Disease mapping in Public Health: from theory to practice?

David Rogers
Oxford University,
Department of Zoology, South Parks Rd.,
Oxford OX1 3PS, UK
david.rogers@zoo.ox.ac.uk

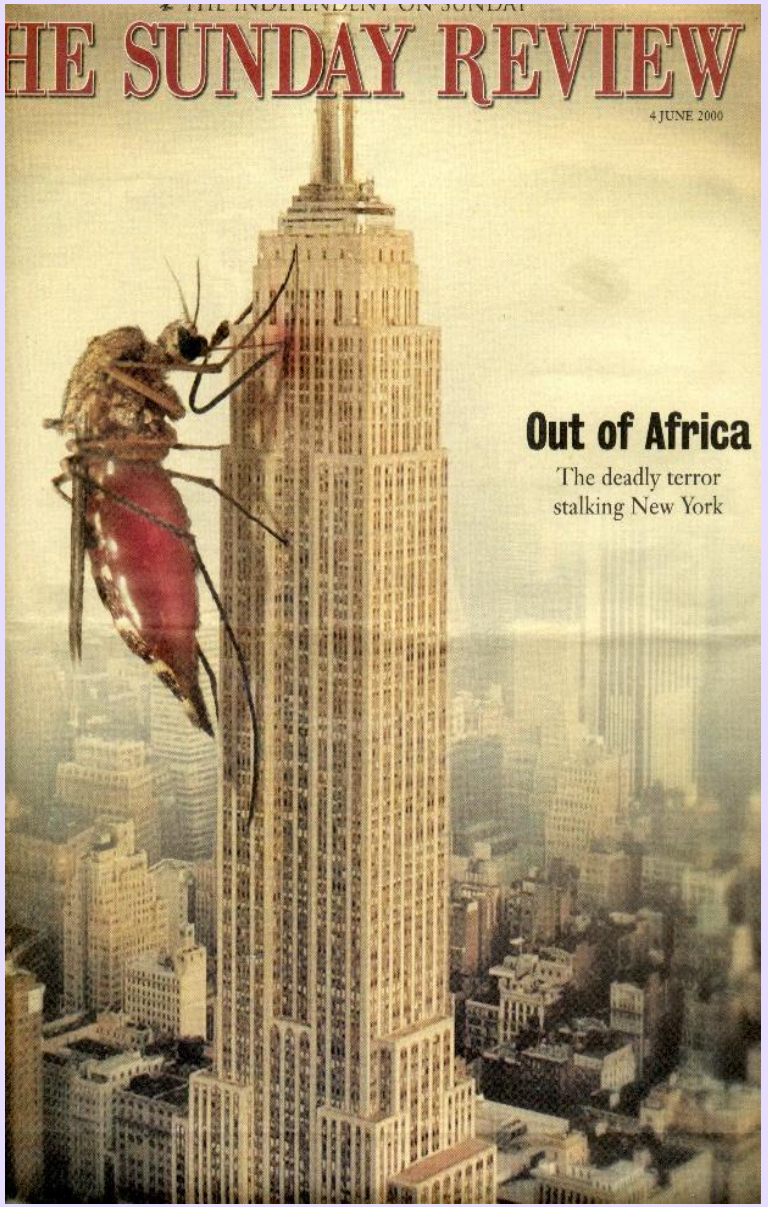
How to use risk maps

- What can be mapped?
- What do PH services require maps of?
- What is a Risk Map?
- Three steps: i) calculation of a risk map
  ii) presentation of a risk map
  iii) communication of risk; to individuals, populations, health services.
- Problems of uncertainty of predictions (false diagnosis).
- What we might learn from risk maps (driving factors/variables etc...,. aetiologies)

Why communicate risk?

- Better preparedness of PH services (doing your job better; but nobody notices if you do it badly)
- Better PR for PH services (good idea; but you don't get fired for not using risk maps)
- Opportunity costs of risk mapping (what else could be done with the same resources? e.g. the clinic's roof is leaking, etc..). PH service costs and benefits
- Opportunity liabilities (what happens if nothing is done to communicate risk? PH high treatment costs, plus e.g. arthritic complications – sequeleae- of flavivirus infections). Societal costs and benefits.

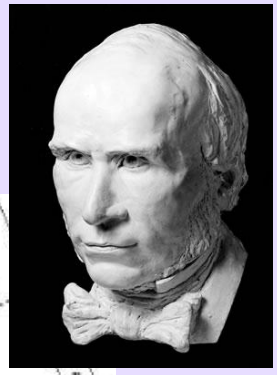
Global Warming Studies and Predictions….
How NOT to communicate risk…..



What is a Risk Map?

- A Risk Map predicts areas at risk of harbouring an insect/tick or other vector, or the diseases these vectors transmit
- Risk Maps may also be used to predict non-vector borne diseases (if environmentally determined)
- A Risk Map is usually on a scale of 0 to 1.0 where values >= 0.5 indicate risk
- Risk Maps are probabilistic and define only the similarity of each area to areas known to harbour the vector or disease elsewhere (hence are like diagnoses!).
- There are many different ways (algorithms) for deriving Risk Maps, mostly statistical (few biological)
- Early Warning Systems predict risk at some future point in time (and space), and require quite different modelling approaches (time series or biological)

John Snow and the Broad St. pump, 1854. The ?first use of predictive Risk Maps



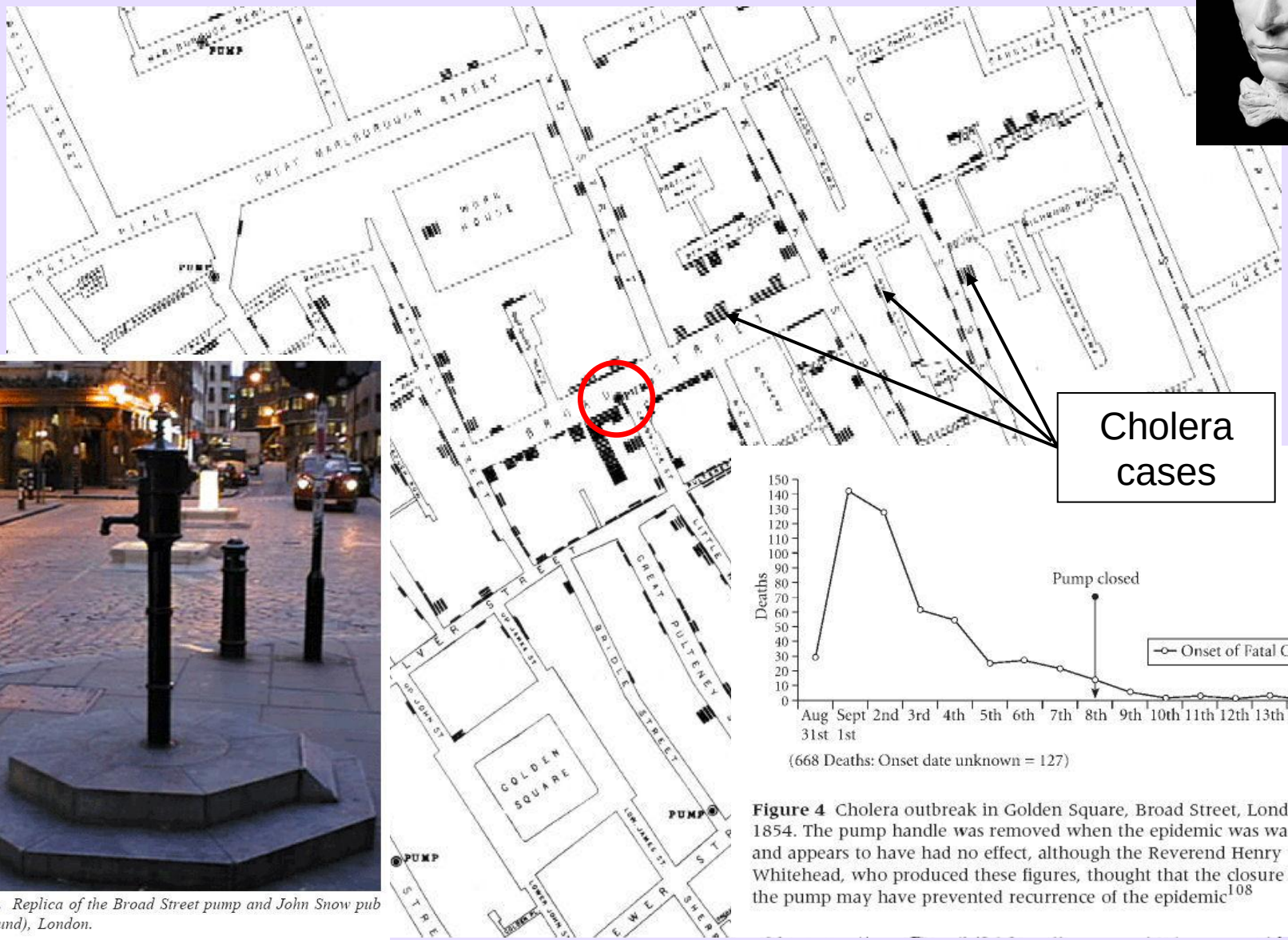


Figure 2. Replica of the Broad Street pump and John Snow pub (background), London.

(668 Deaths: Onset date unknown = 127)

Figure 4 Cholera outbreak in Golden Square, Broad Street, London 1854. The pump handle was removed when the epidemic was waning and appears to have had no effect, although the Reverend Henry Whitehead, who produced these figures, thought that the closure of the pump may have prevented recurrence of the epidemic[108]

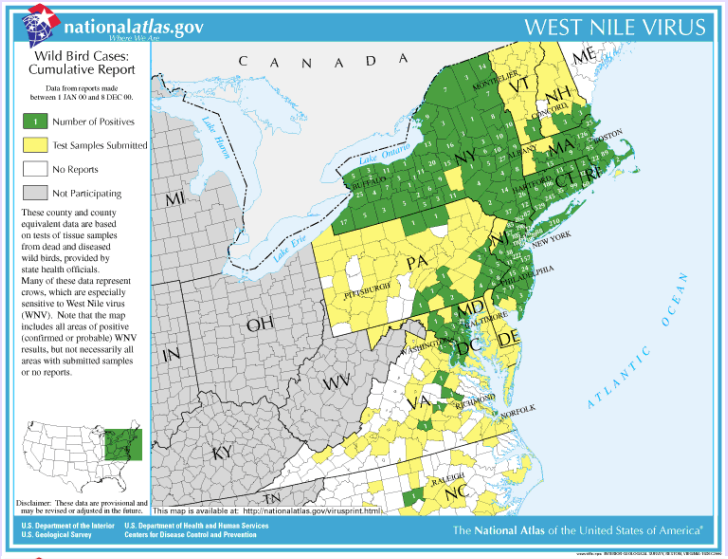
Examples of risk maps

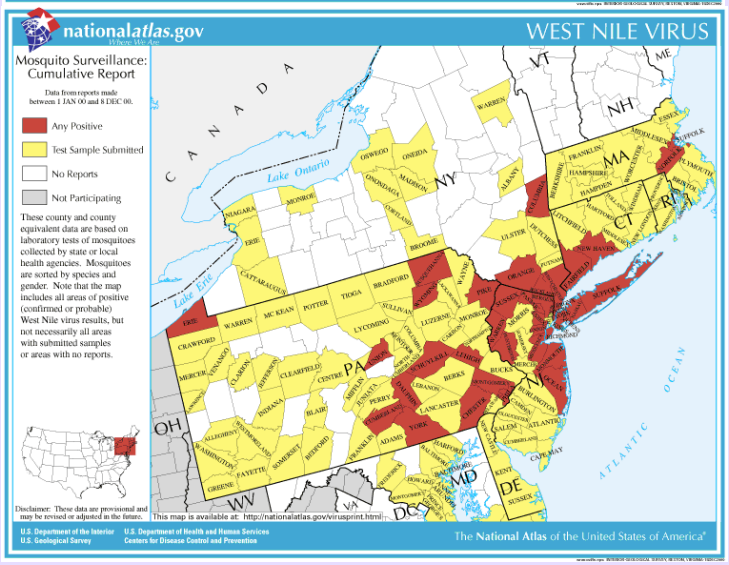
1. West Nile Virus in the USA

West Nile Virus Transmission Cycle

West Nile virus

West Nile Virus risk mapping: the emerging situation



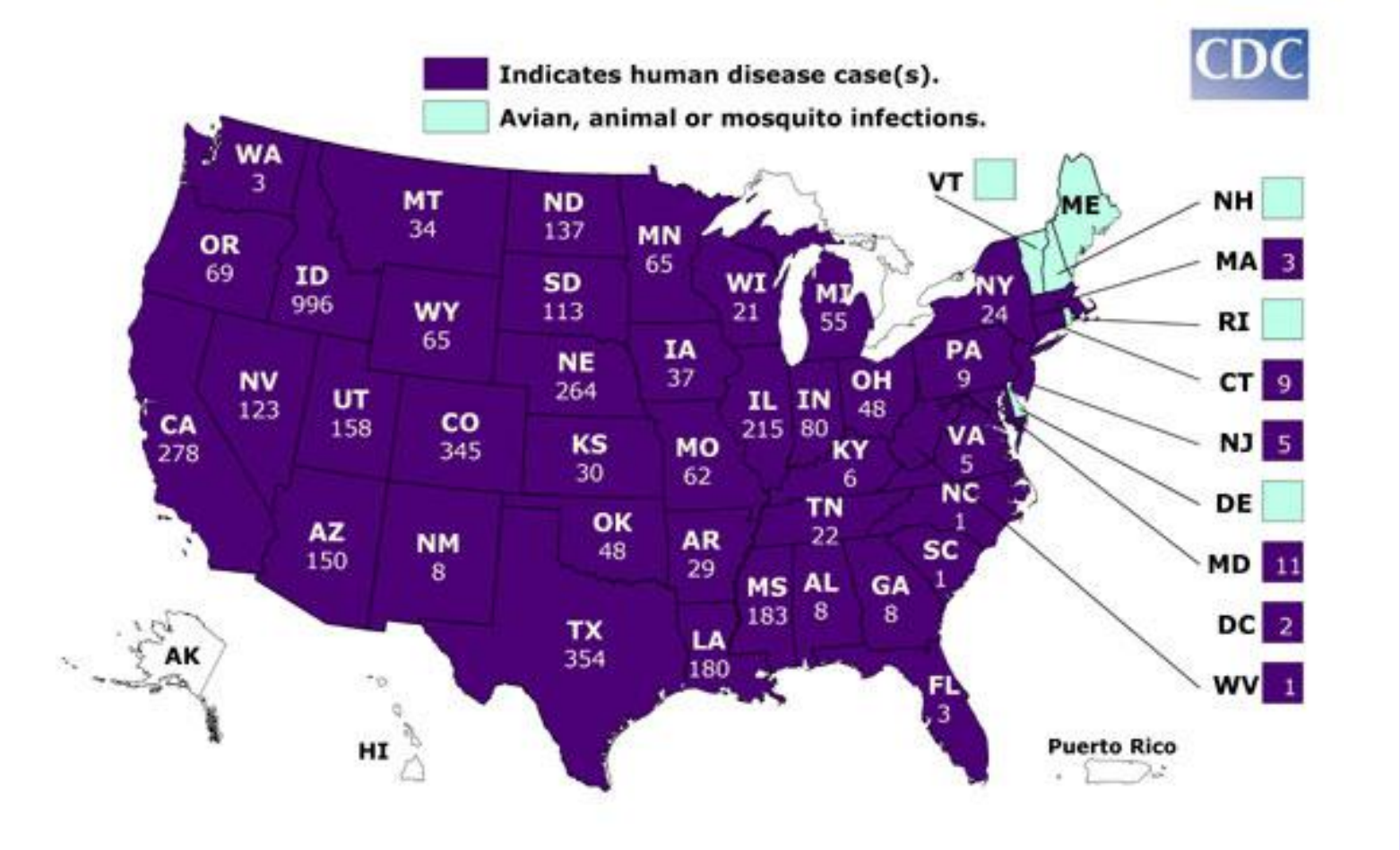


1. 1999. WNV first reported in New York, in August. 62 clinical human cases, 7 deaths (all >67 yrs). Serosurvey in Queens suggested many sub-clinical cases.
2. 2000. WNV seropositive birds recorded from 12 states in the NE USA, in an area 10 times larger than in 1999.
3. 2001. Further expansion of range southwards (Florida, Georgia) and westwards.
4. 2002. WNV spreads to more than 40 states. > 4000 human cases and 284 deaths.

Examples of regularly updated CDC maps of the distribution of WNV positive birds (above, in green) and mosquitoes (below, in red) (*nationalatlas.gov* in 2000, *cindi.cdc.gov* from 2001 onwards).

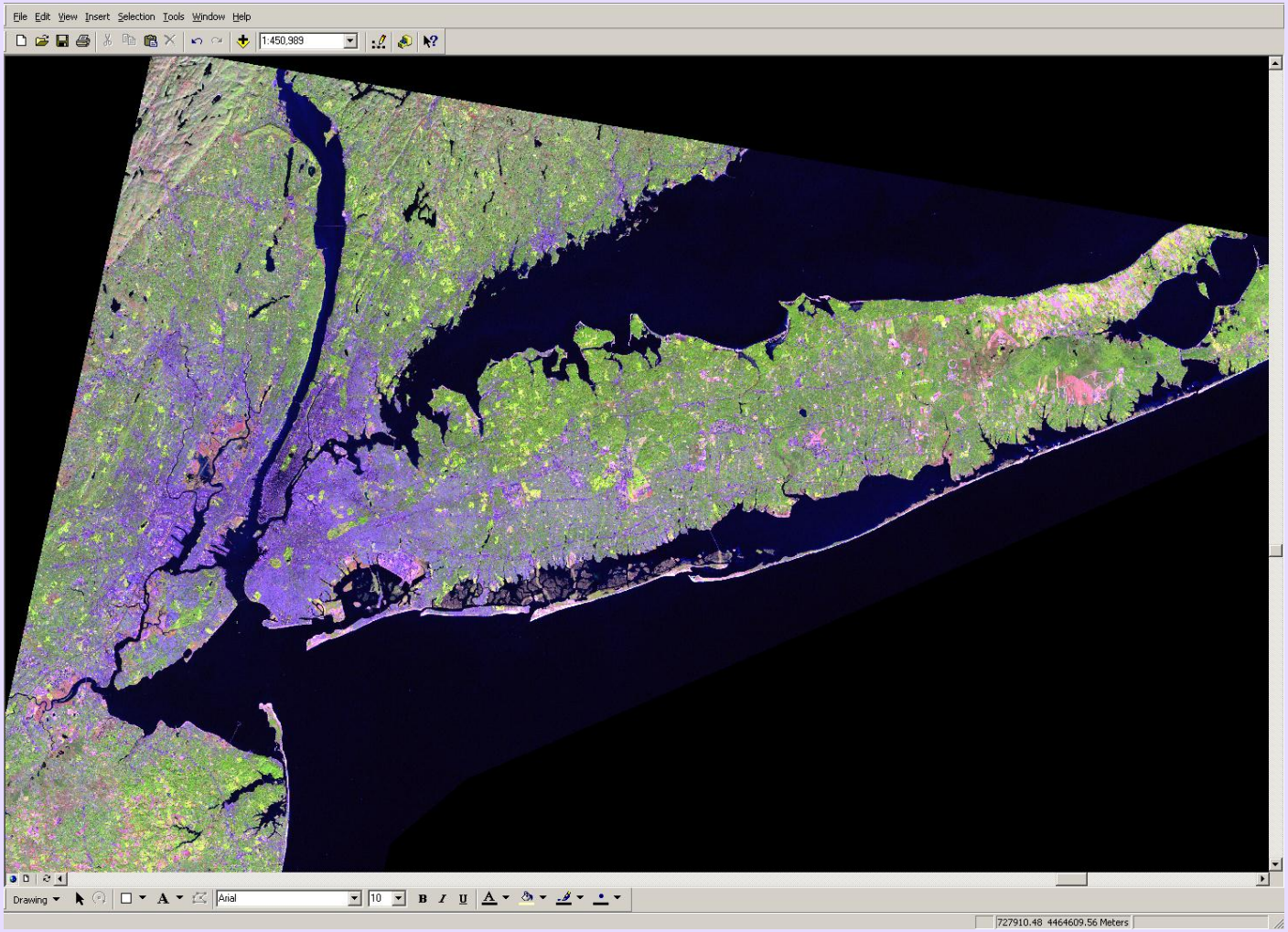
The Spread (and numbers) of Human West Nile Virus cases in the USA 1999 to 2006

1999 2000 2001 2002 2003 2004 2005 2006

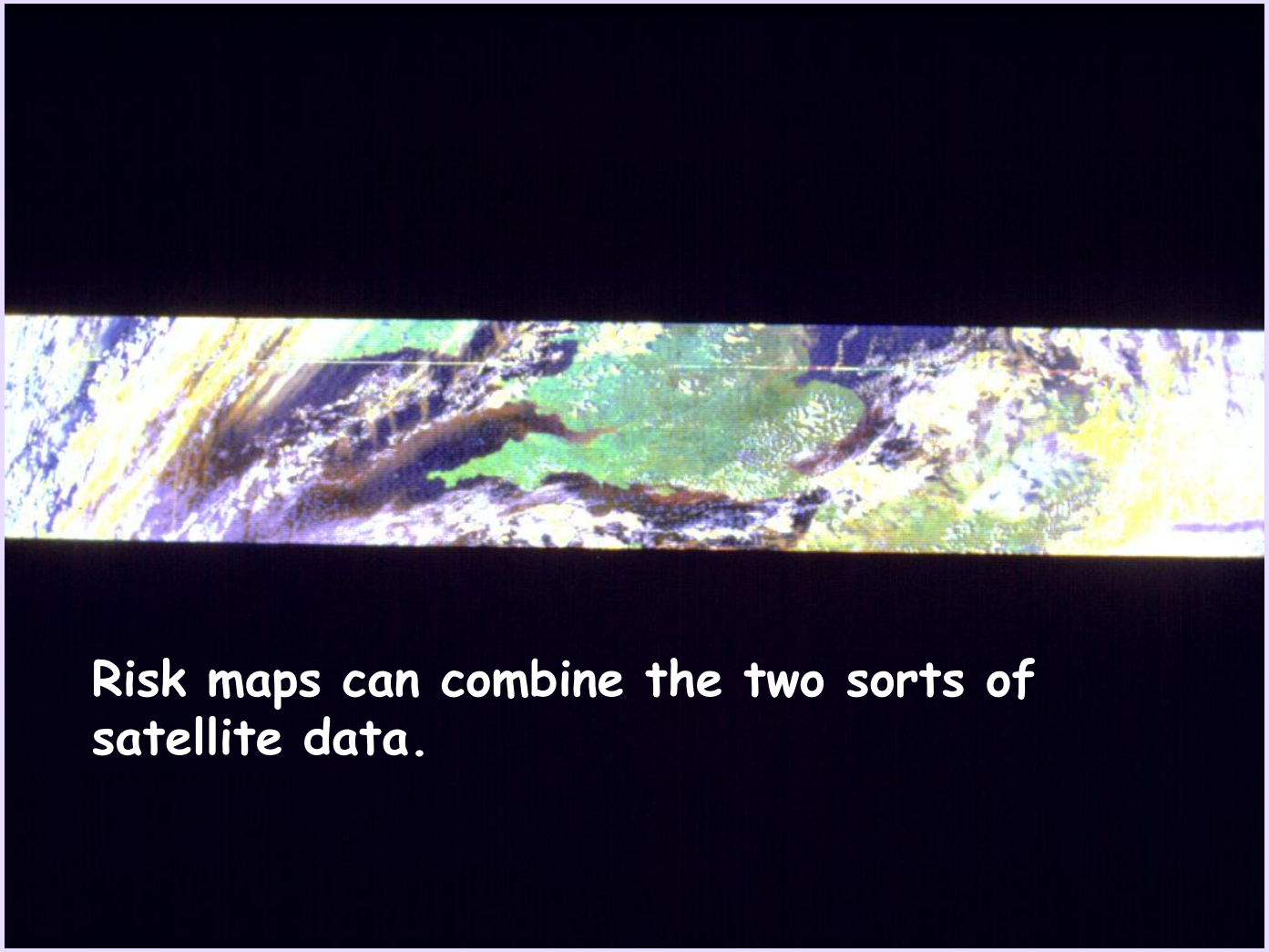


Human cases are the darker colors

Landsat data (here for New York) have lots of spatial, but no temporal information

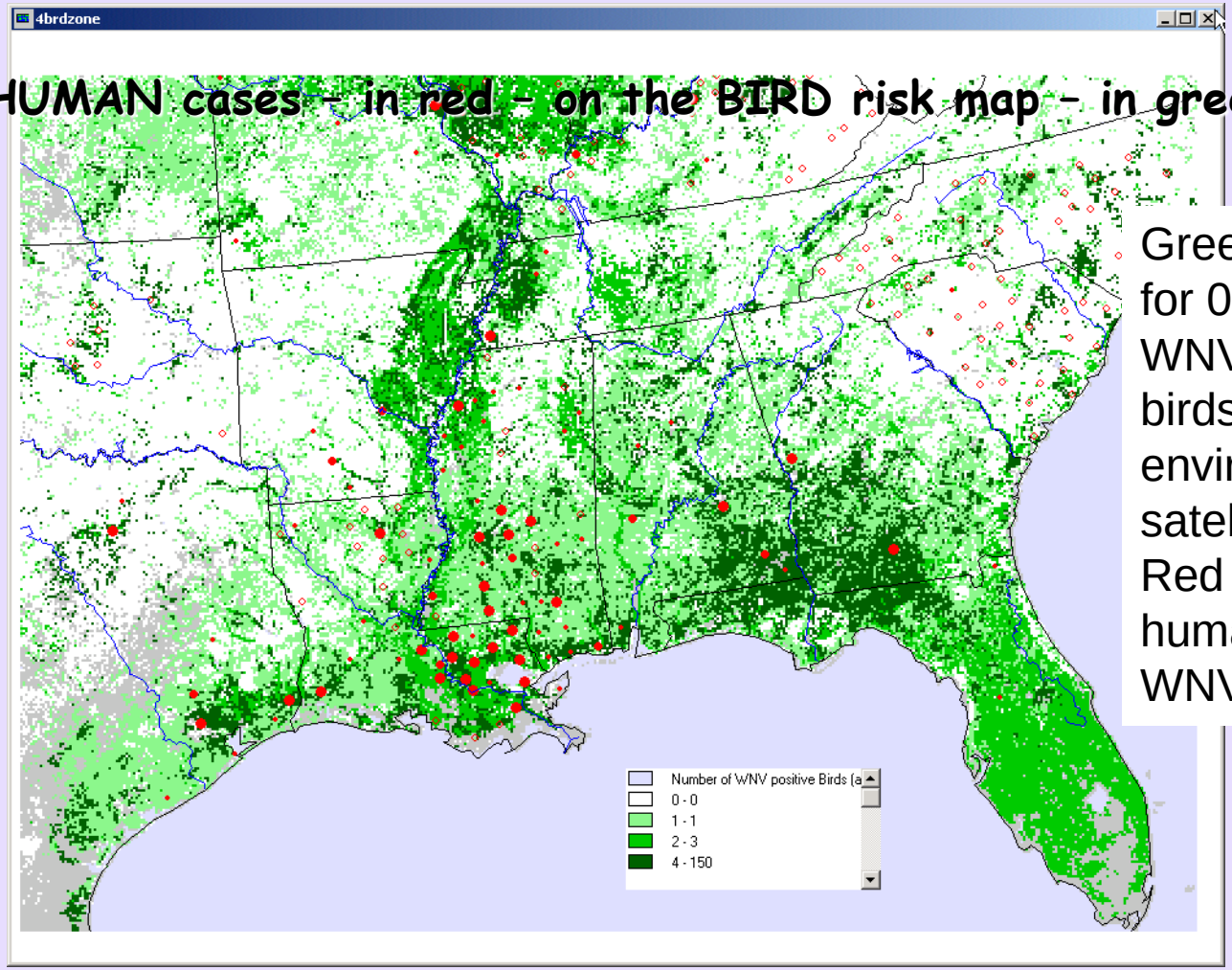


Meteorological satellite data (here for the UK) have lots of temporal, but little spatial information.



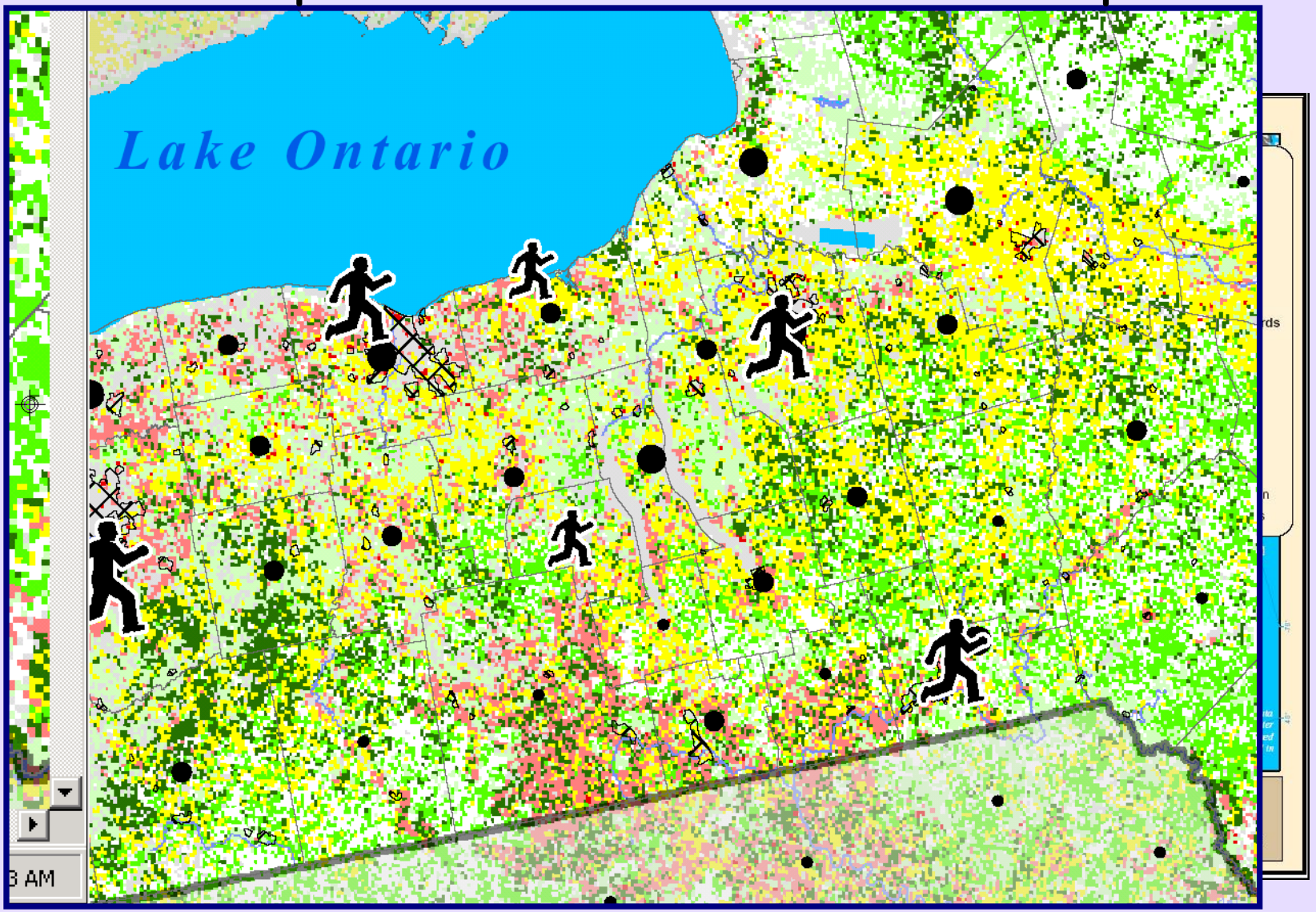
Risk maps can combine the two sorts of satellite data.

Is a WNV risk map for birds (reservoir hosts) a guide to risk to humans?



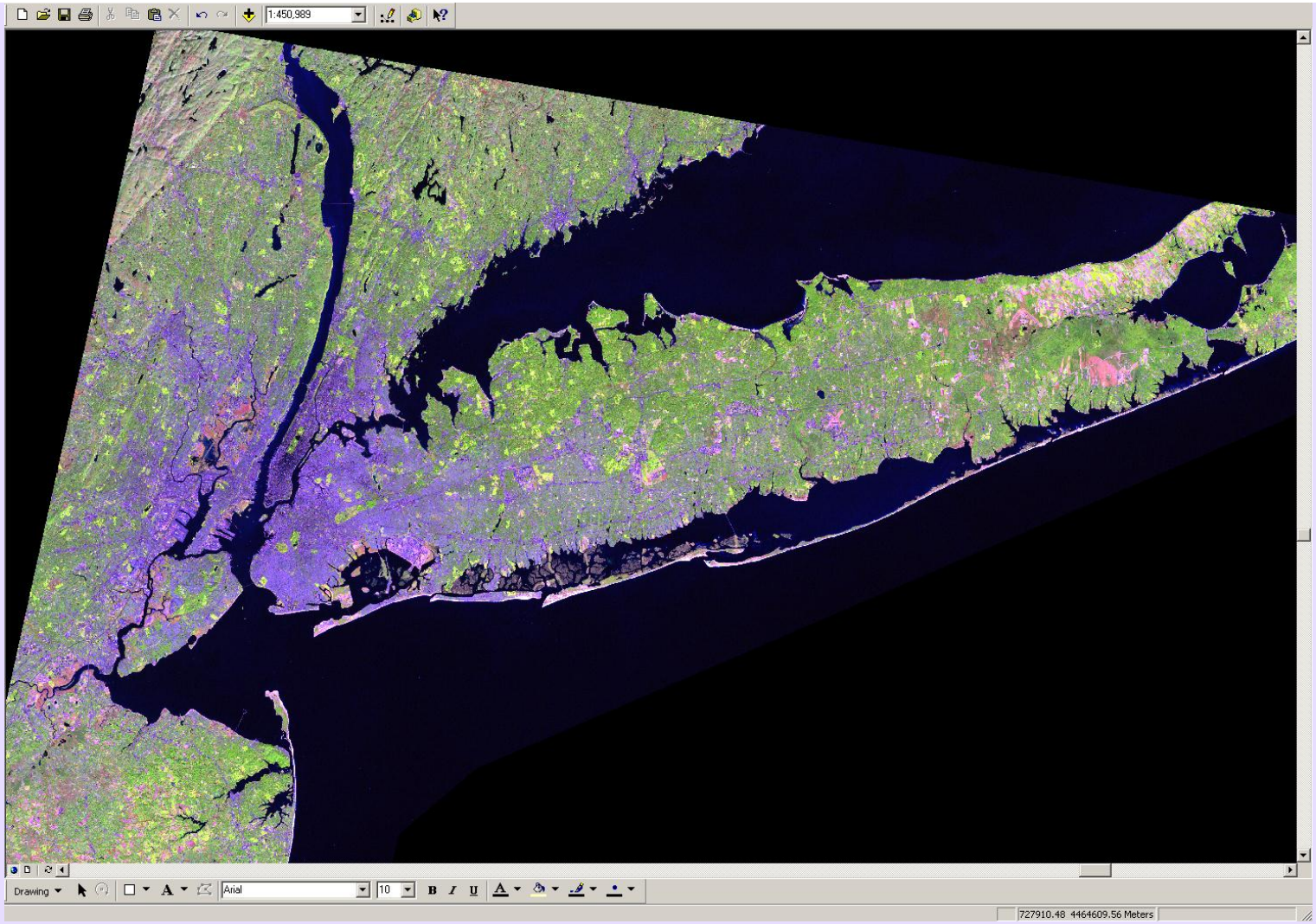
Green = Risk Map for 0, 1, 2 etc WNV-infected birds, derived from environmental satellite data.
Red = 1, 2, 3 etc. human cases of WNV

WNV Risk Maps were distributed as full resolution .pdf files

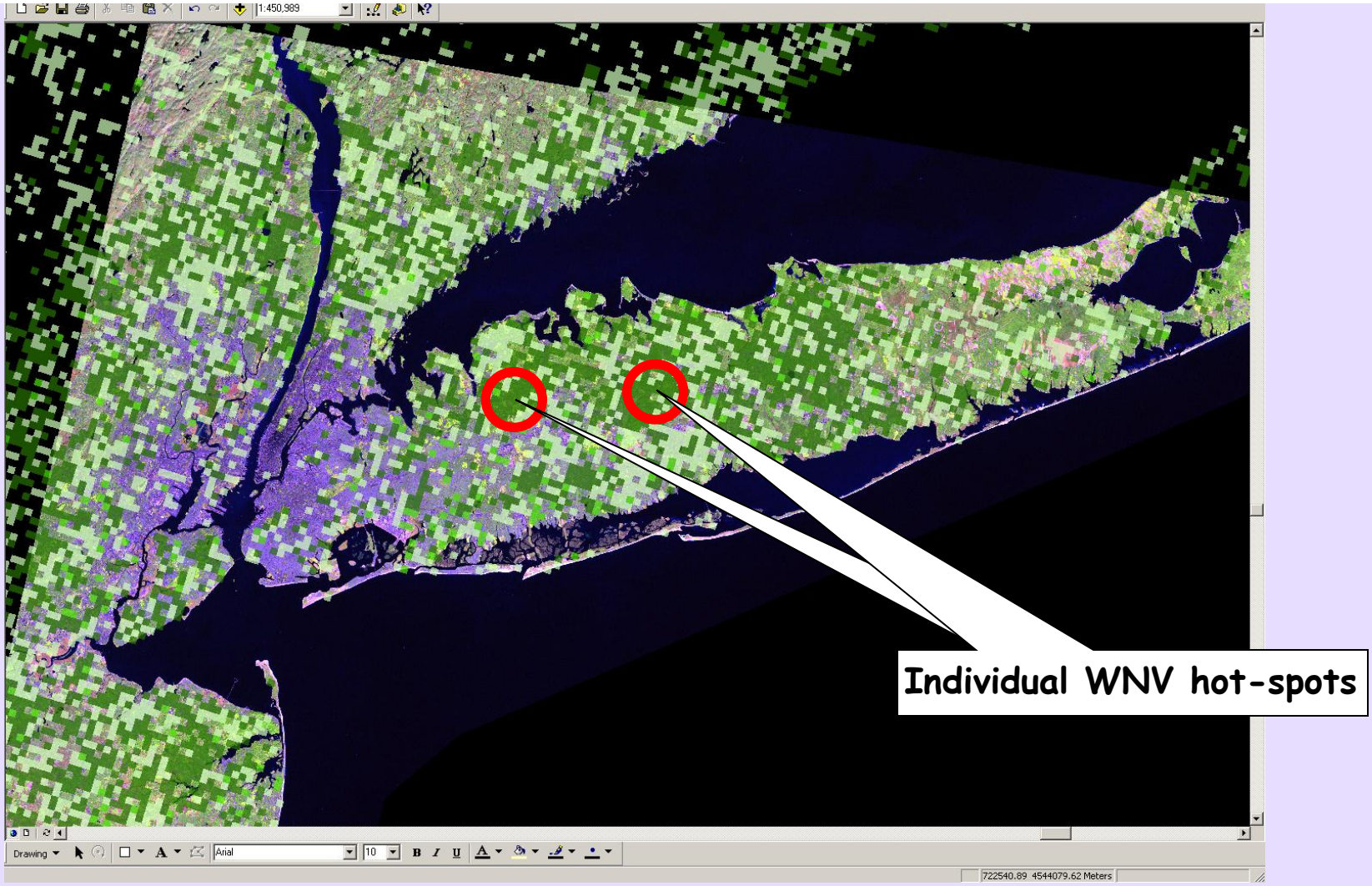


Constructing human risk maps for West Nile Virus in the USA

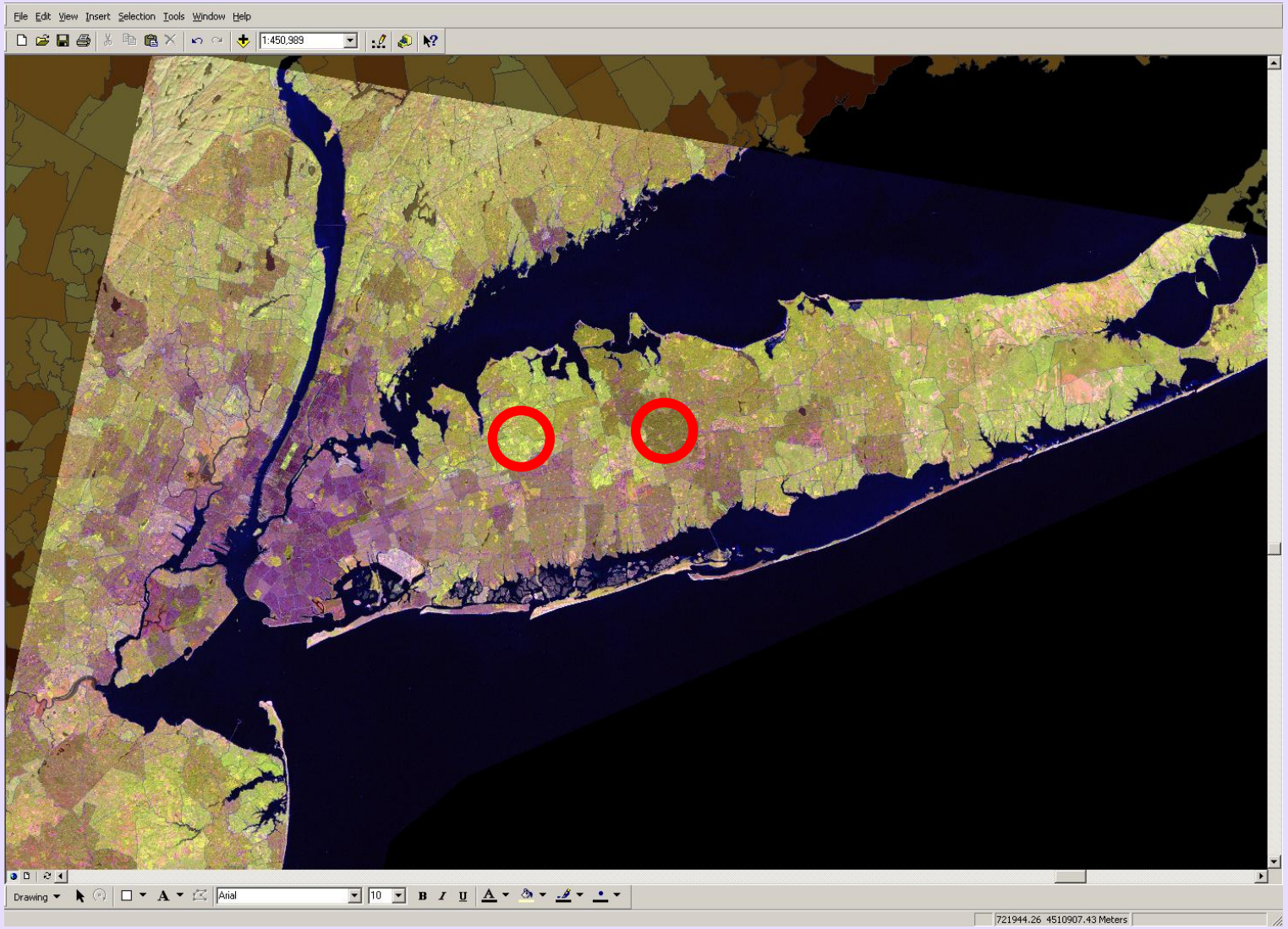
Landsat TM image processed to highlight urban/rural differences (5,4,3 in RGB)



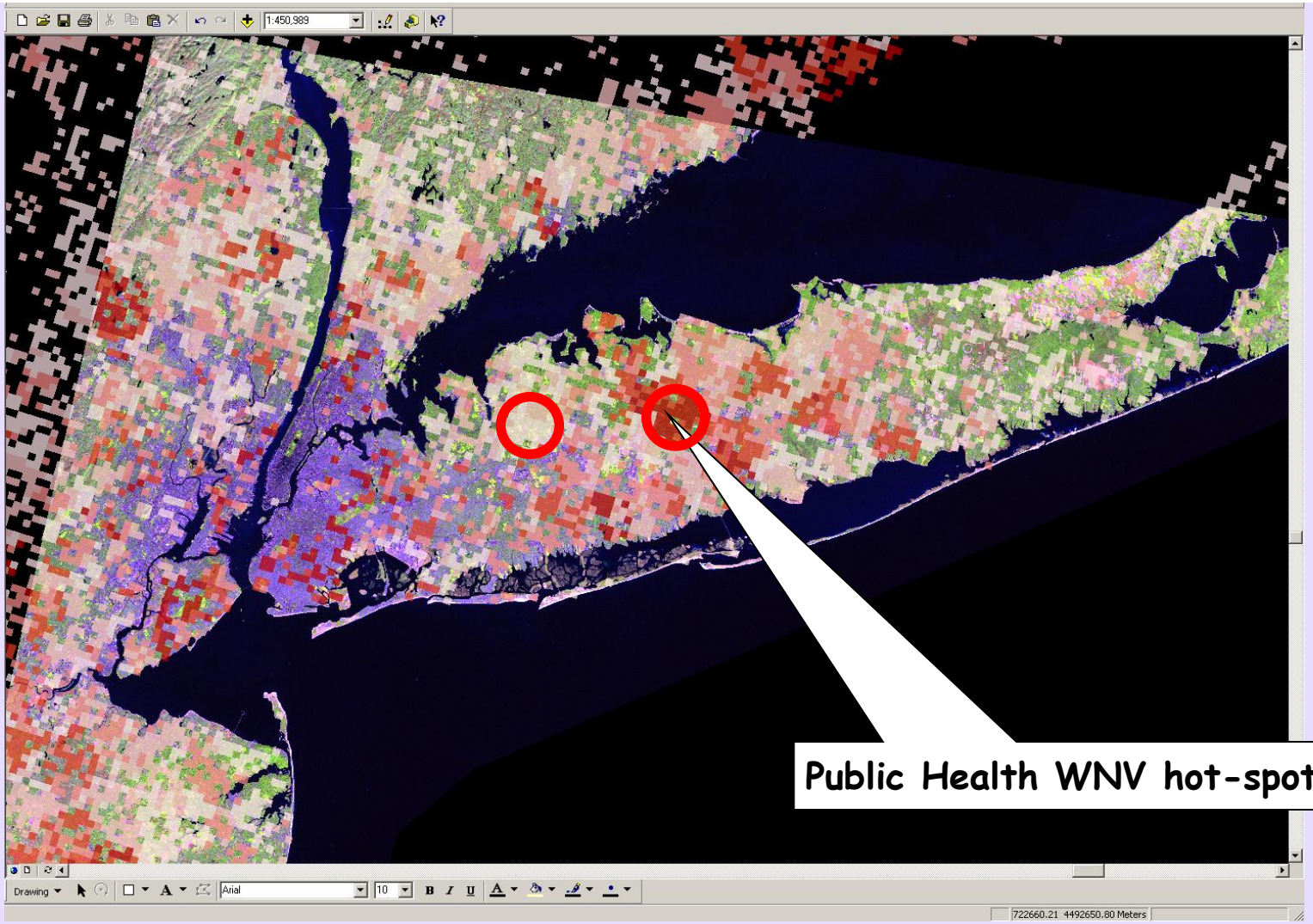
WNV-infected bird risk map (green) on Landsat image – a guide to individual human risk



Human population density by zip5 region (brown) on Landsat image



Human population by zip5*Infected bird risk = population-weighted WNV Risk Map, i.e. a guide to human population risk (of more relevance to PH services)



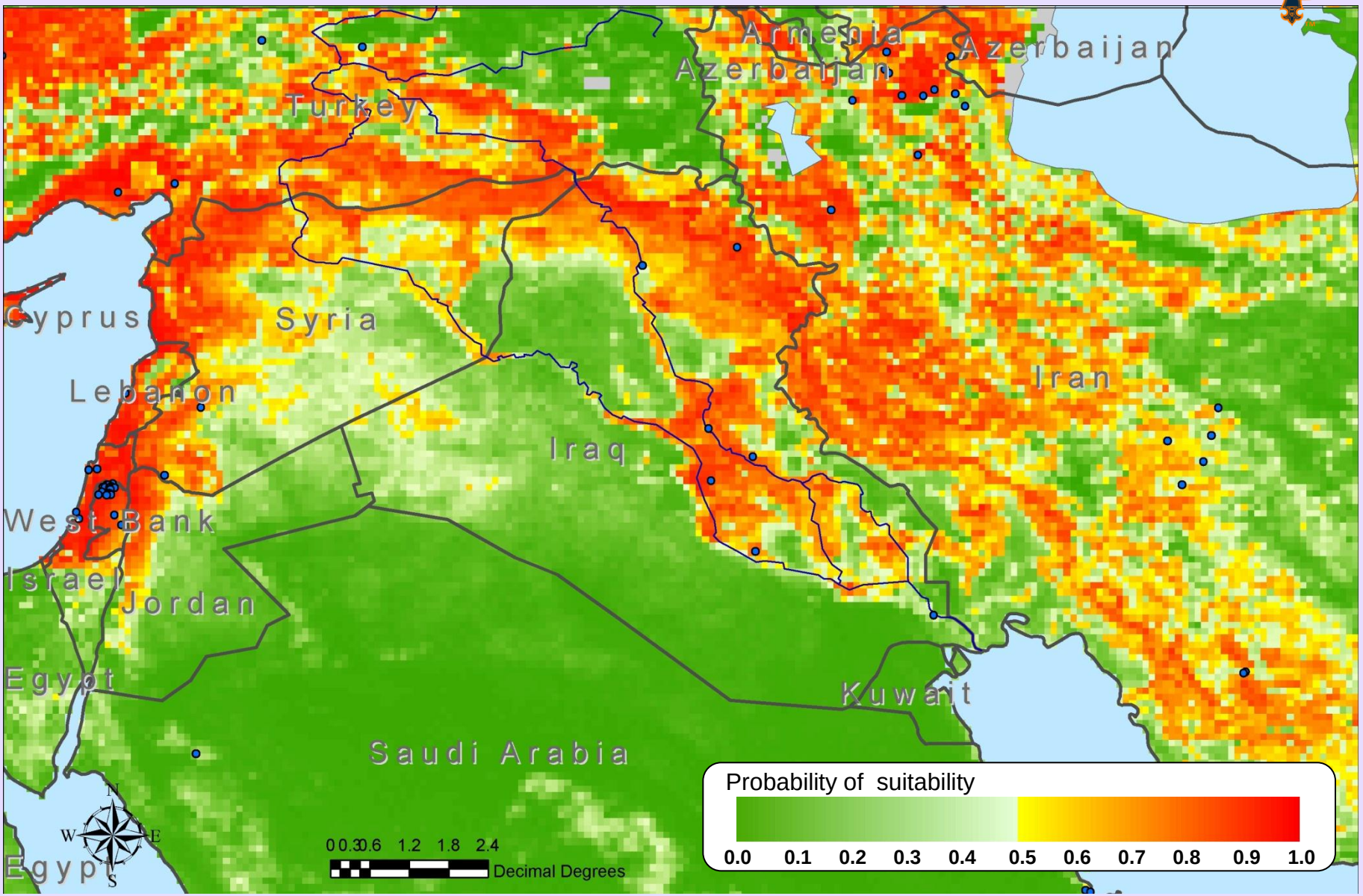
Seasonal Model of WNV-infected birds

Examples of risk maps

2. The leishmaniases in the Middle East

New Risk maps for old diseases

Visceral Leishmaniasis

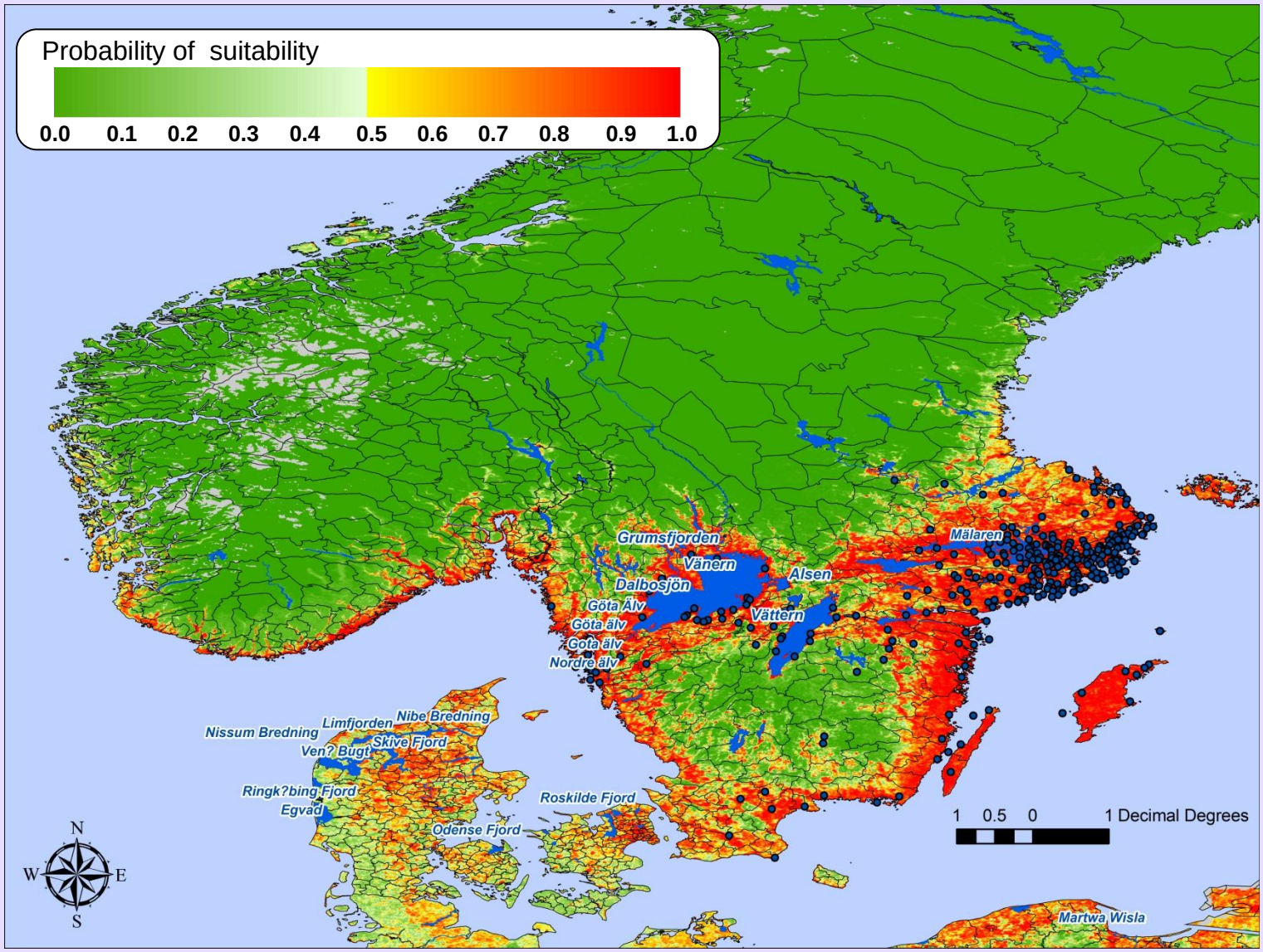


Examples of risk maps

3. Tick-borne encephalitis (TBE) in Europe

Risk map for recent TBE in Sweden

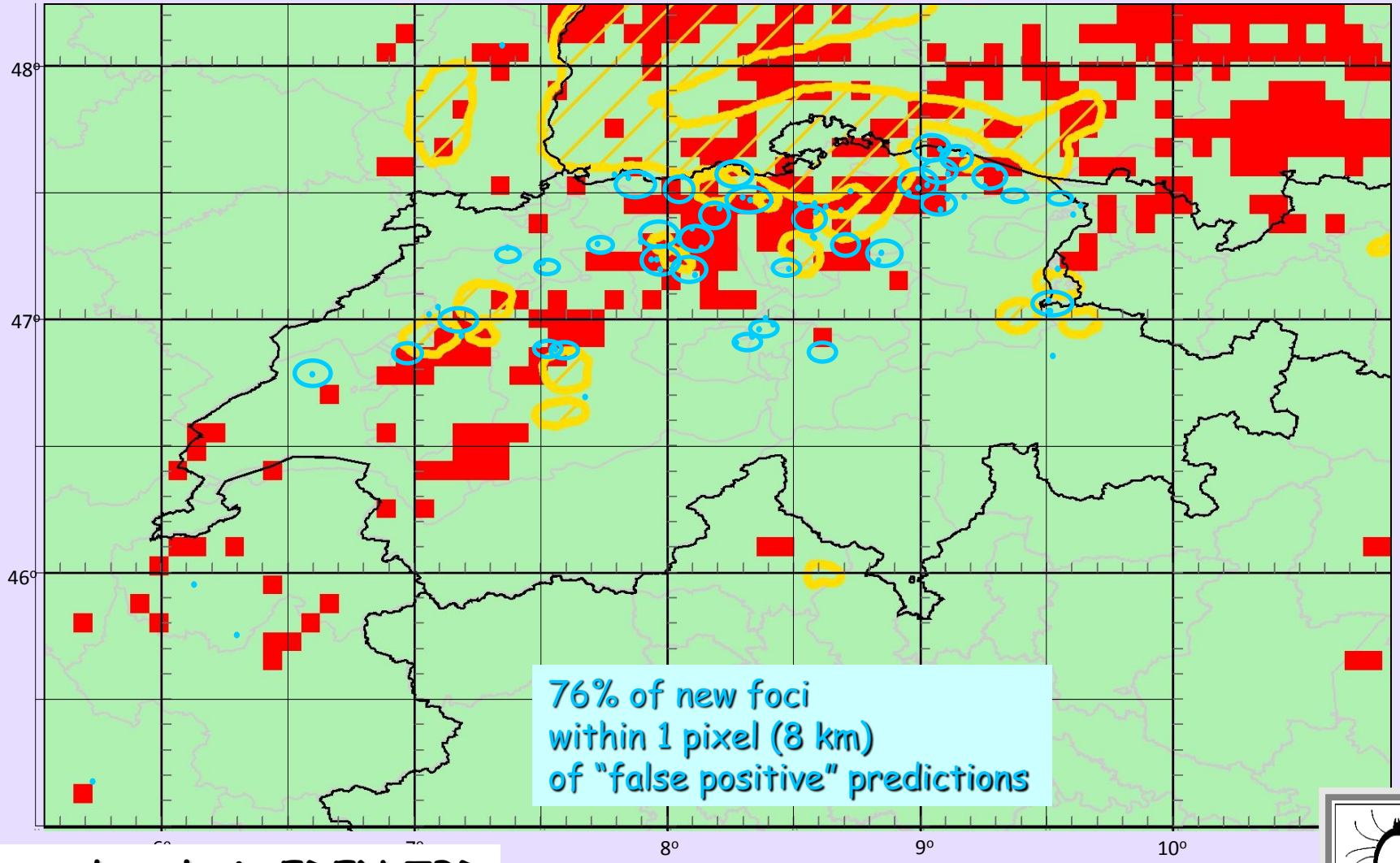
in collaboration with Gert Olsson and Swedish PH services



Satellite-derived predicted distribution of Tick-Borne Encephalitis compared with established foci (mapped 1997)

Switzerland

New foci since 2000 (www.bag.admin.ch)



Data and analysis EDEN TBD

Randolph SE (2000), *Advances in Parasitology* 47, 217-243

Network of independent but synergistic biological and non-biological factors contributing to the recent increase of TBE in Eastern Europe.

Examples of data from Estonia, Latvia, Lithuania.

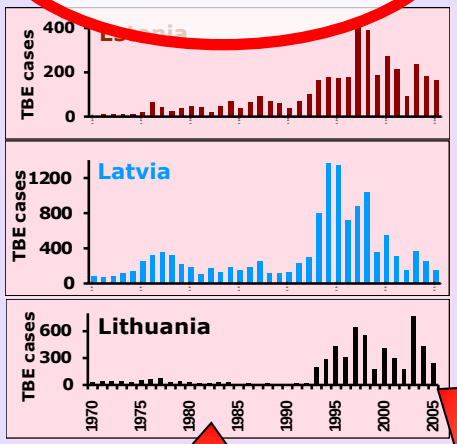
Sociological Change

Economic changes

Increased Disease Incidence

Agricultural Change

Climate Change



Human behaviour

Vector Behaviour

Environmental Change

Vector Abundance

Host abundance

Data and analysis EDEN TBD

Sumilo et al, PLoS ONE 2007, 6, e500

**"We do these things not because they are easy,
but because they are hard."**

President J.F. Kennedy, on committing the USA to landing a man on the moon before the end of the 1960s.

The Future?

Albrecht Durer. The Revelation of St. John: the four riders of the Apocalypse. 1497/98

Conquest
War
Famine
Death/Disease

Chikungunya in La Réunion

Tot
(his

Number of cases imported to

• 1 dot = 1 imported case

Paris

Lyon

Confirmed presence
of *Aedes albopictus*

Marseille

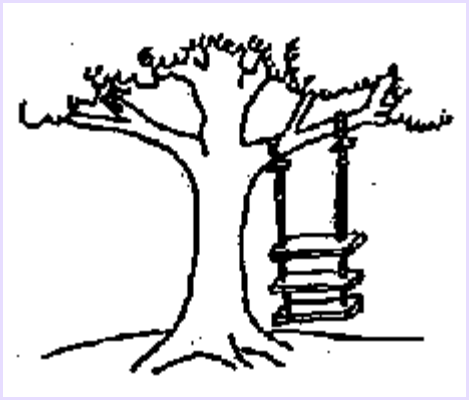
0 90 180 360 km

Corsica

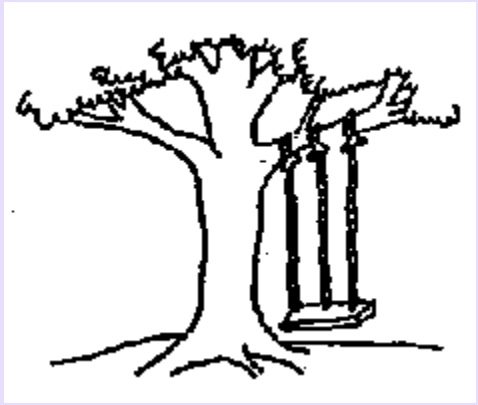
Aedes albopictus

….and imported back into France

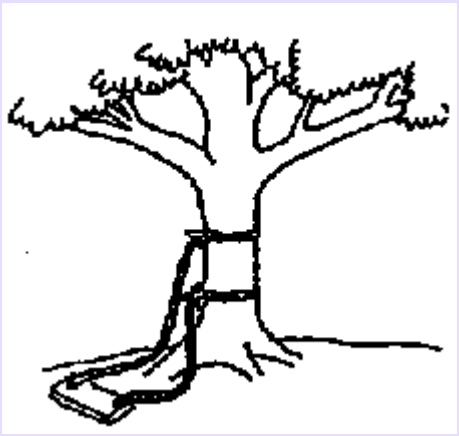
Swings (and Roundabouts)?



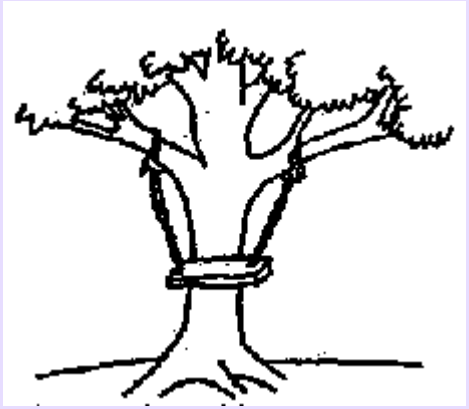
AS MARQUETING REQUESTED IT



AS SALES ORDERED IT

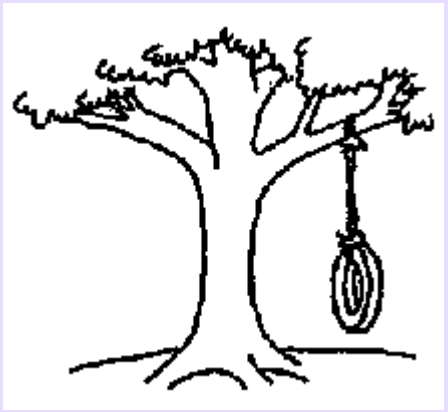


AS ENGINEERING DESIGNED IT



AS WE MANUFACTURED IT

AS FIELD SERVICE INSTALLED IT



WHAT THE USER WANTED

Disease mapping in Public Health: from theory to practice?

Important questions (EDENext et al)

What are the important infectious diseases (prevalence, incidence, PH costs)?

Do these have environmental and other links?

What datasets exist for these diseases; spatial and temporal?

Can they be (anonymised and) shared with the modellers?

Do PH services need and/or want Risk Map predictions?

What sort of Risk Maps are required (spatial/temporal)?

How would they improve PH services?

How should Risk Maps be presented, explained and communicated to users (PH services, clinicians, general public)?

Who else to involve (economists, sociologists, anthropologists, affected groups)?

How to begin collaboration?

Aedes albopictus – the Asian Tiger Mosquito

Lessons from Chikungunya in La Réunion

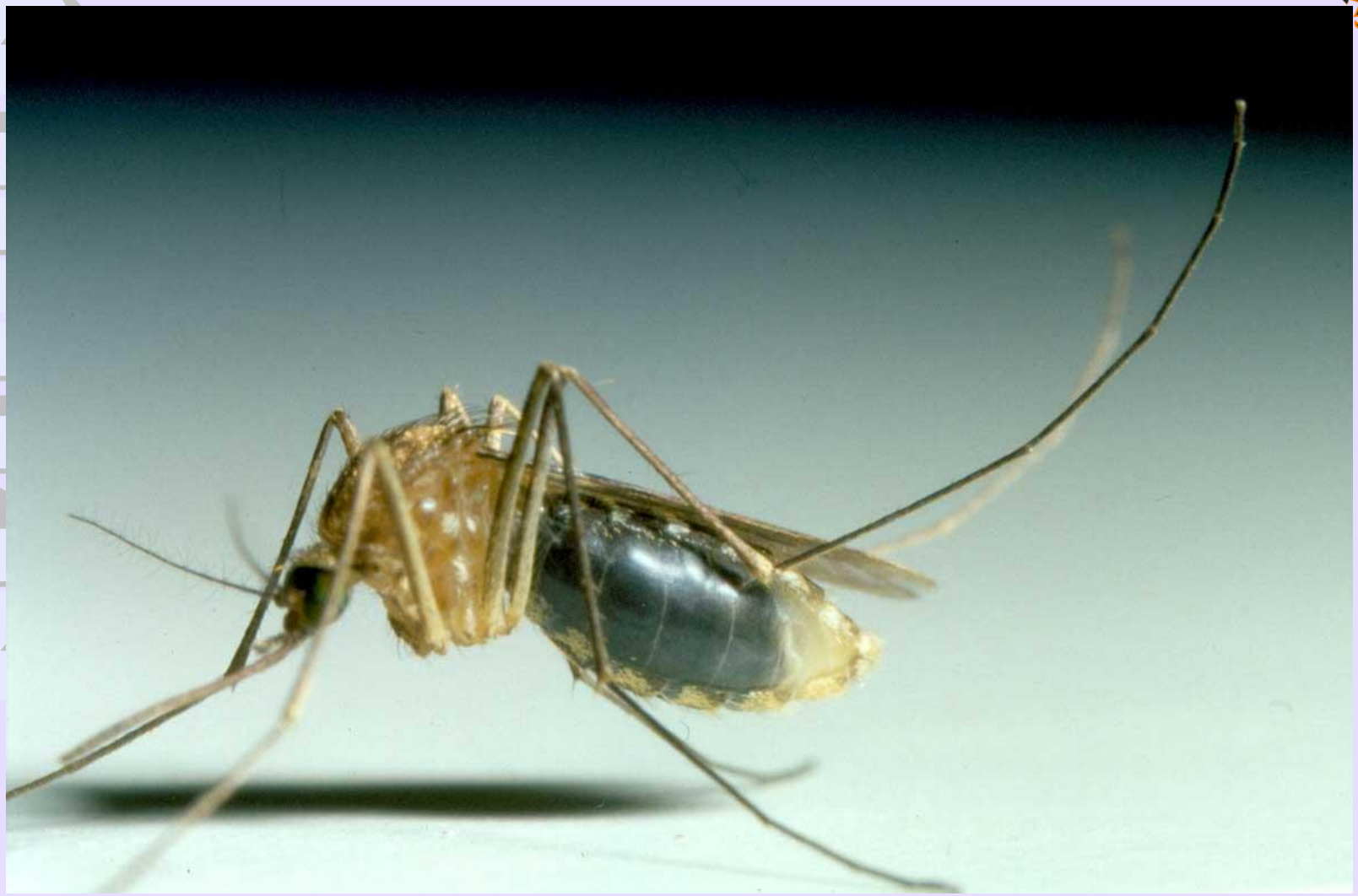
Why do we need Models?

We never have enough data of the right sort (where? when? how much disease?)

		Time: Poor	Time: Rich
Space	Poor	Global malaria Japanese encephalitis Hantavirus Presence/absence Suitability	Asian Tiger mosquito Cholera Tsetse Spread through time Variation through time
	Rich	Malaria, East Africa Bluetongue, Europe OW screwworm, Iraq Presence/absence Abundance	Dengue, SE Asia West Nile Virus, USA Presence/absence Abundance through space & time

Models increase the spatial and temporal resolution of disease risk

Culex pipiens – vector of West Nile Virus (WNV)



Network of independent but synergistic biological and non-biological factors

Examples of data from Estonia, Latvia, Lithuania.

Sociological Change

Economic changes

Environmental awareness?

Climate Change

Global brightening ??

Sudden increase in Spring temperature

Increased Disease Incidence

Higher unemployment

wealth & leisure

Agricultural Change

Decline of agriculture

Human behaviour

Changes in exposure to ticks in forests?

Vector Behaviour

Increased co-feeding transmission of TBEV

Vector Abundance

More hosts for adult ticks

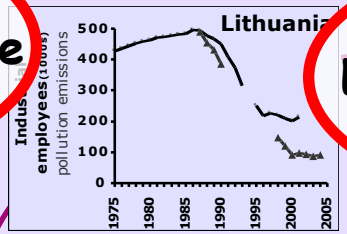
Environmental Change

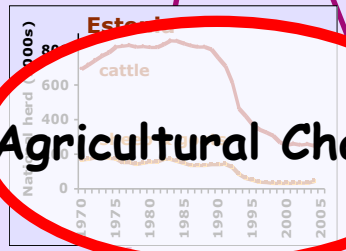
Regeneration of shrubs

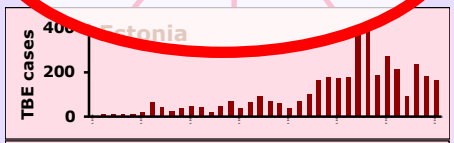
Increase in rodent populations? (transmission hosts)

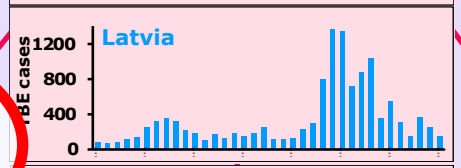
Host abundance

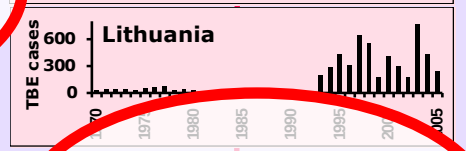
More ticks

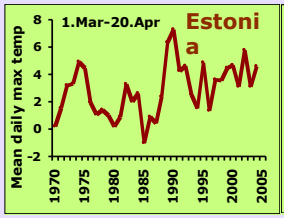


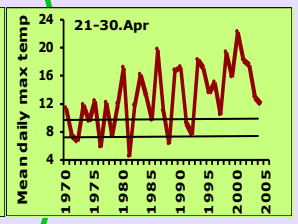


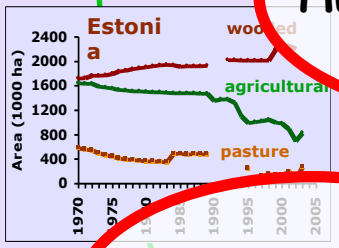


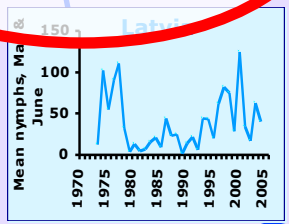


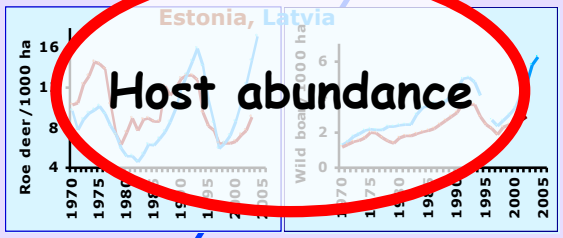












Data and analysis EDEN TBD

Sumilo et al, PLoS ONE 2007, 6, e500