

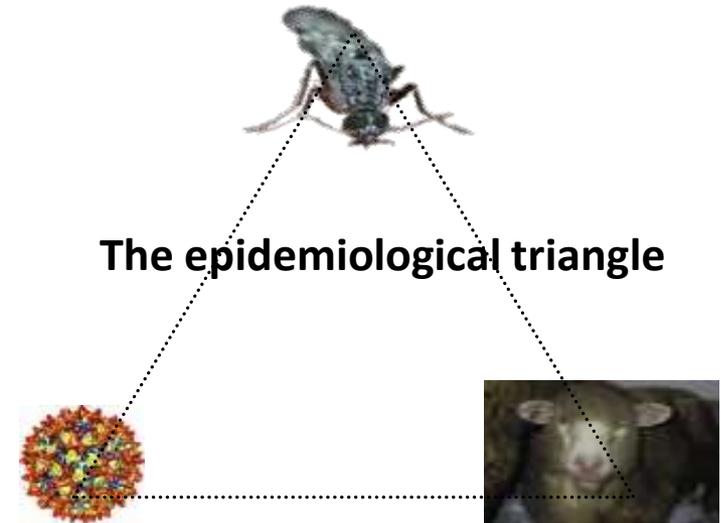
# ENVIRONMENTAL CHANGE AND THE RISK POSED BY NEW HOST-VECTOR-PATHOGEN INTERACTIONS

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# Emerging vector-borne diseases – what are we up against?

- Increasing emergence of vector-borne pathogens worldwide with huge impacts on livelihoods and economies
- Multi-host, multi-vector systems
- Multiple drivers govern arrival, establishment, spread
  - Trade and travel
  - Climate and land use change
  - Human behaviour and social context
- Involve novel host-vector-pathogen interactions (ecological or evolutionary)

E.g. Bluetongue virus serotype 8 and Schmallenberg virus in Northern Europe



## Novel Orthobunyavirus in Cattle, Europe, 2011

Bernd Hoffmann,<sup>1</sup> Matthias Scheuch,<sup>1</sup> Dirk Höper,



OPEN ACCESS Freely available online

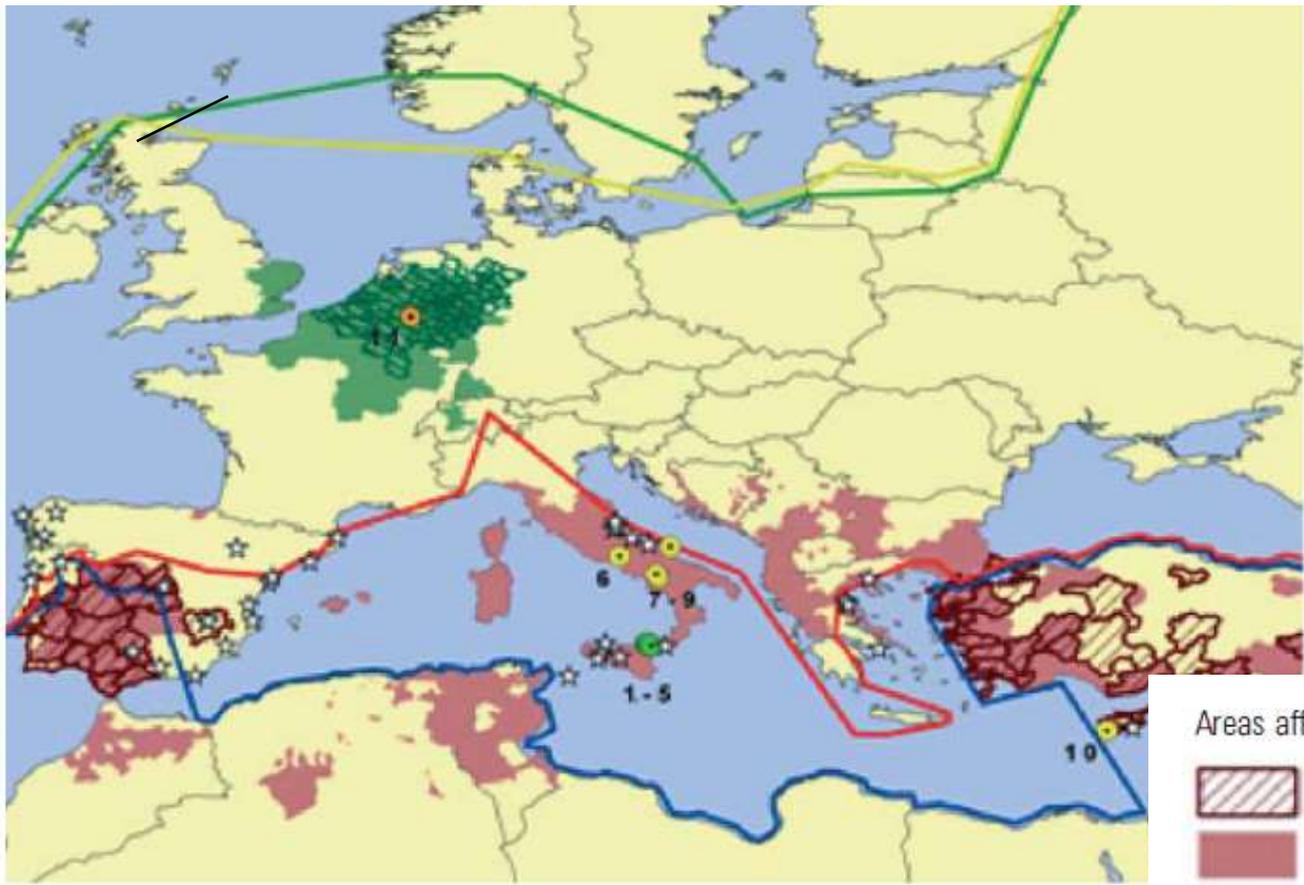
PLoS ONE

## Iquitos Virus: A Novel Reassortant *Orthobunyavirus* Associated with Human Illness in Peru

Patricia V. Aguilar<sup>1,4\*</sup>, Alan D. Barrett<sup>2</sup>, Mohammad F. Saeed<sup>2</sup>, Douglas M. Watts<sup>1,3b</sup>, Kevin Russell<sup>1</sup>, Carolina Guevara<sup>1</sup>, Julia S. Ampuero<sup>1</sup>, Luis Suarez<sup>2</sup>, Manuel Cespedes<sup>4</sup>, Joel M. Montgomery<sup>1</sup>, Eric S. Halsey<sup>1</sup>, Tadeusz J. Kochel<sup>1</sup>

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# European midge species 'latently competent' to bluetongue and Schmallenberg virus



- Biting hosts?
- Reproductive behaviour?
- Breeding sites?
- Susceptibility to infection?



*C. obsoletus* complex



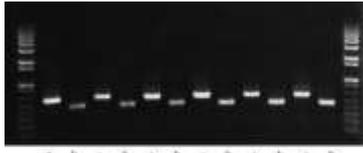
*C. pulicaris* complex



*Culicoides imicola*

# Challenges and weapons in our battle against emerging diseases

## 1. How can we better understand and predict disease emergence?



**New diagnostic tools**

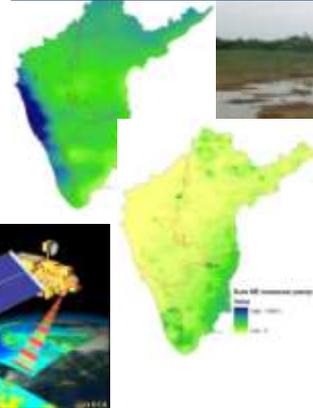
**Molecular basis of**

- infectivity
- susceptibility
- insecticide resistance

**Statistical and biological models of vectors and disease**

- intrinsic and extrinsic drivers
- Key species interactions and networks
- Test out theoretical paradigms e.g. Does biodiversity protect us against disease?

**Multi-scale, spatial datasets of social, climate, land use drivers**



## 2. How can we integrate this improved understanding into frameworks for risk communication and disease management?

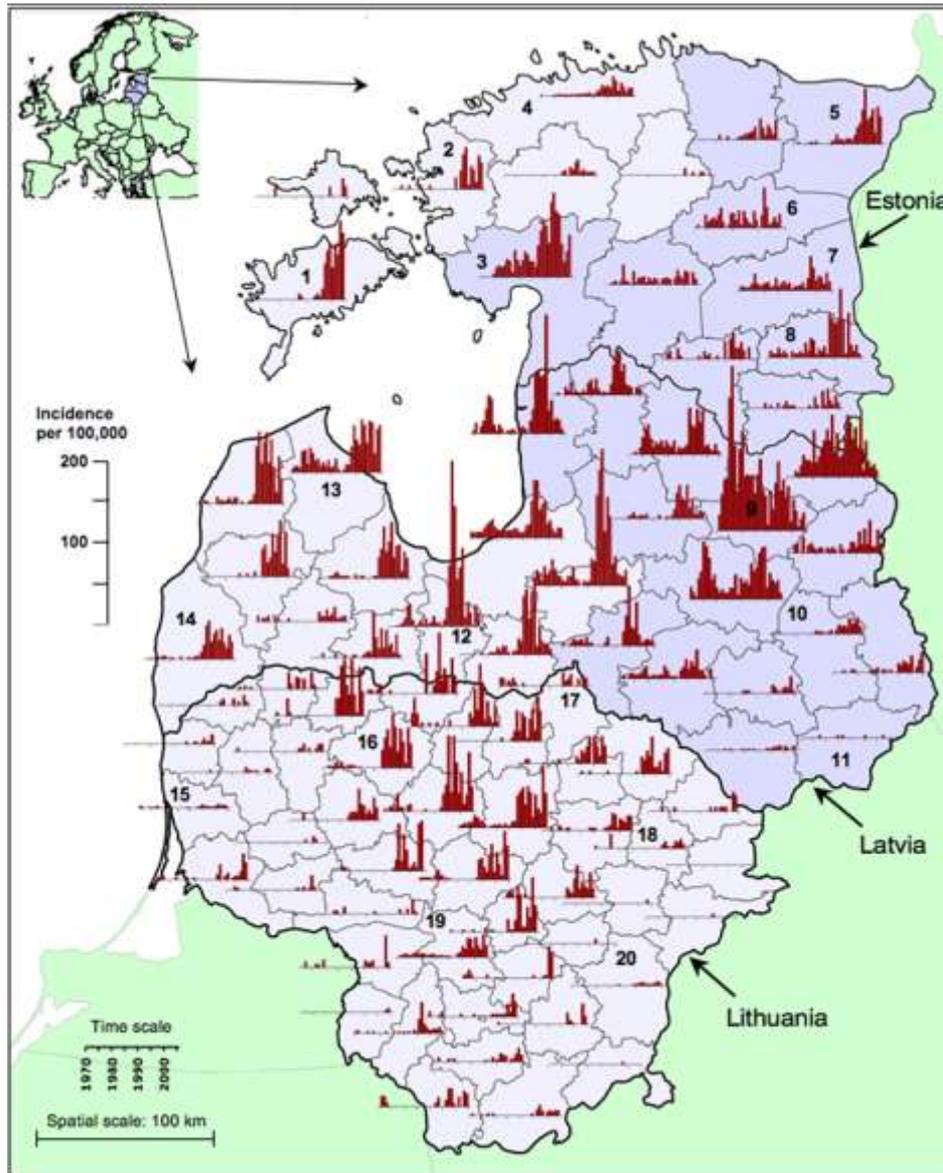
**Trait-based models of disease**

**Ecosystem approaches to disease management**

**Policy relevant early warning systems and risk frameworks**

**Pressure-state-response frameworks**

# Is emergence convincingly linked to climate change?: Tick-borne encephalitis virus in eastern Europe



- Geographic variation in timing of upsurge
- Not explained by:
  - variation in warming
  - changes in health care systems



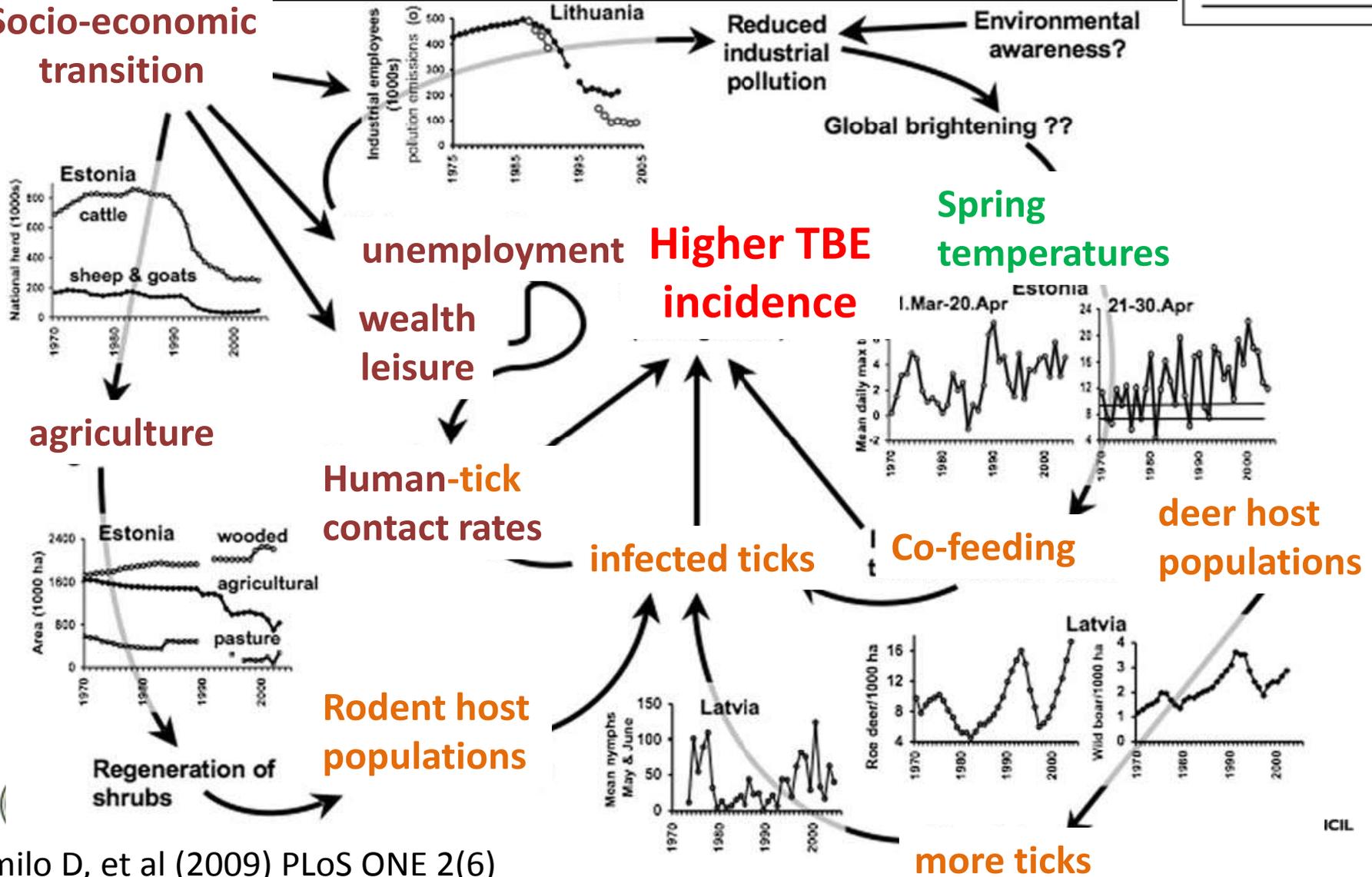
Sumilo et al. 2009, PLoS ONE 2(6)

Sumilo et al. 2008, Vaccine 26, 2580-2588

# Socio-economic factors determine human exposure to disease: Tick-borne encephalitis virus in eastern Europe



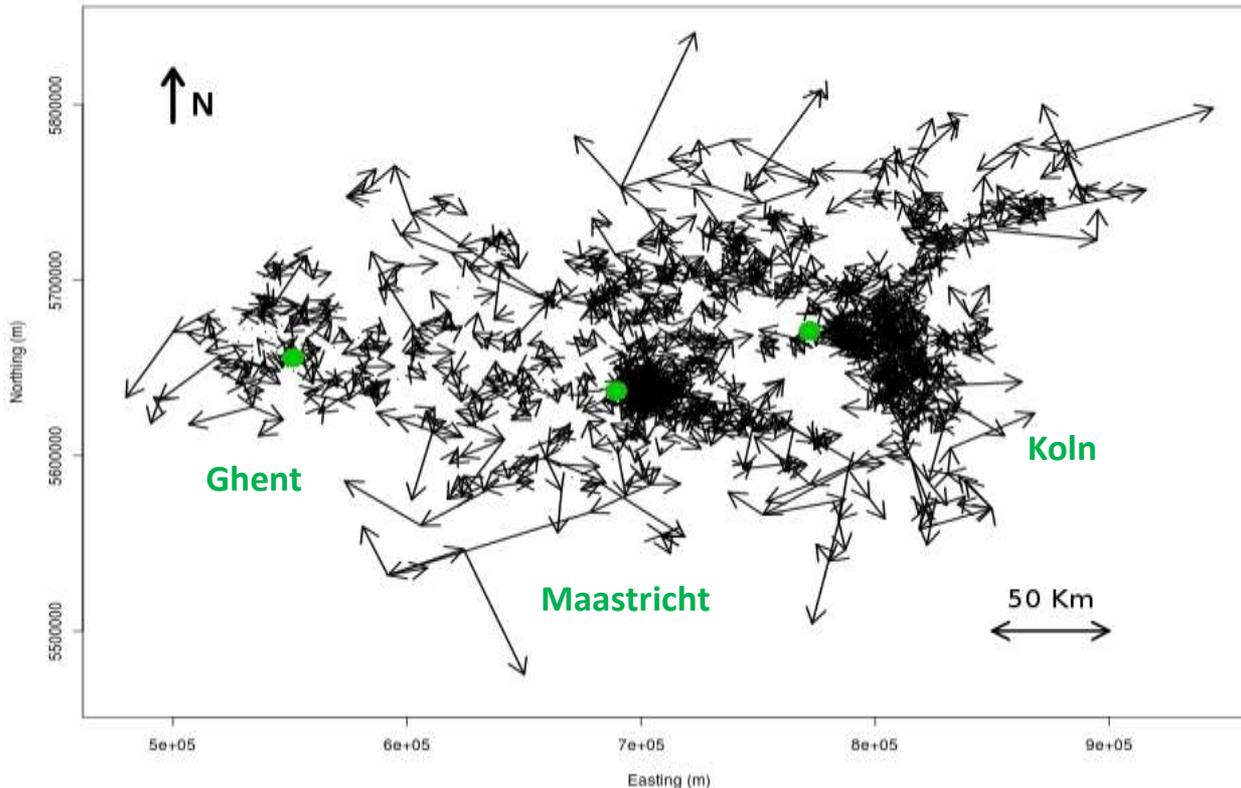
## Socio-economic transition



# Intrinsic processes govern spread of orbiviruses across landscapes following arrival in new land masses



- Traditional view: midges are passengers on the wind
- BTV-8 spread across Northern Europe, analysed role of random and upwind active midge movements versus 'passive' downwind spread



- largely local scale (2km a day), disease moves in short hops, few downwind or long distance movements
- 70% farms transmission "dead ends"
- Implications for scale of control and surveillance

# How does exposure to infection depend on how individuals use ecosystems? Malaria in Camargue



- *Anopheles* mosquitoes historically transmitted *Plasmodium* malaria
- Patch work landscape, different uses by mosquitoes and people determine exposure and re-emergence
- Who is most at risk and where?  
Socio-economic surveys + agent-based modelling





# How does exposure to infection depend on how individuals use ecosystems? Malaria in Camargue

## Agent based model

Linard et al. 2009 Ecological Modelling

People vary in movements and protective behaviours  
Groups of people using the landscape

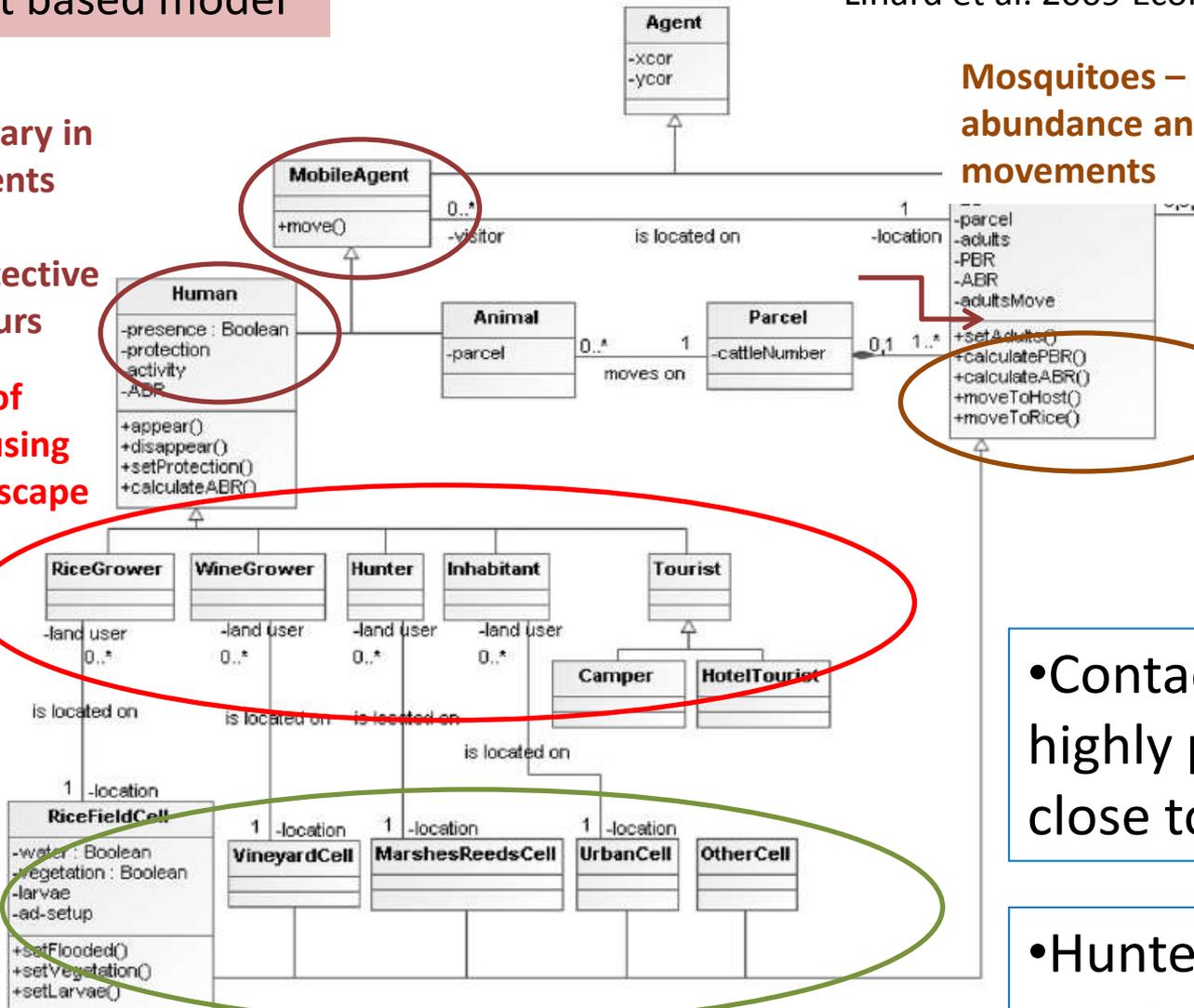
Mosquitoes – abundance and movements

## Predictions

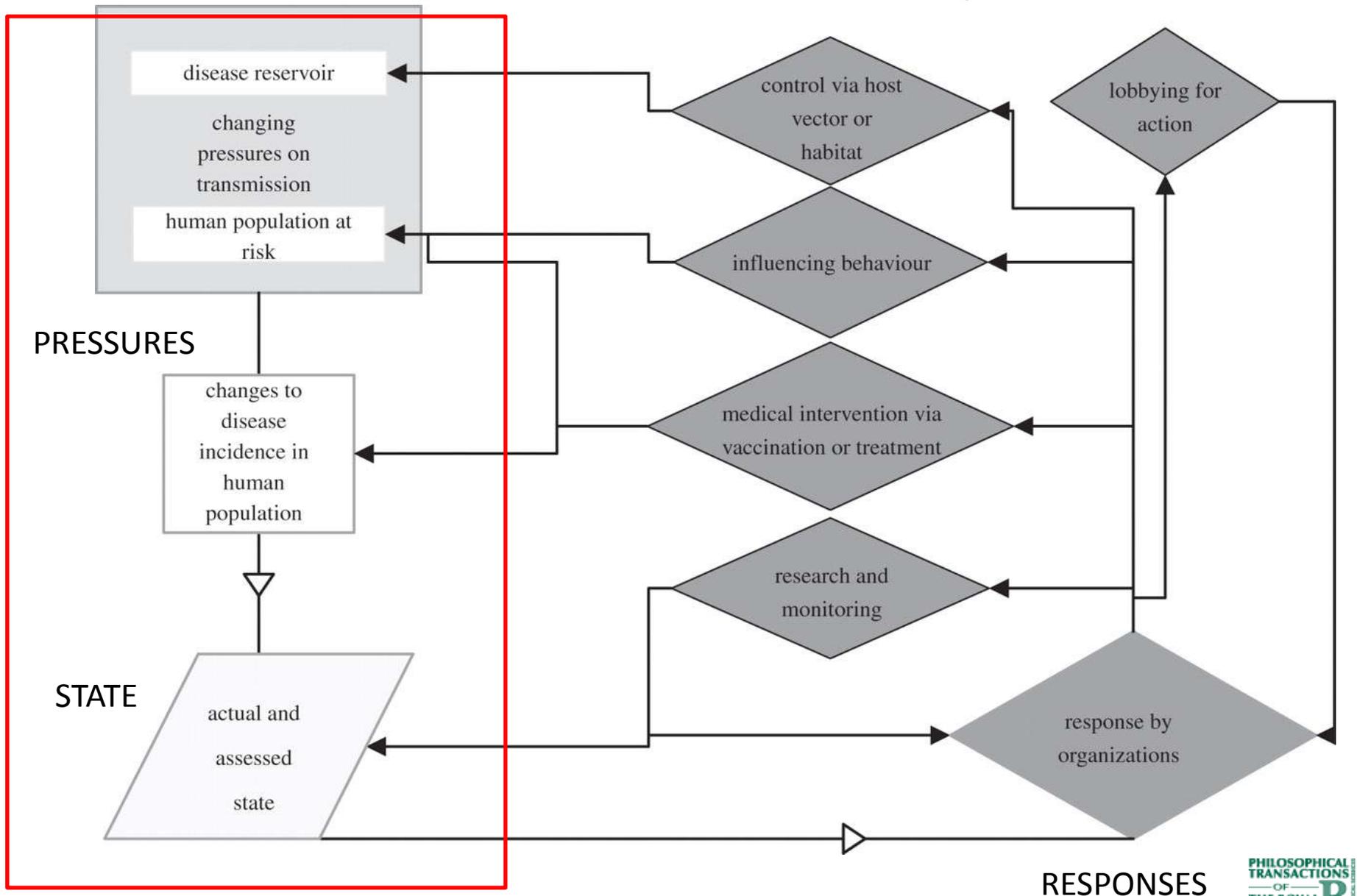
• Contact rates highest in highly populated areas close to rice fields

• Hunters most exposed agents – sunset activity

Landscape patchwork



# Integrating ecological understanding into frameworks for risk communication and disease management.



# Horizon-scanning for new pathogens: promise of trait-based risk assessment

## How can we predict latent suitability of host and vector communities for emergence of different pathogens?

- Lab assessments of susceptibility/infectivity, costly and time consuming – “Needle in a haystack”
- Trait-based models useful for establishing general patterns in invasion biology
- Can we link ecological traits of hosts and vectors to susceptibility (under different environmental conditions)?
- Can we link functional traits of pathogens to their virulence, infectivity and propensity for emergence and spread?
  - e.g. Woolhouse et al. TREE 2005. Directly transmitted RNA viruses most likely to jump between host species
  - 2011 ESA Annual Meeting : Toward Trait-based Disease Ecology: Integrating Theory and Data Across Kingdoms



