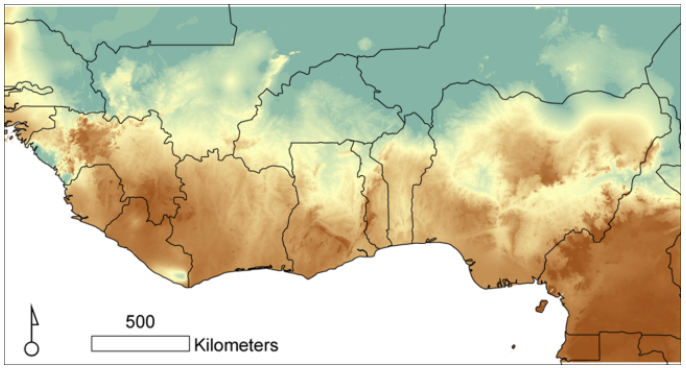
- Maps the hosts using environment rather than mapping the environment
- Uses proxies of assemblage of resources (a necessity?)
- Mosquito data resolution

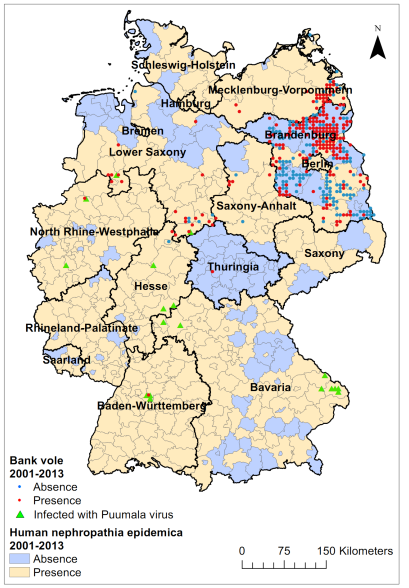
Where do people get exposed

- Residence?
- Other activities

How can we represent this?

- Issue of scale
- Issue of representation





Zeimes, Reil, Jacob, Ulrich, Vanwambeke, in prep.

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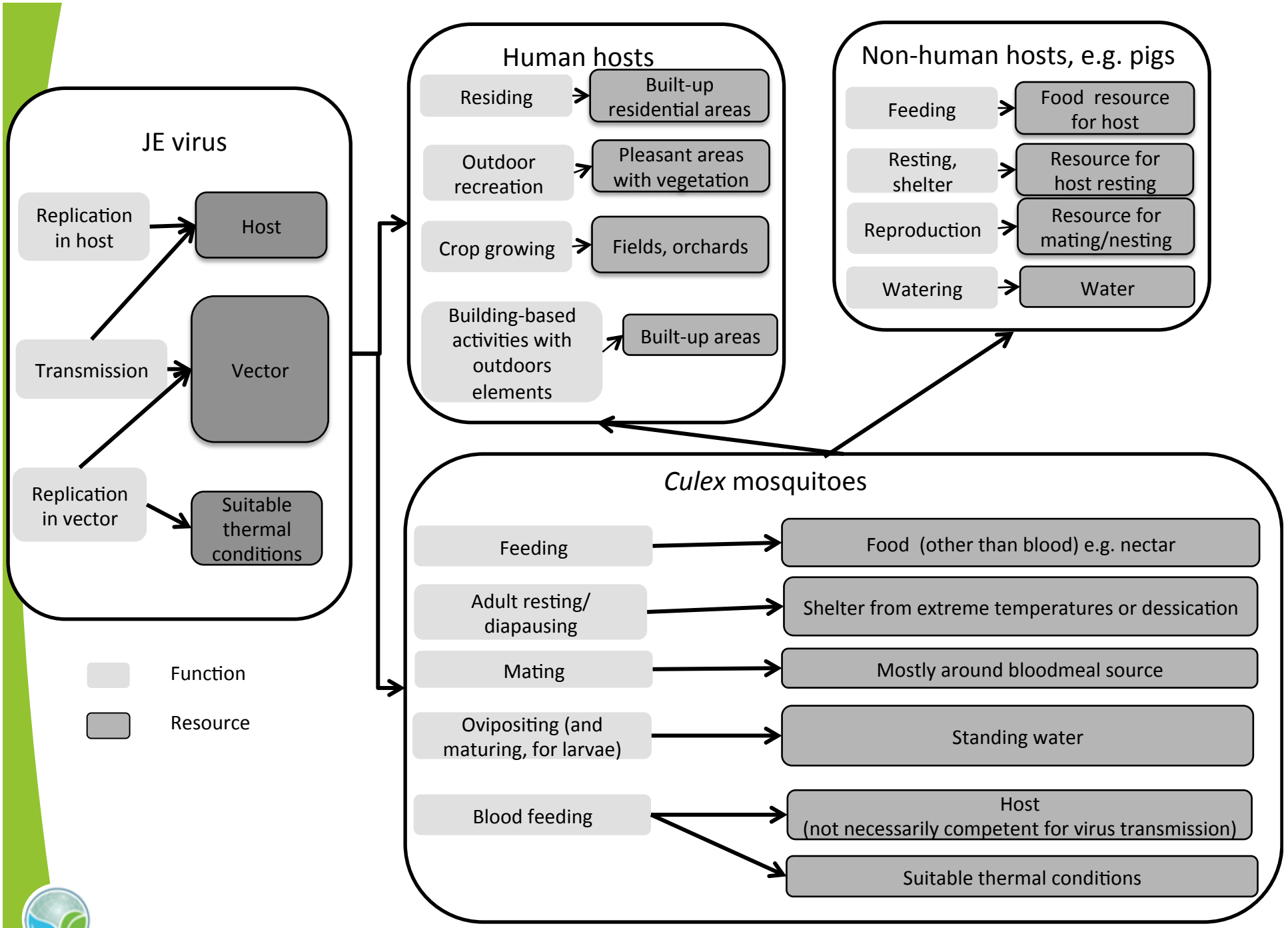
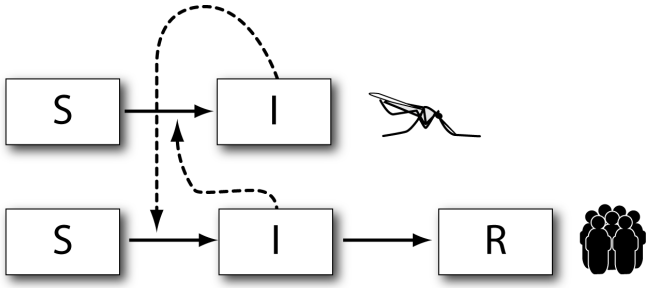
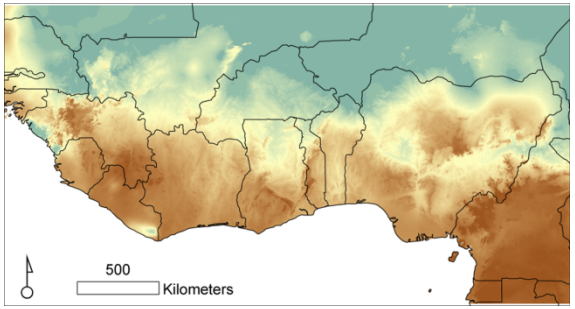

JE virus
Replication in host
Host
Transmission
Vector
Replication in vector
Suitable thermal conditions
Human hosts
Residing
Built-up residential areas
Outdoor recreation
Pleasant areas with vegetation
Crop growing
Fields, orchards
Building-based activities with outdoors elements
Built-up areas
Non-human hosts, e.g. pigs
Feeding
Food resource for host
Resting, shelter
Resource for host resting
Reproduction
Resource for mating/nesting
Watering
Water
Culex mosquitoes
Feeding
Food (other than blood) e.g. nectar
Adult resting/ diapausing
Shelter from extreme temperatures or dessication
Mating
Mostly around bloodmeal source
Ovipositing (and maturing, for larvae)
Standing water
Blood feeding
Host (not necessarily competent for virus transmission)
Suitable thermal conditions
Function
Resource

RBHC applied….

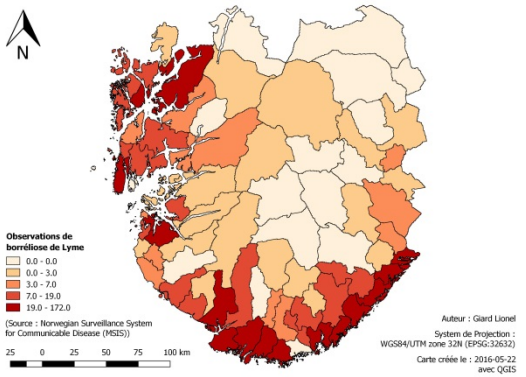
Mechanistic models, e.g. R_0



Statistical models: e.g. species distribution models, regression models.



Expert-based methods: e.g. multi-criteria decision



Challenges… Data are keyholes