Public Health Agency of Canada | Agence de santé publique du Canada

Environment and Public Health:

Climate, climate change and zoonoses

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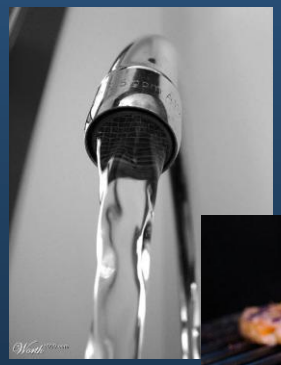
Environment and zoonoses

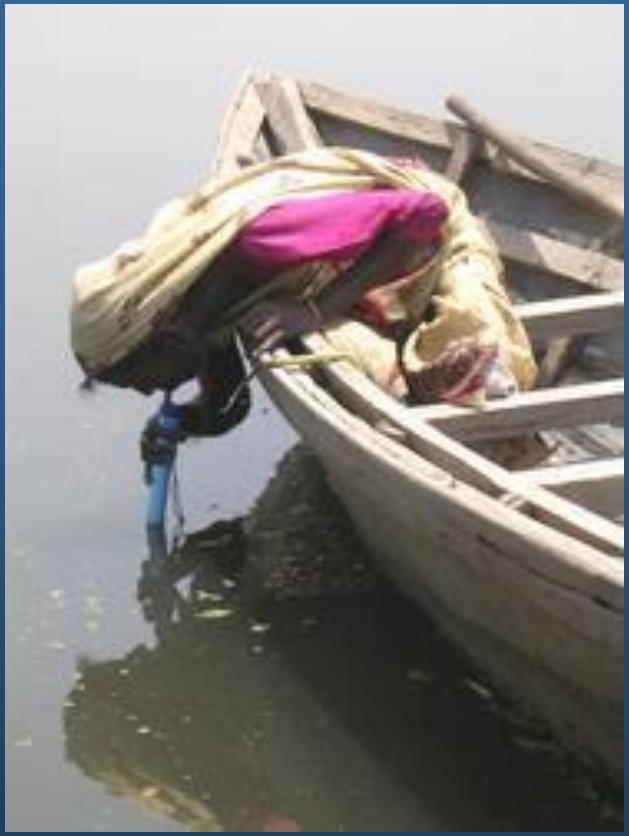
- Environmental SOURCES:
  - Agroenvironment
  - Natural environment
- Transmission ROUTES:
  - Direct contact
  - Water
  - Food
  - Vectors



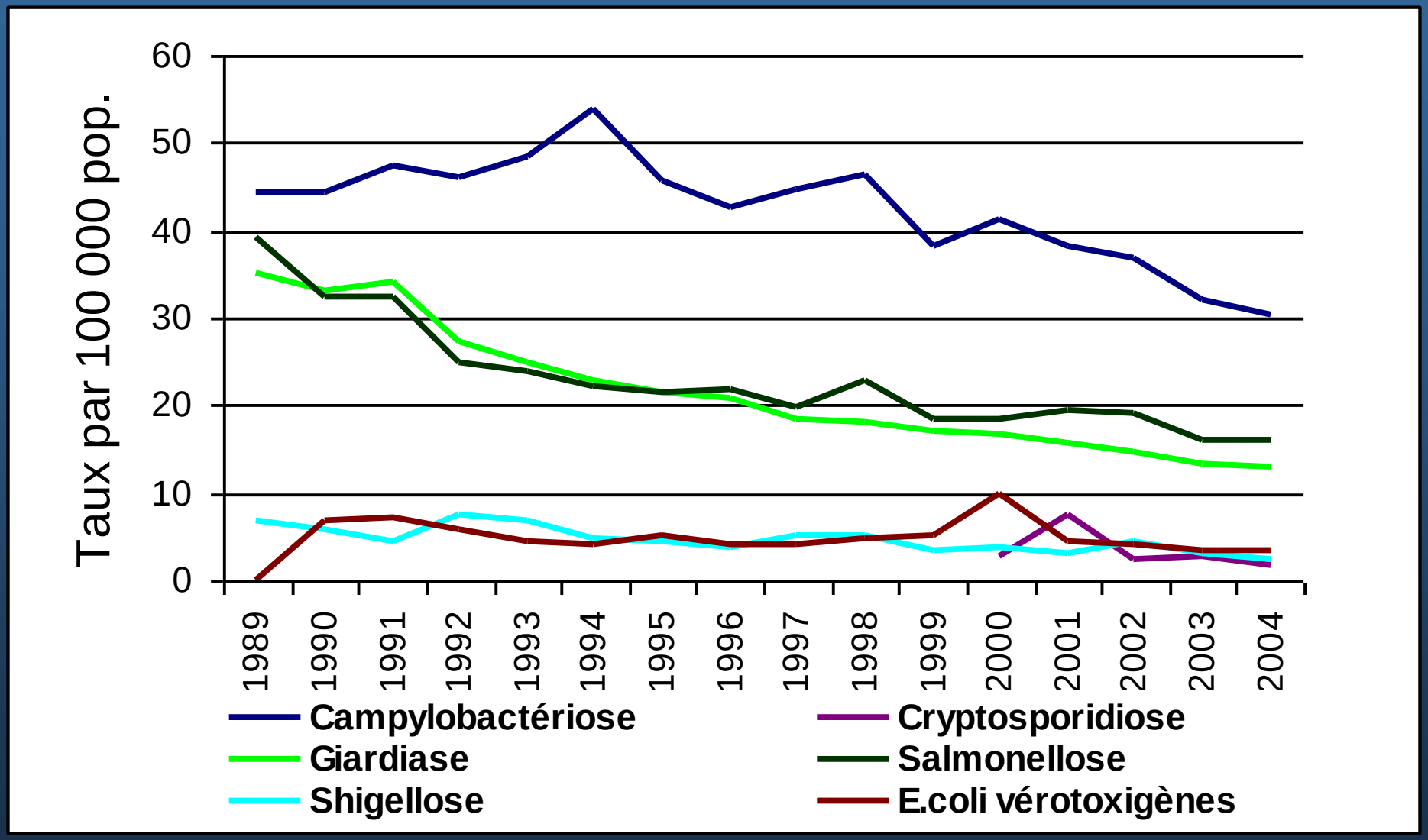
Zoonoses and the agroenvironment

Zoonoses in the agroenvironment: a long history of public health intervention

- Legislated:
  - Control of zoonoses on-farm (culling)
  - Meat inspection (and condemnation)
  - Food packaging/handling and processing
  - Water treatment

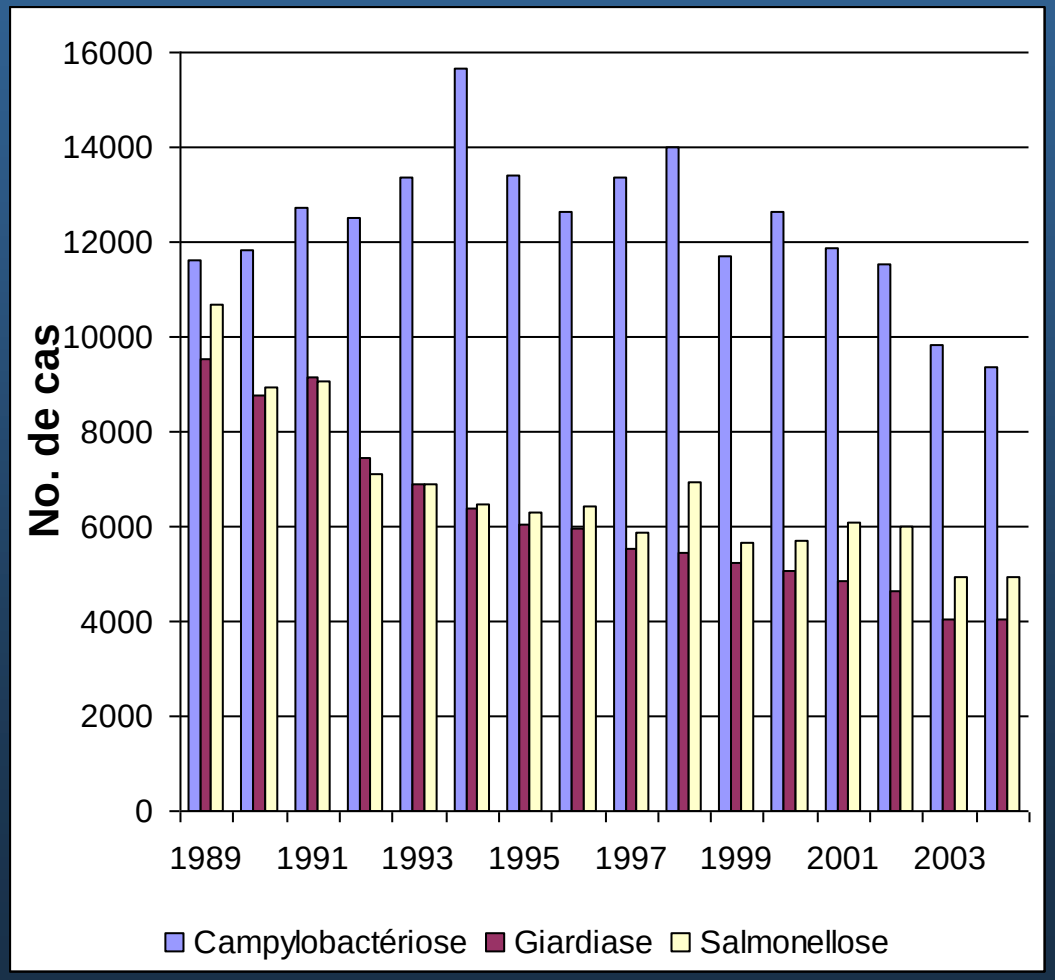


265 Splitting backbones and final inspection — hogs ready for cooler, Swift & Co., Chicago, U.S.A. Copyright 1906 by H. C. White Co.


Taux par 100 000 pop.
60
50
40
30
20
10
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Campylobactériose
Cryptosporidiose
Giardiase
Salmonellose
Shigellose
E.coli vérotoxigènes

But despite all that.....

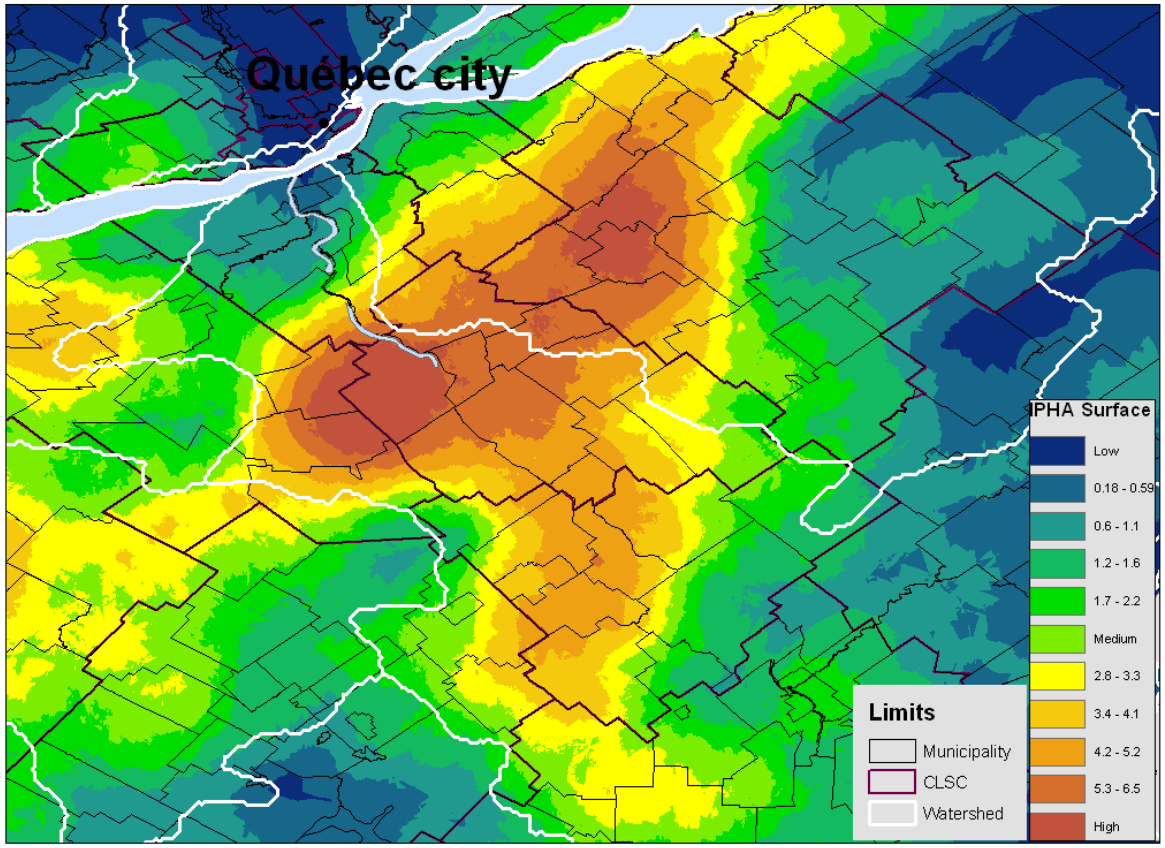
Endemic disease



Outbreaks

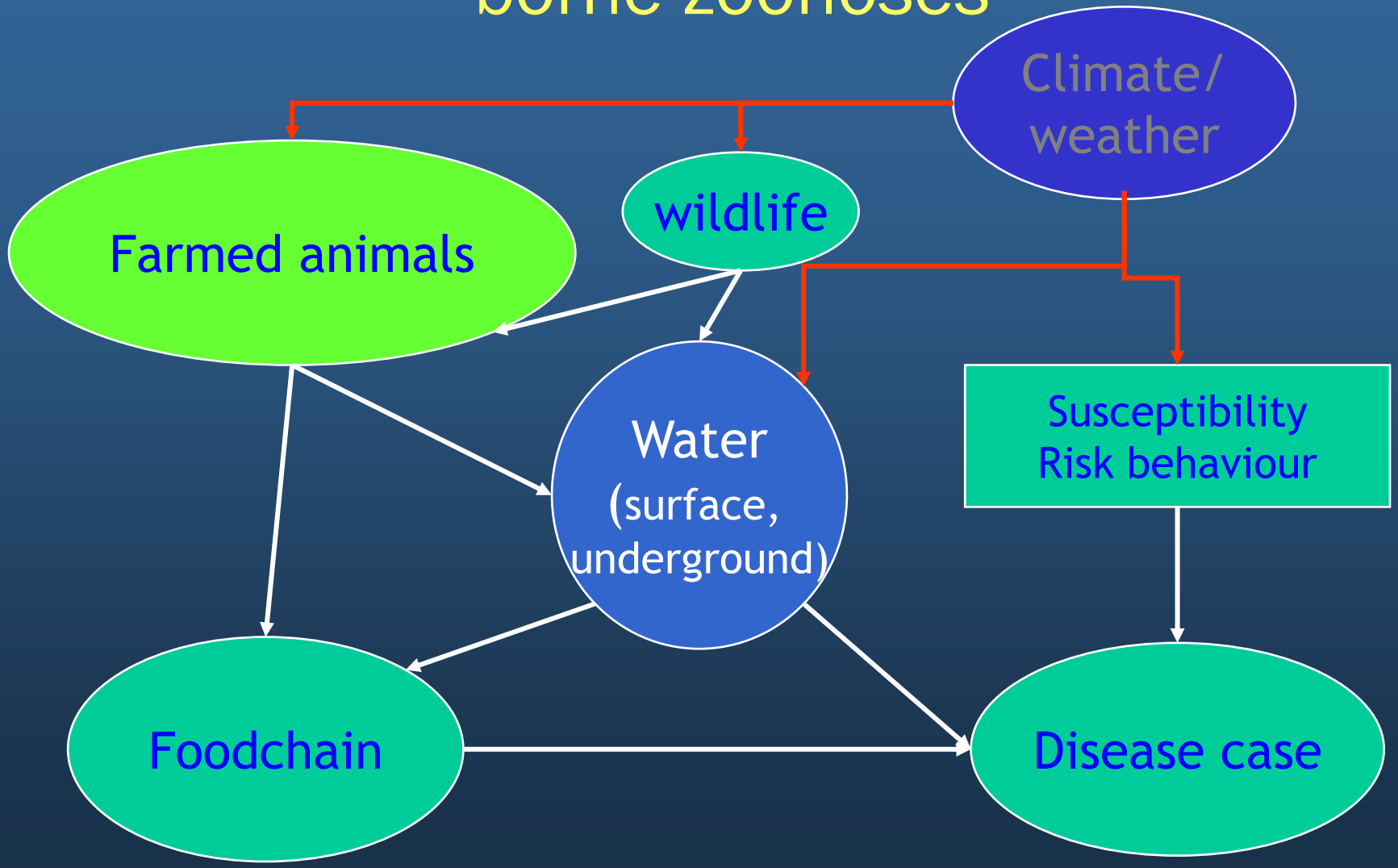
The Walkerton water tower, inviting business to locate in the town

Spatial variation in risk associated with landscape/watershed geography and intensity of agricultural systems

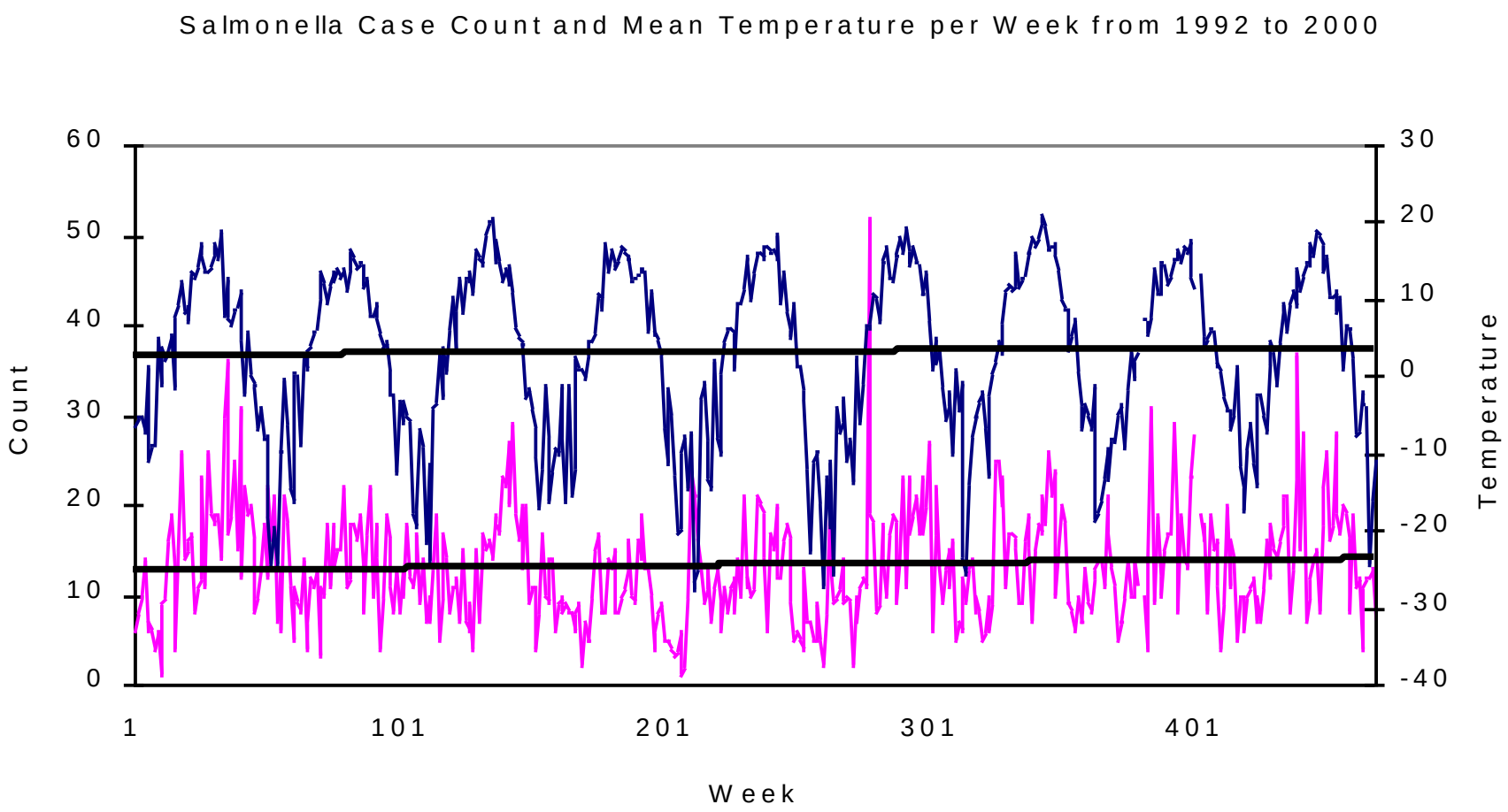


Ravel et al. Int J Hygiene Env Health 2004

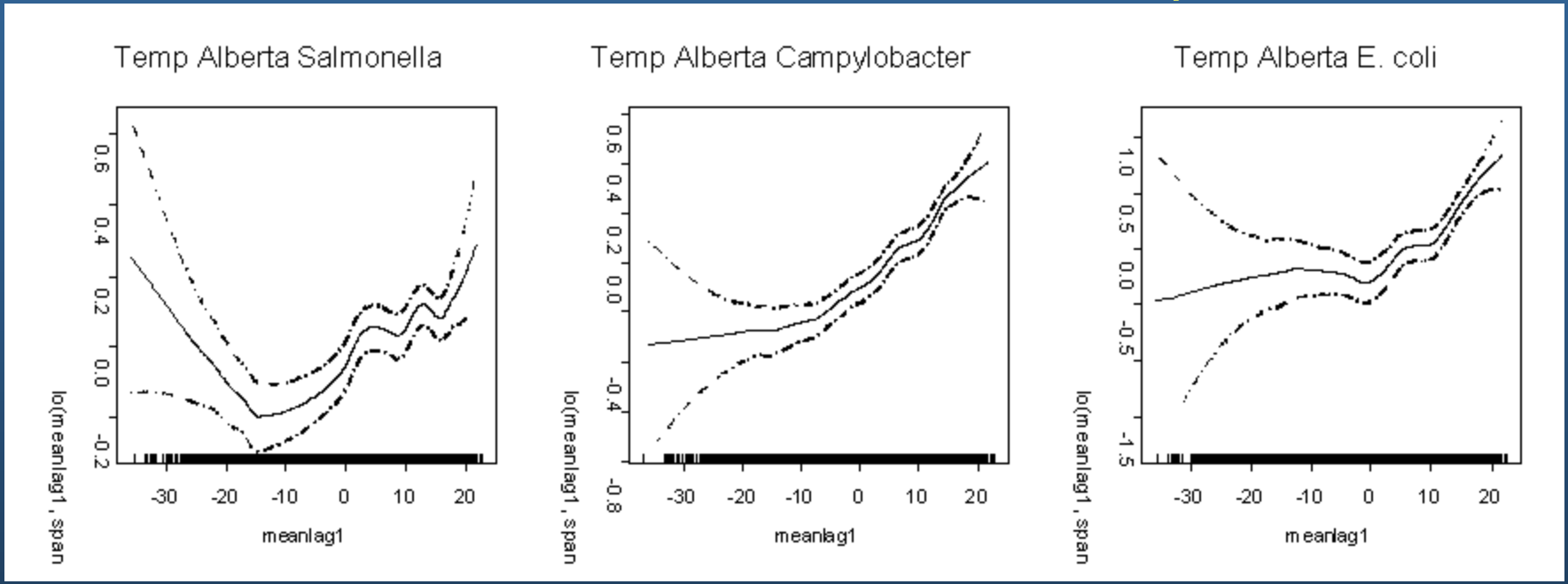
Origins and linkages of food and water-borne zoonoses



Seasonal climate driven incidence of endemic disease



Accounting for seasonality, incidence of endemic disease increases with ambient temperature



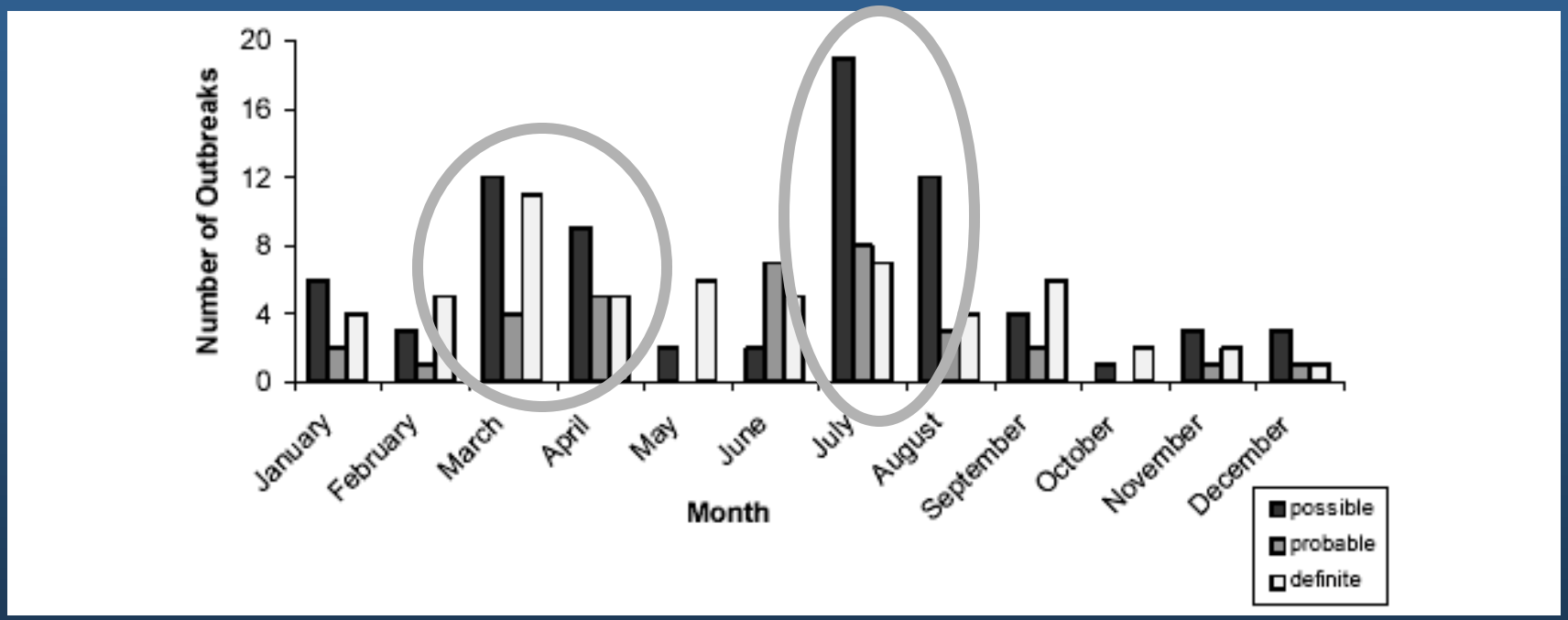
Salmonella incidence increases 1.2 % per degree above -10˚C

Campylobacter incidence increases 2.2 % per degree above -10˚C

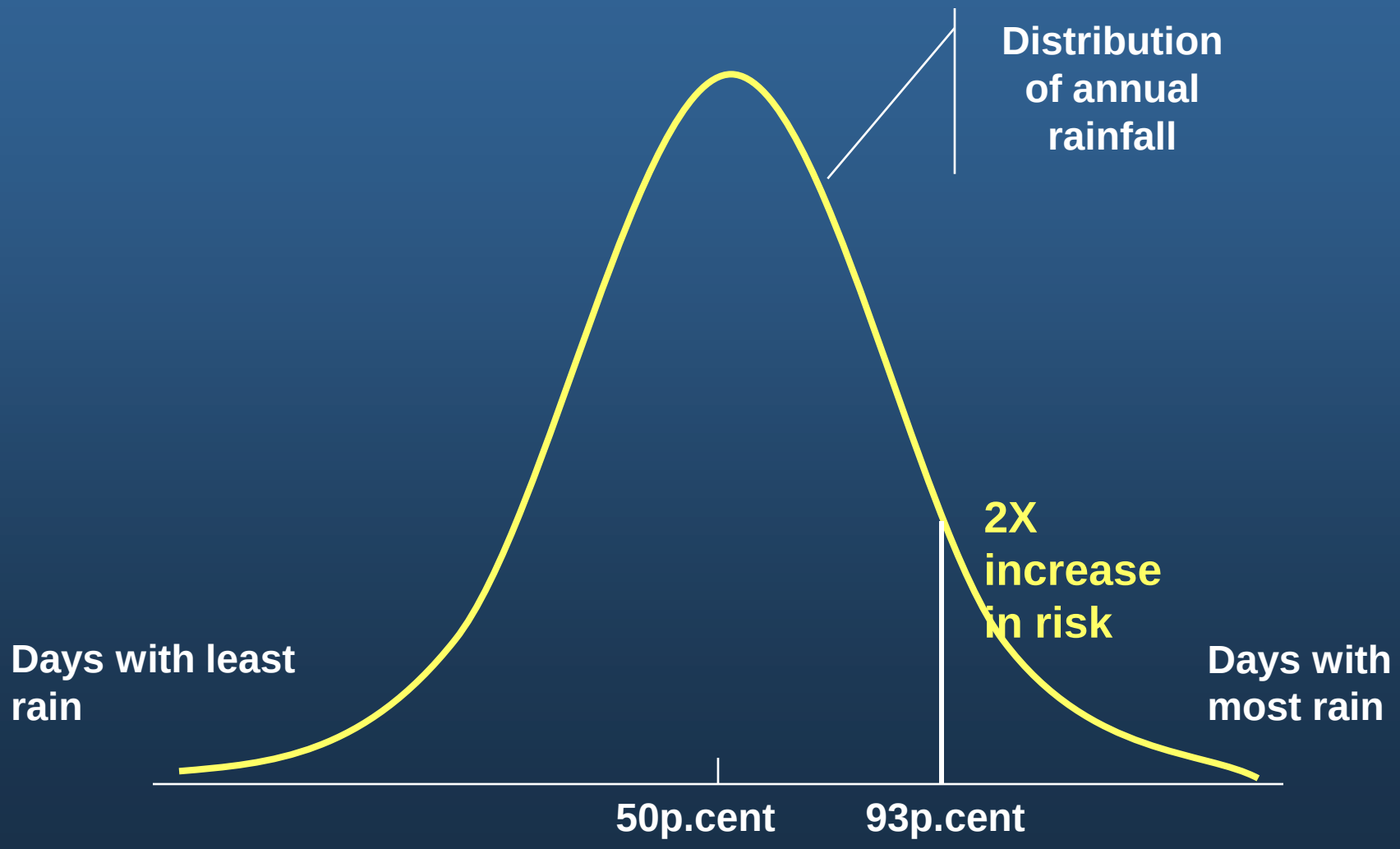
E. coli incidence increases 6.0 % per degree above -10˚C

Fleury et al. Int J Biometeorol. 2006

Incidence of waterborne disease outbreaks increase with frequency of heavy rainfall events

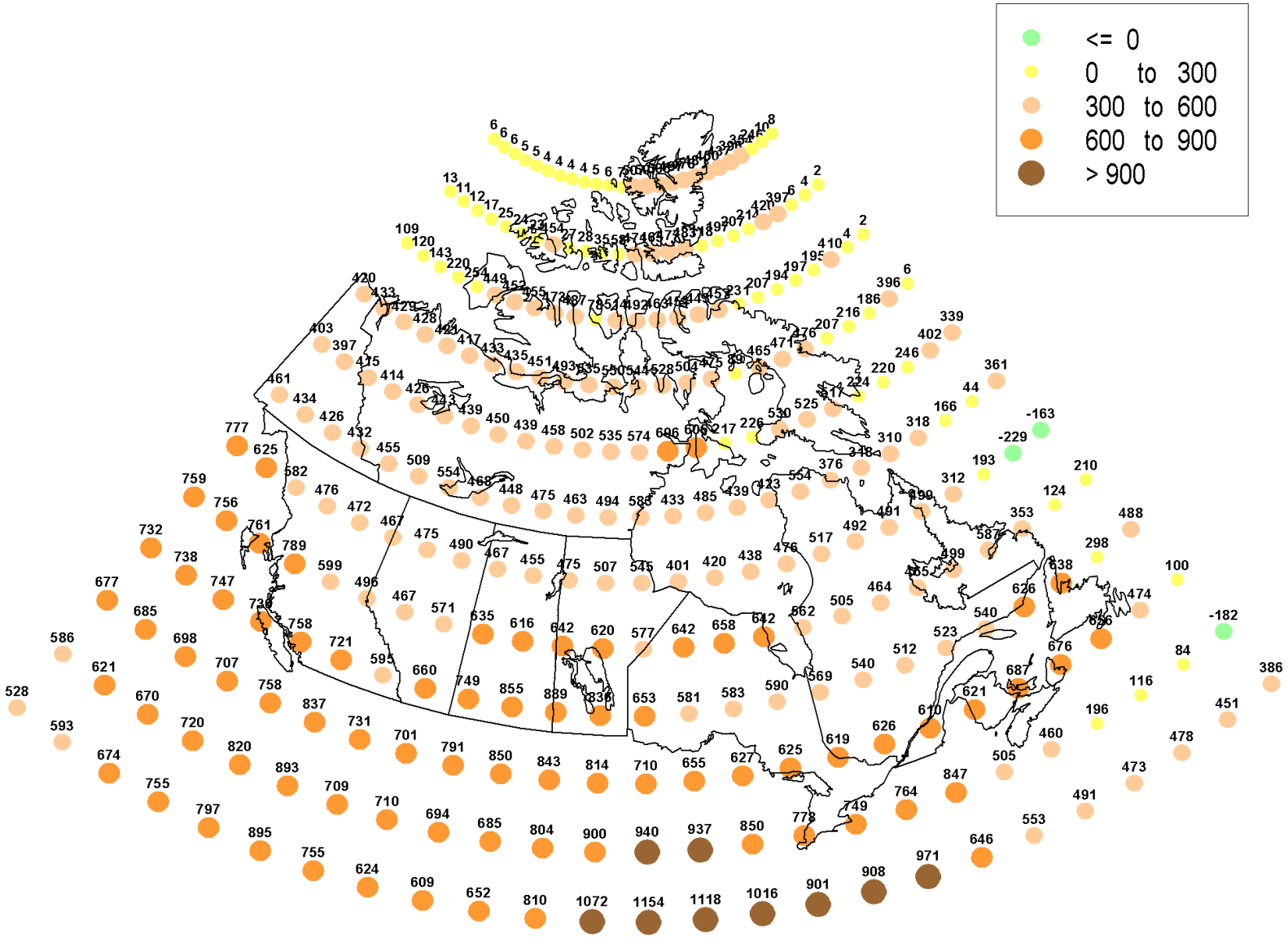


Heavy rainfall > 93 percentile associated with 2 x risk of a waterborne disease outbreak: Thomas et al., Int J Environ Health Res. 2006



Change in annual degree-days > 0°C from 1961-1990 to 2040-2069 [CGCM2 A2]

(Remerciement - A. Maarouf, EC)



Change in annual degree-days > 0°C from 1961-1990 to 2070-2099 [CGCM2 A2]

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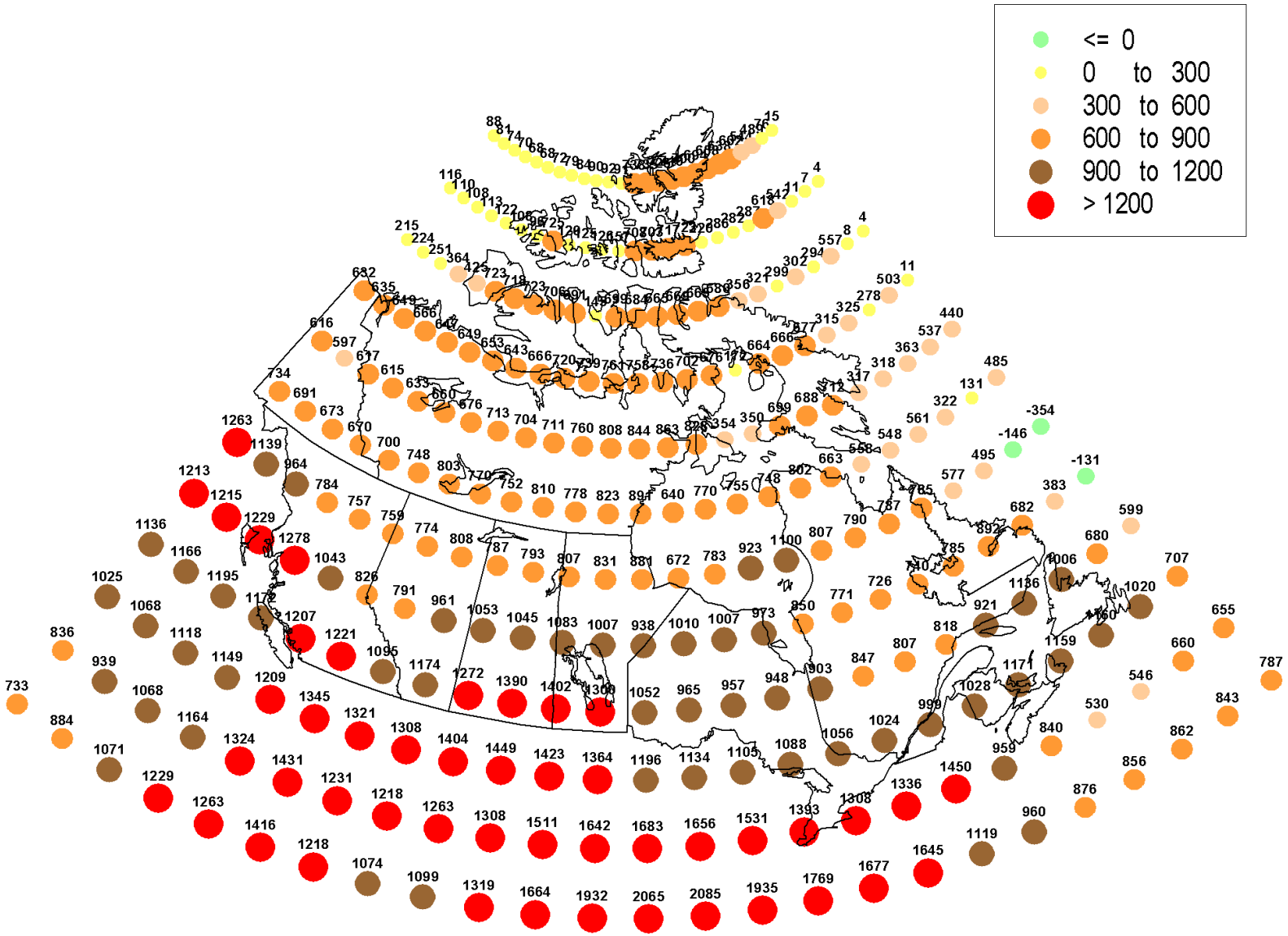
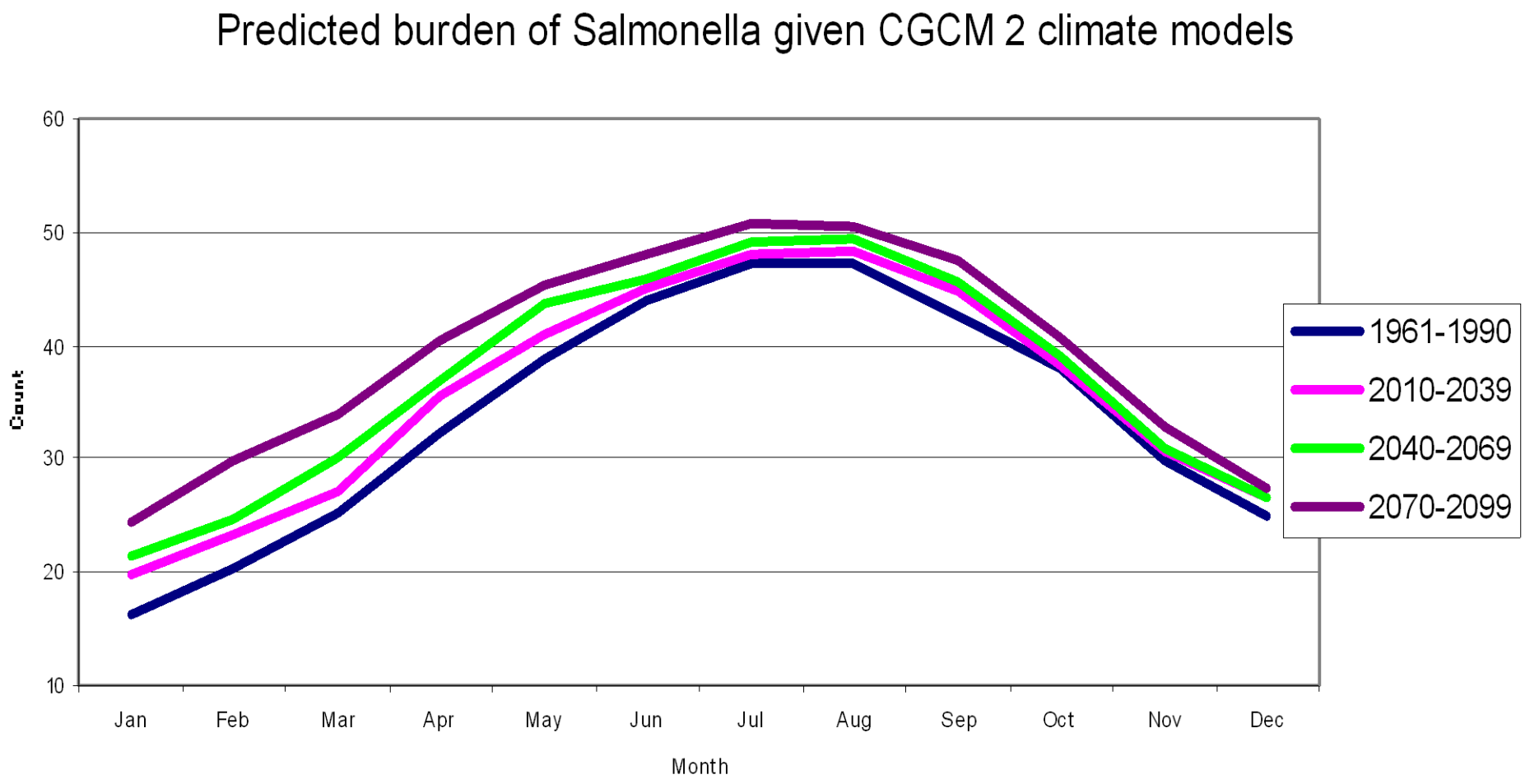
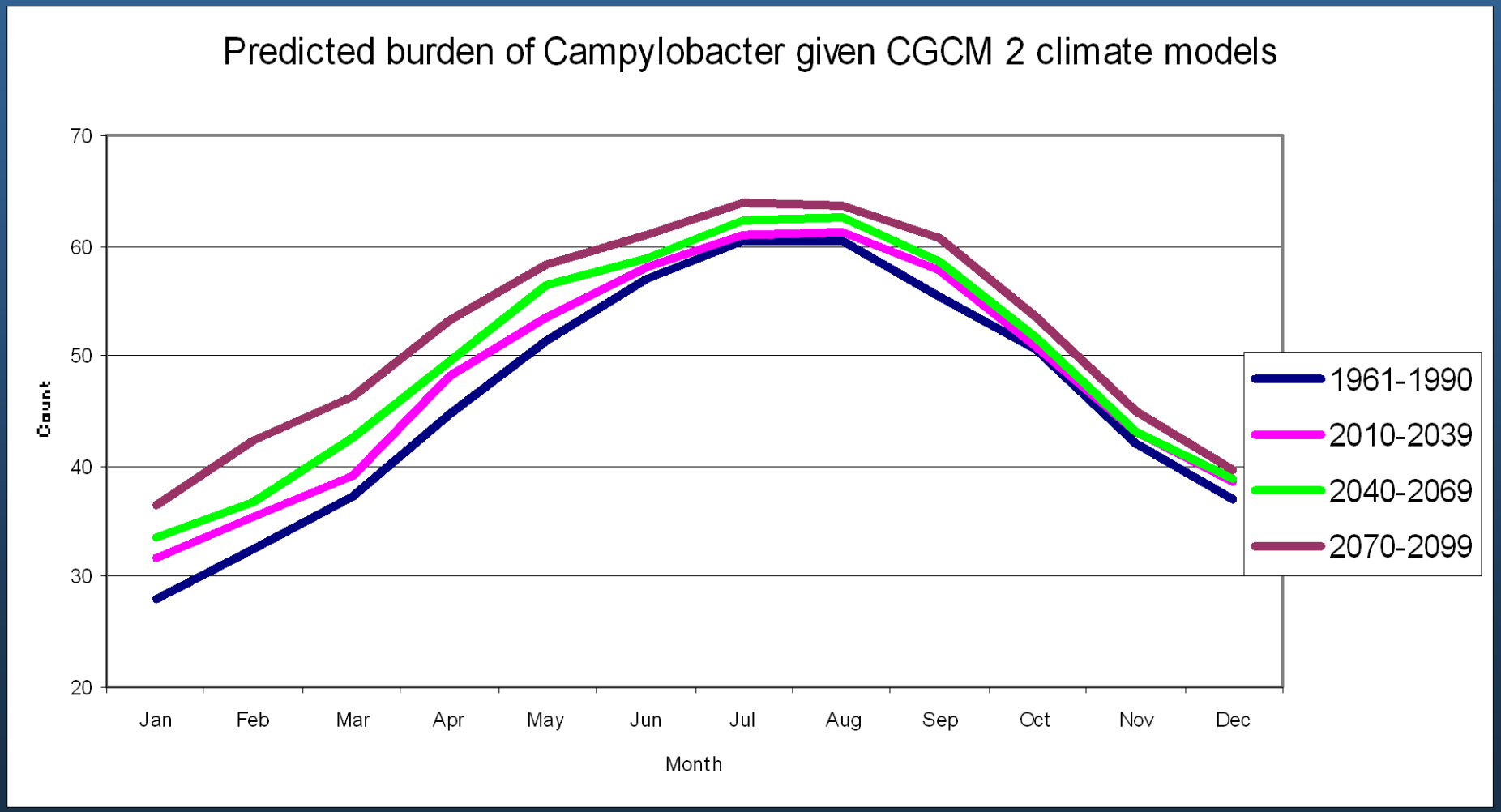


Crude incidence of salmonellosis with climate change



Crude incidence of campylobacter infections with climate change (Fleury et al)



Zoonoses and the natural environment

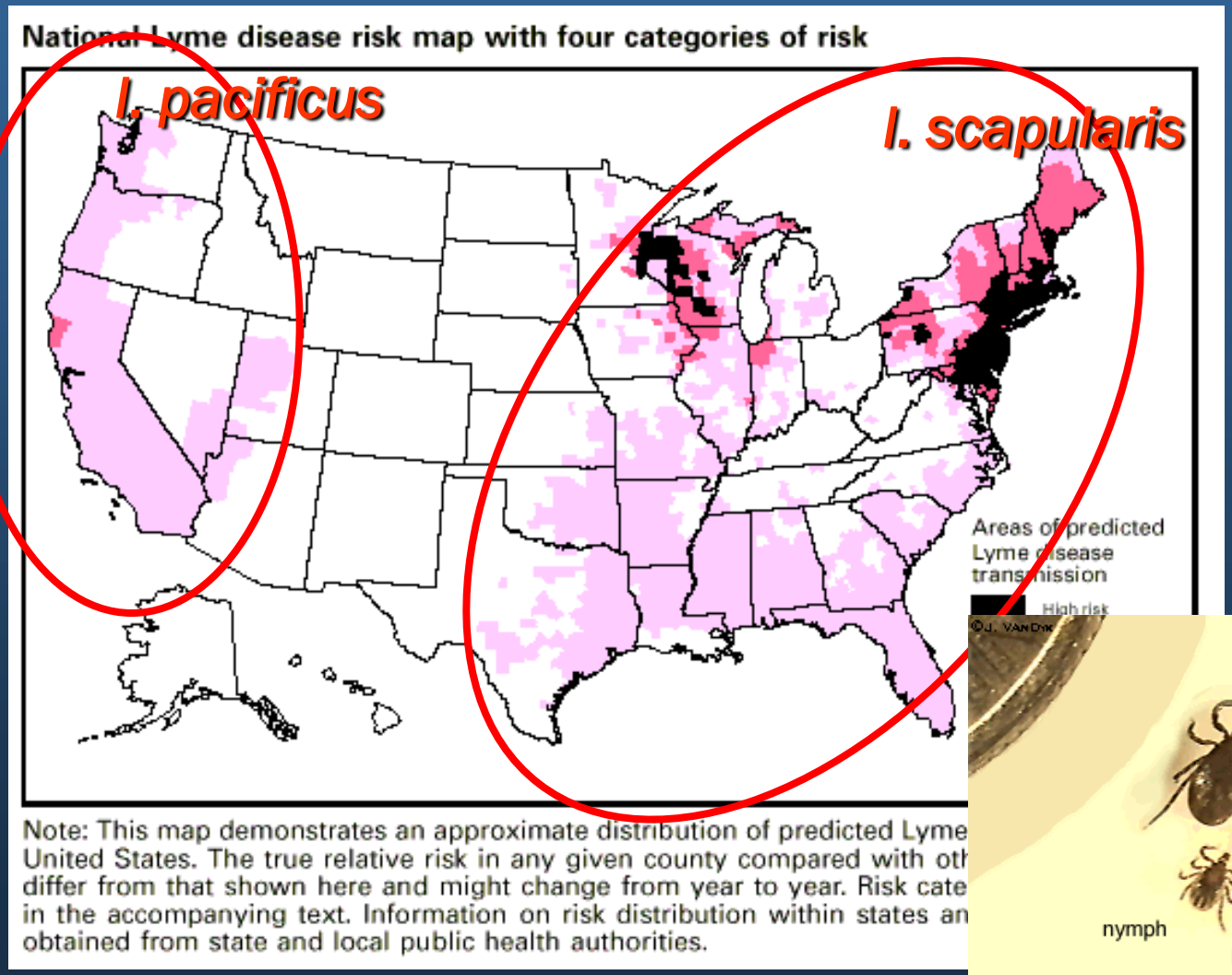
Emerging/re-emerging infectious diseases

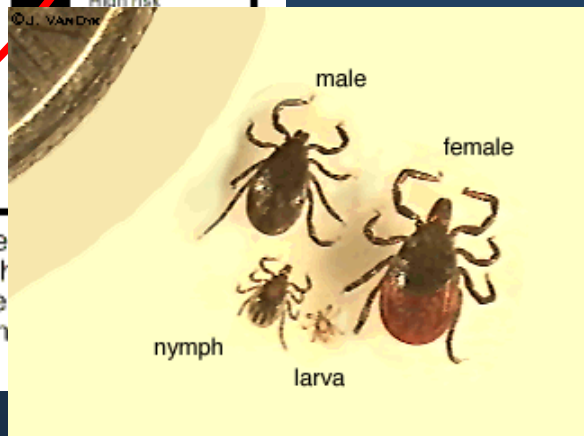
1. Human awareness (Lyme, SARS)
2. Introduction of exotic parasites into existing suitable host/vector/human-contact ecosystem (West Nile, Rabies)
3. Geographic spread from neighbouring endemic areas (Lyme, Rabies)
4. Ecological change causing endemic disease of wildlife to 'spill-over' into humans/domesticated animals (Lyme, Hantavirus, Nipah)
5. True 'emergence': evolution and fixation of new, pathogenic genetic variants of previously benign parasites/pathogens (HPAI)

Lyme disease: Emergence by range expansion

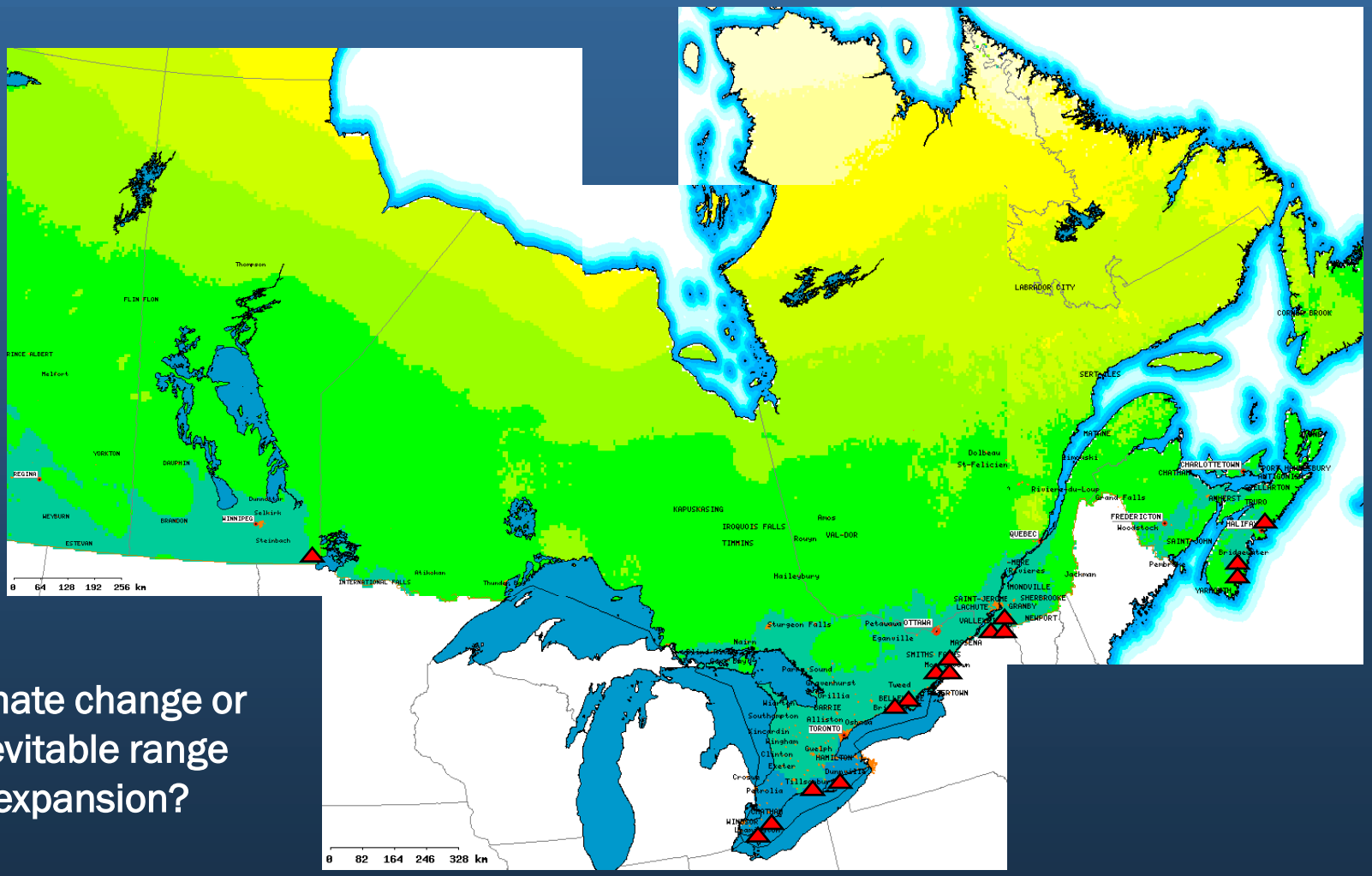
Lyme disease distribution in the USA

ca 20 000 cases/year in USA = ca 8 000 cases/year in Canada





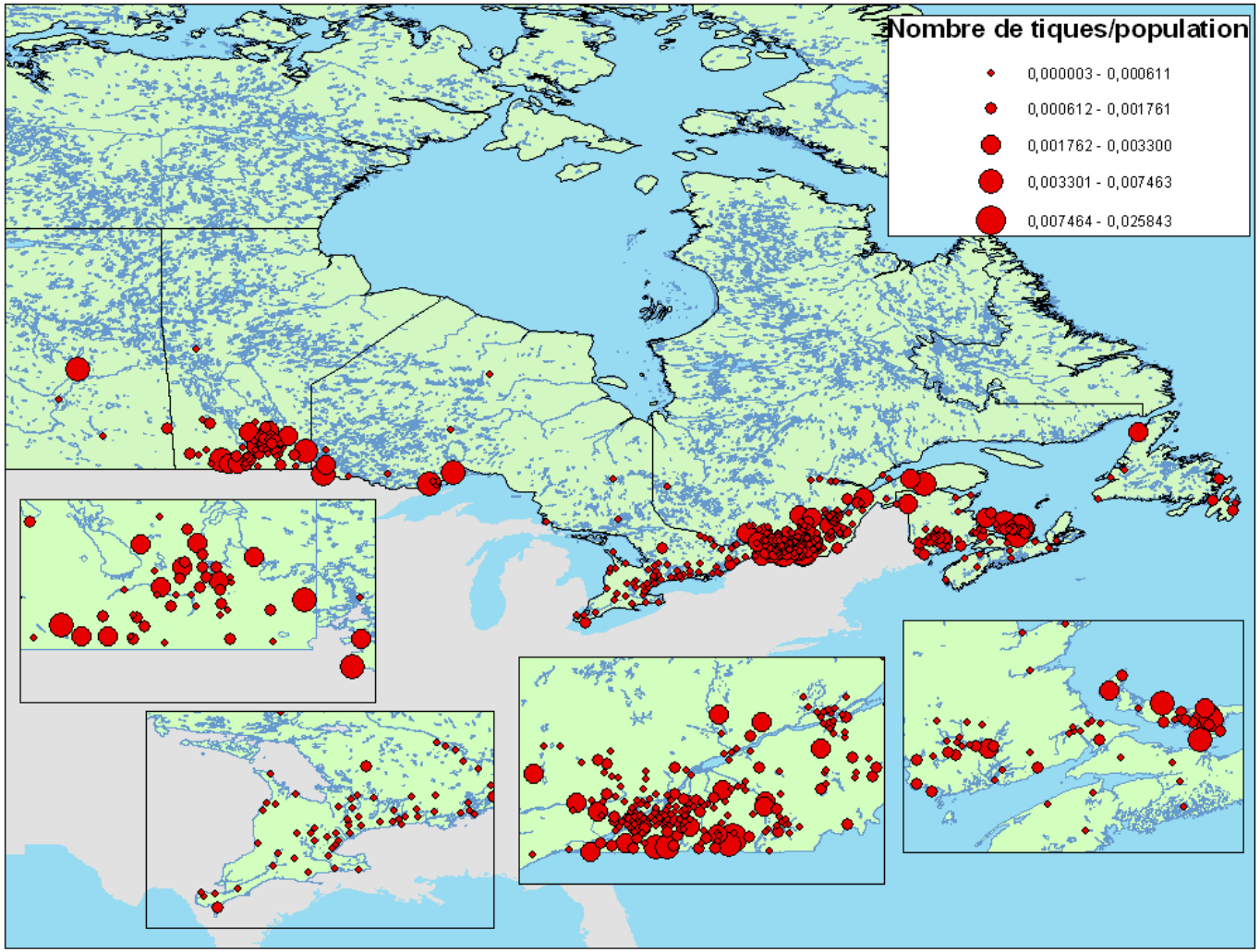
Reproducing (and self-sustaining) populations of *I. scapularis* in Canada



Climate change or inevitable range expansion?

1970 1997 2007

Distribution of *I. scapularis* submitted to PHAC by the public: carried by migratory birds



Ogden et al., (2006a) J. Med. Entomol, Ogden et al., (2008) Appl Env Microbiol

- *I. scapularis* are being seeded into a wide geographic region of Canada
- Host densities are high
- Habitat is suitable (Ogden et al., 2006b. J. Med. Entomol.)

- Why haven't populations set up more widely?
- Could climate be a limiting factor?
- If so will climate change affect this limitation?

How can climate affect vector-borne disease ecology?

Affecting geographic distribution of vectors

- Vector survival [T,RHP(mossies)]
- Vector activity (biting rate) [T,RHP]
- Host species range and density [T,RHP] (ticks)
- Habitat distribution [T,RHP]

Affecting existence of, and force of infection in, endemic transmission cycles

- Vector abundance [T,RHP]
- Vector seasonality [T,RHP]
- Extrinsic incubation period (latent period in mossie, duration of dvlpt in tick) [T]
- Host species abundance & demography[T,RHP]

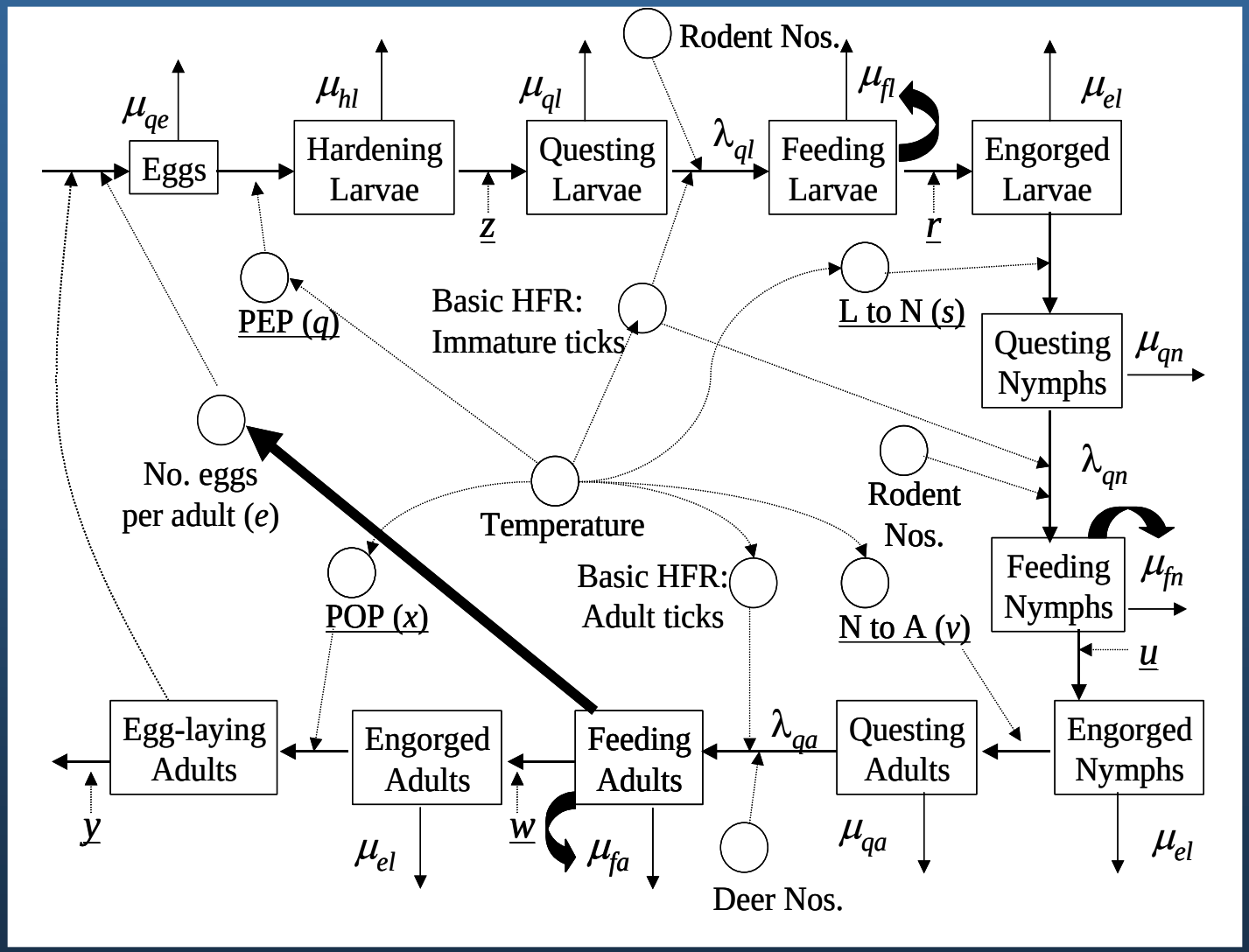
General VBD

$$R_0 = \frac{Na^2 \beta_{V-I} \beta_{I-V} p^n}{H(r+h)(-\ln p)}$$

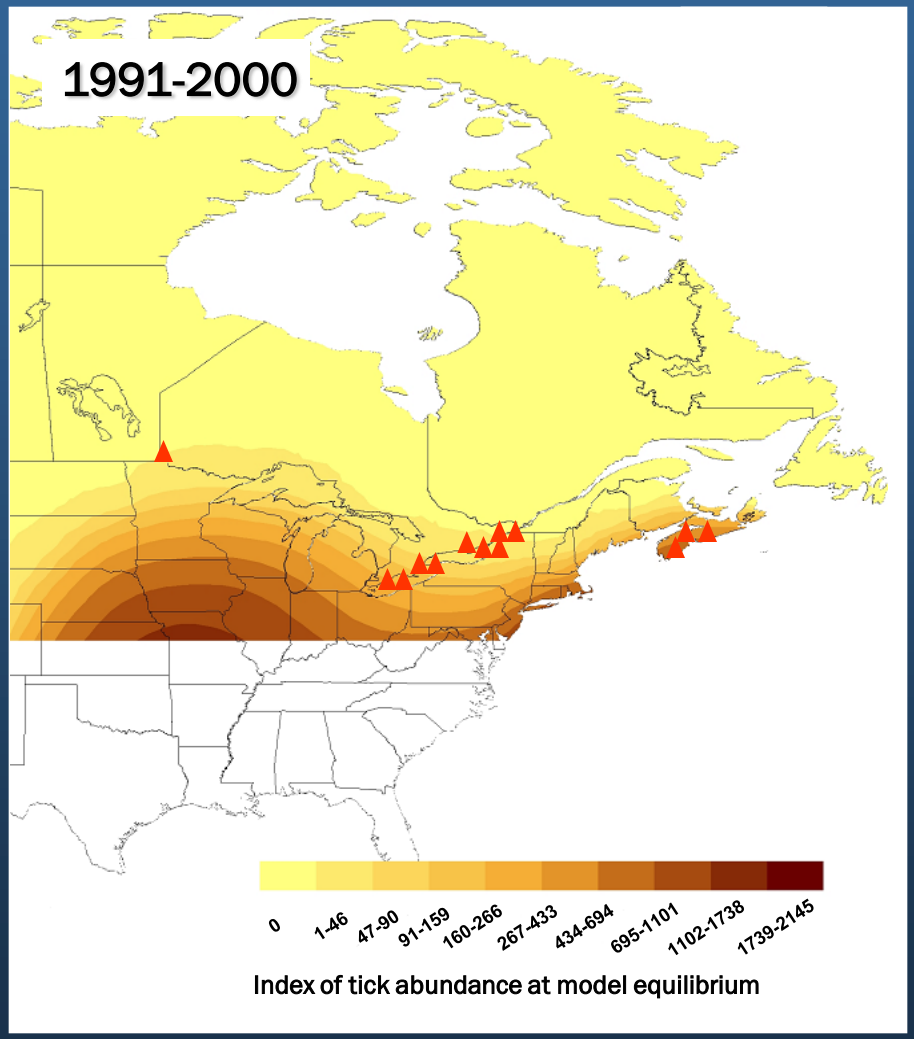
TBD (Randolph Parasitol Today 1998)

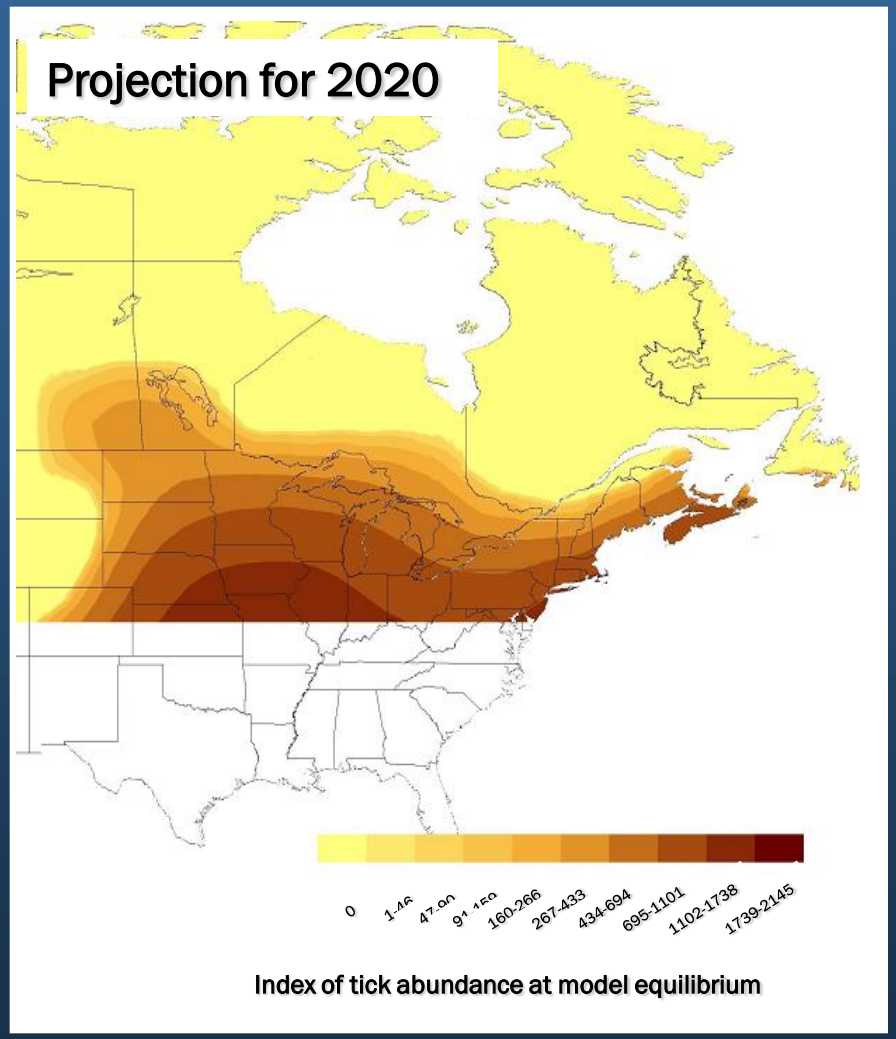
$$R_0 = \frac{Nf \beta_{V-T} \beta_{T-T} \beta_{T-V} p^n F}{H(r+h)}$$

Dynamic simulation model of *I. scapularis* populations

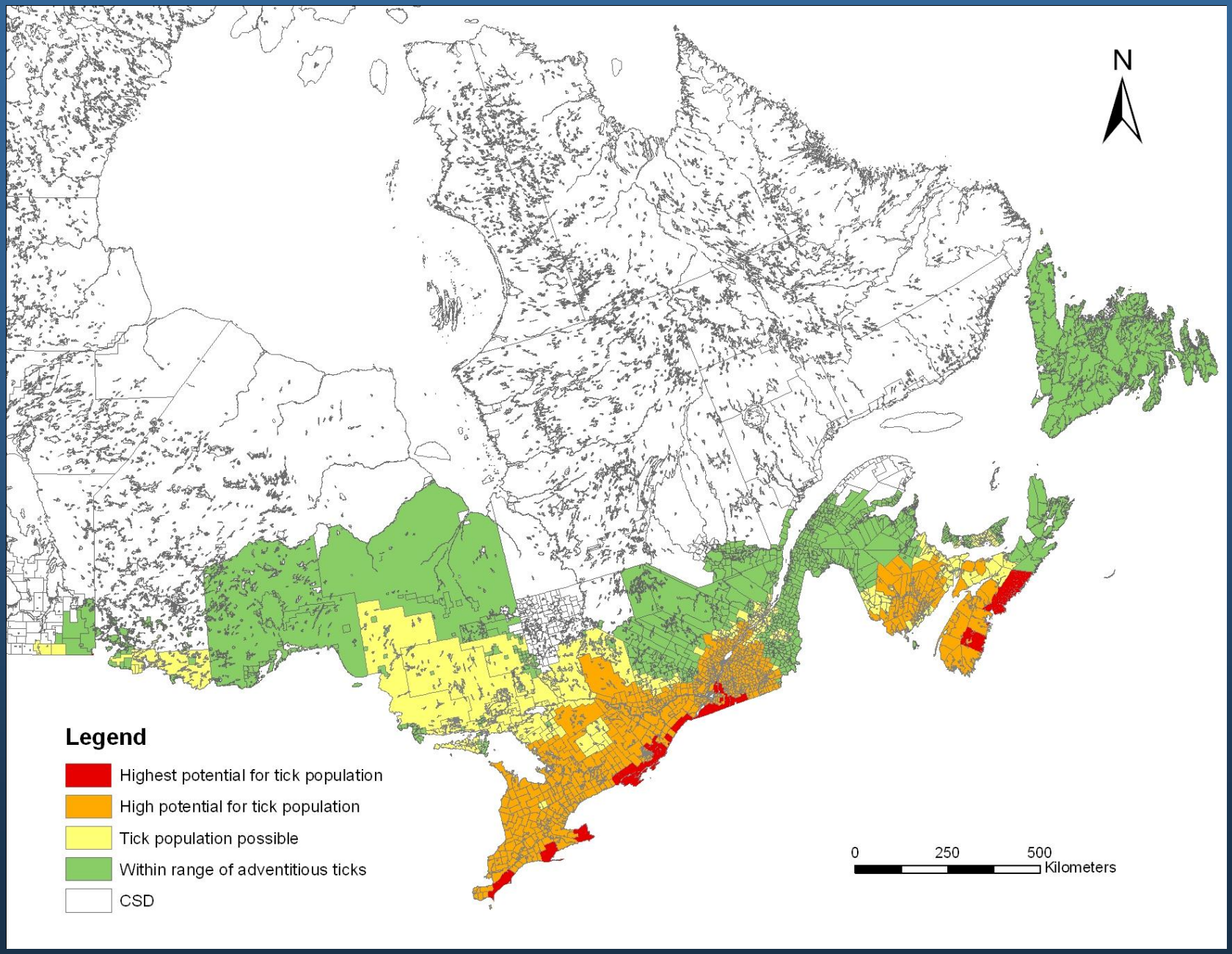


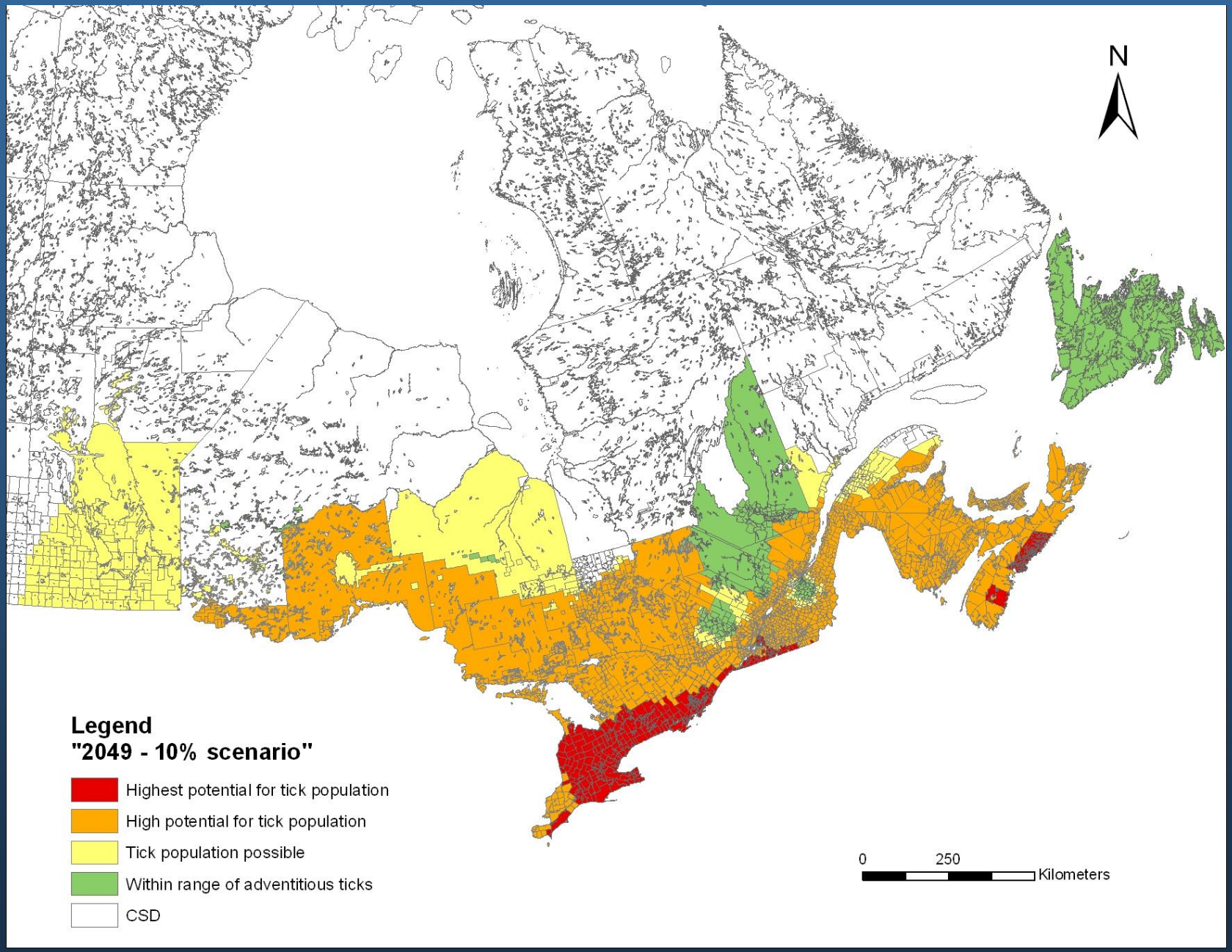
Simulation model output suggests temperature conditions constrain *I. scapularis* distribution, but if so, that will change with climate change

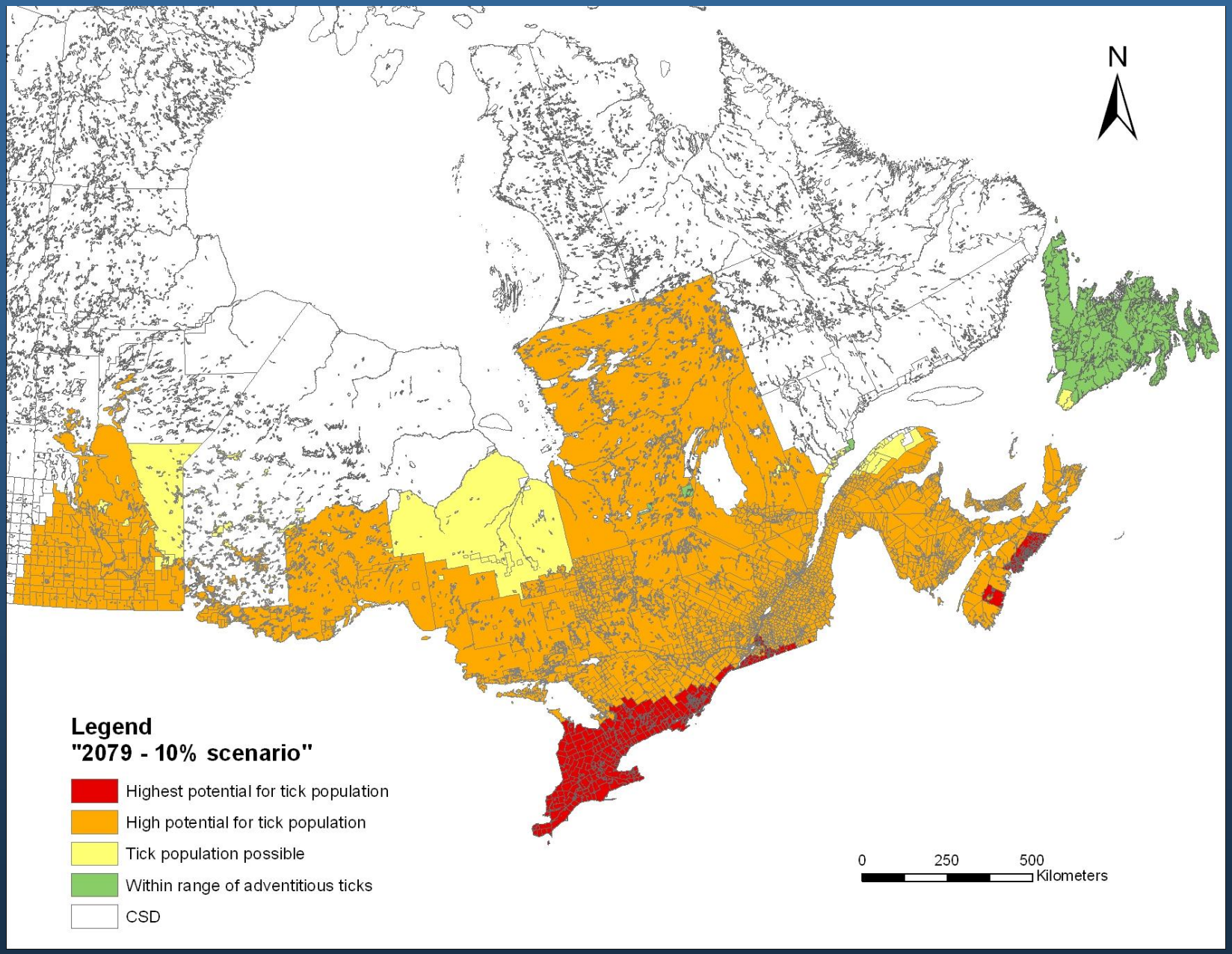


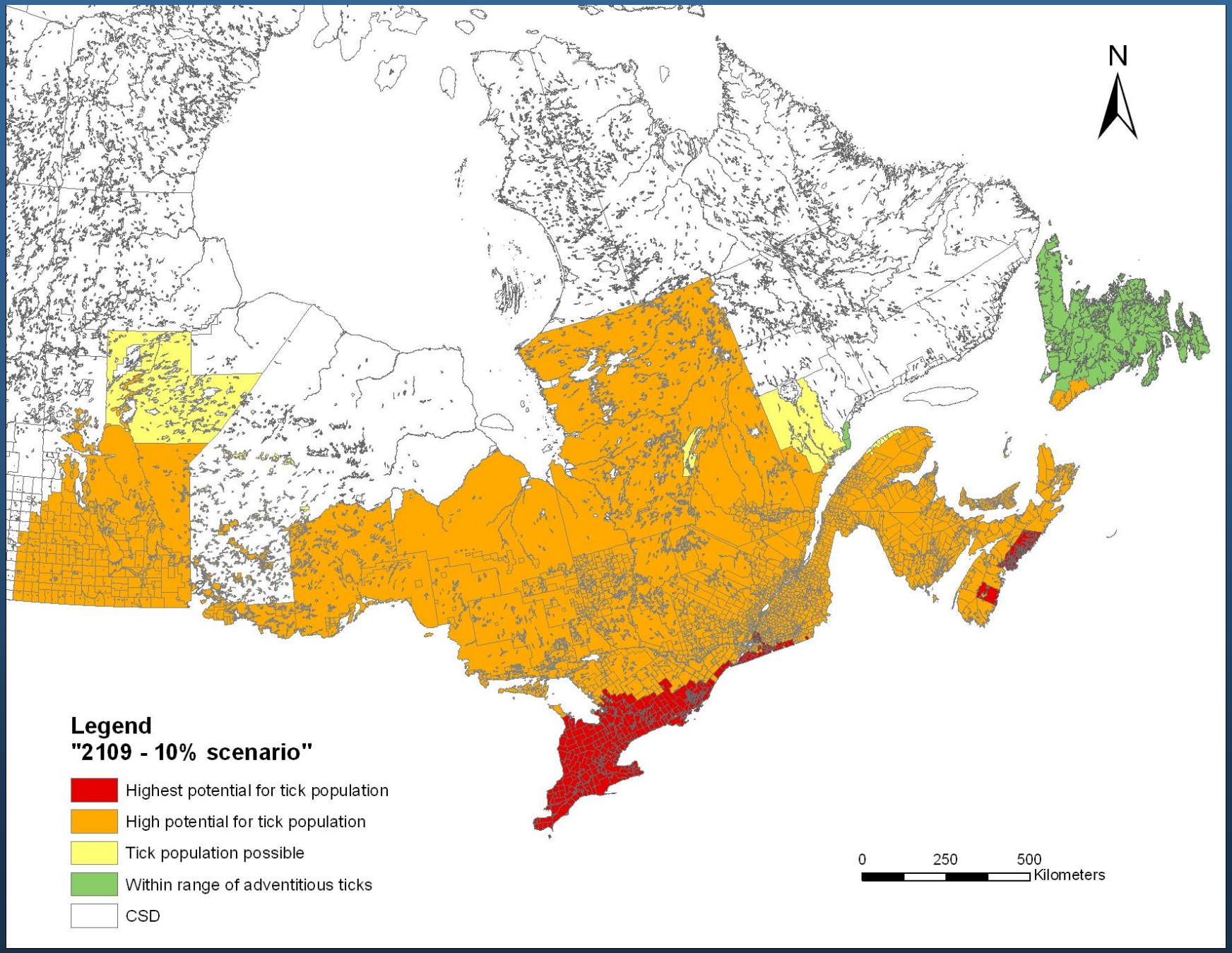


Ogden et al. Int. J. Parasitol. 2005, 2006


N
Legend
Highest potential for tick population
High potential for tick population
Tick population possible
Within range of adventitious ticks
CSD
0
250
500
Kilometers

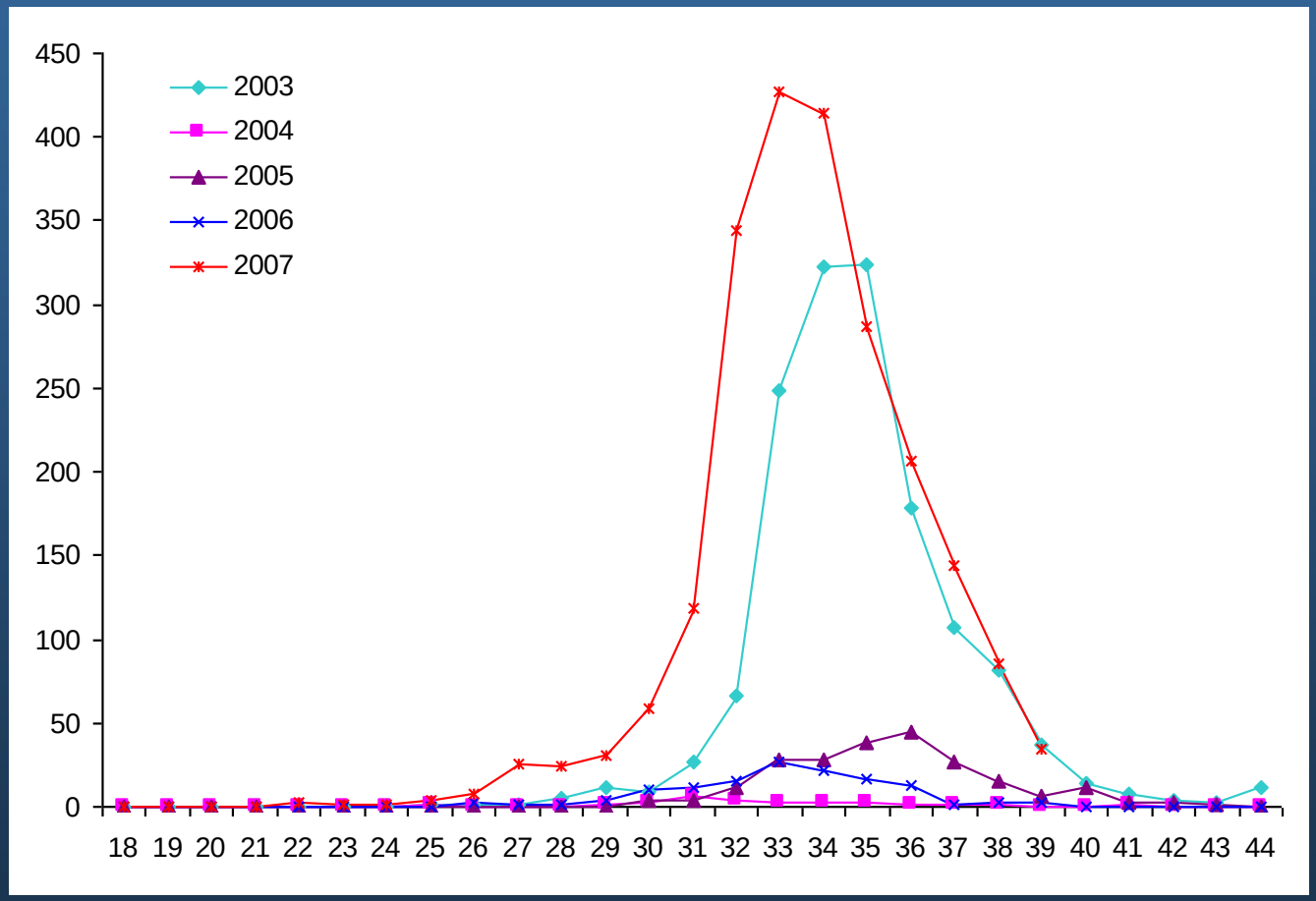

N
Legend
"2049 - 10% scenario"
Highest potential for tick population
High potential for tick population
Tick population possible
Within range of adventitious ticks
CSD
0
250
Kilometers


N
Legend
"2079 - 10% scenario"
Highest potential for tick population
High potential for tick population
Tick population possible
Within range of adventitious ticks
CSD
0
250
500
Kilometers

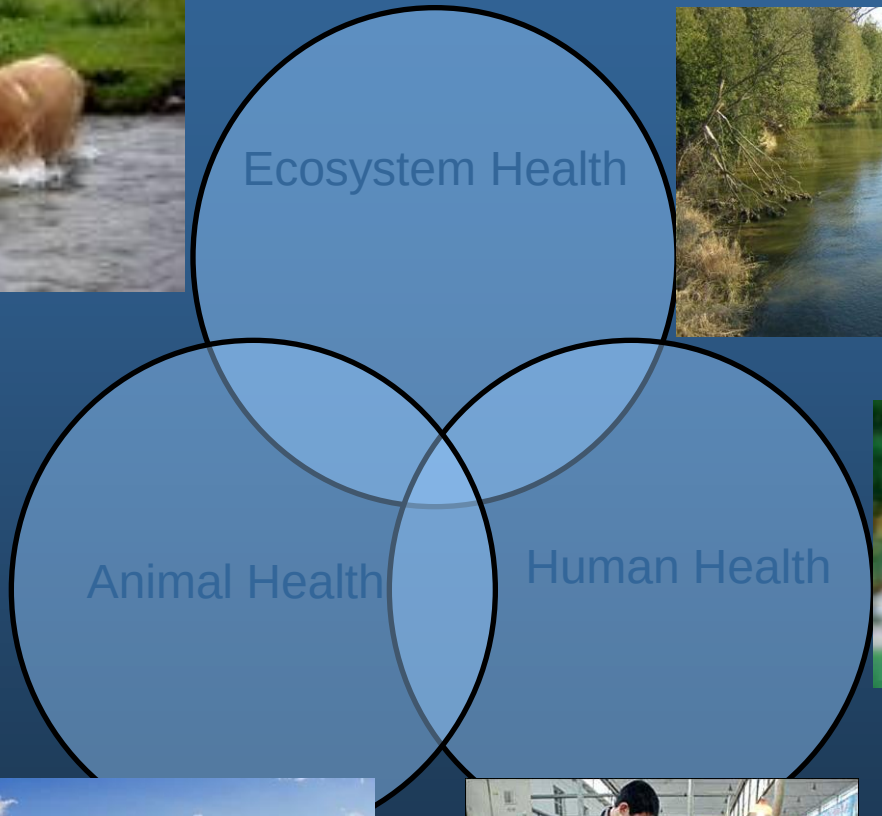

N
Legend
"2109 - 10% scenario"
Highest potential for tick population
High potential for tick population
Tick population possible
Within range of adventitious ticks
CSD
0
250
500
Kilometers

Emergence by spillover: West Nile virus

West Nile Virus Cases in Canada 2003 to 2007



One World, One Health



Emergence of zoonoses at the wildlife-livestock-human interface

- Most emerging infectious diseases are zoonoses
- Most are generalist pathogens with a wide range of host species
- Most remain zoonoses
  - Nipah
  - Hendra
  - WNV
  - Zoonotic Avian Influenza
  - Lyme
- A few become human-to-human transmitted
  - Pandemic Avian Influenza (Spanish flu)
  - HIV-AIDS
  - SARS
  - Haemorrhagic fevers
- Environmental change is a major driver of emergence!

Conclusions

- Zoonoses are a significant endemic cause of disease in Canada
- Important foodborne and waterborne zoonoses arise from the agroenvironment despite controls
- Climate is an important driver of the incidence of both cases and outbreaks
- Climate is an important determinant of the geographic occurrence of vector-borne zoonoses, and a driver of outbreaks via effects on vector abundance
- Climate change is likely to increase the incidence of foodborne, waterborne and vector-borne zoonoses in Canada
- Climate change may drive the emergence of zoonoses at the wildlife-livestock-human interface
- Global emerging infectious diseases can rapidly become local diseases