



Climate change effects on the epidemiology of infectious diseases and the impacts on Northern societies

## Climate-change Effects on the Geographic Distribution of Infectious Diseases in the Arctic

Tomas Thierfelder & Birgitta Evengård

with contributions from the entire CLINF consortium

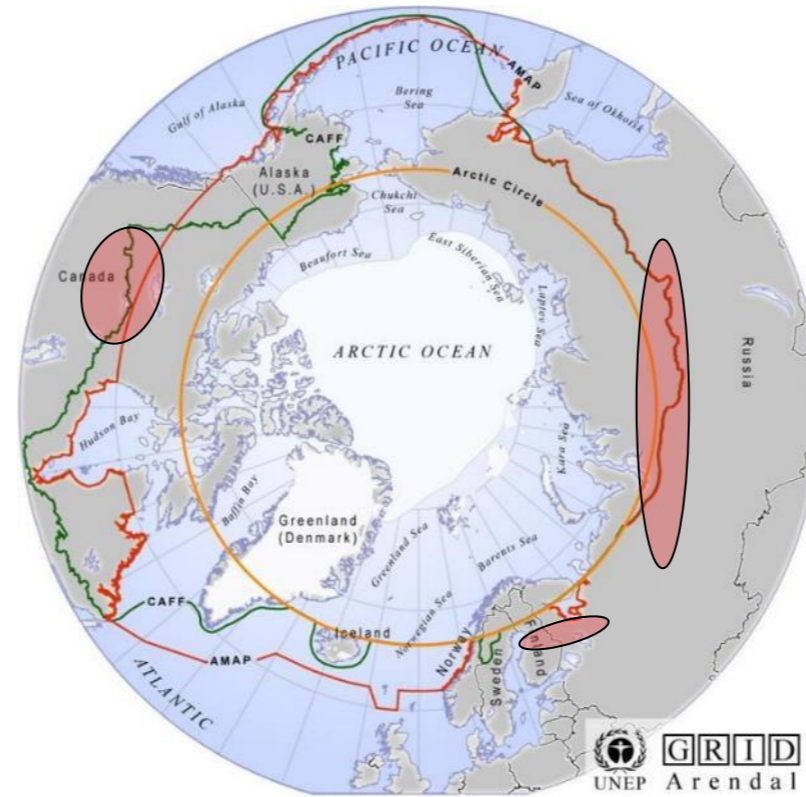
[www.clinf.org](http://www.clinf.org)

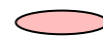
Photos: Carl-Johan Utsi



# The CLINF NCoE

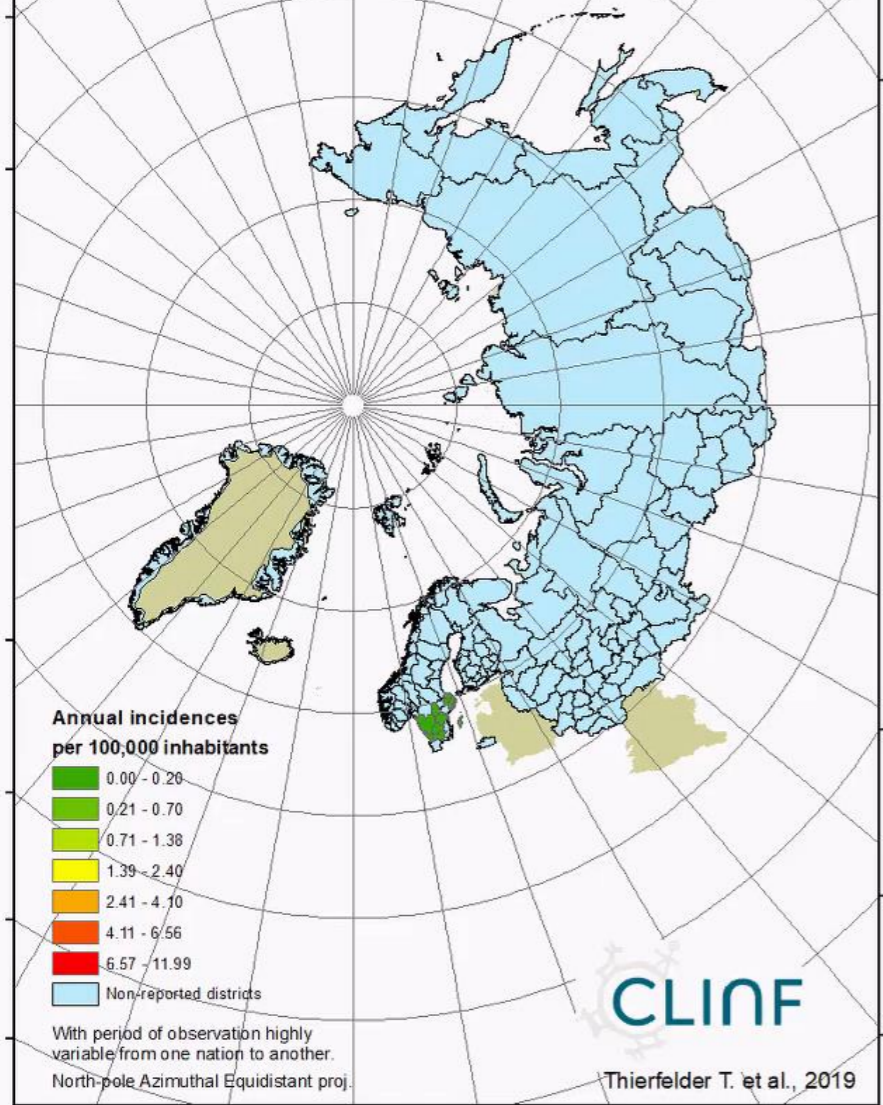
Climate-change Effects on the Epidemiology of Infectious Diseases  
and the Impacts on Northern Societies: [www.clinf.org](http://www.clinf.org)



 Geographic CSI extension (hypothetic)  
CSI = Climate Sensitive Infection

- ✓ Warming landscapes
  - ✓ Migrating vector organisms
  - ✓ Changing societal exposure
  - ✓ Societal effects
  - ✓ One-Health
- 
- ~ 60 peer-reviewed publications including Nature and Science
  - Many conference invitations
  - Many media appearances
  - Accelerating educational impact

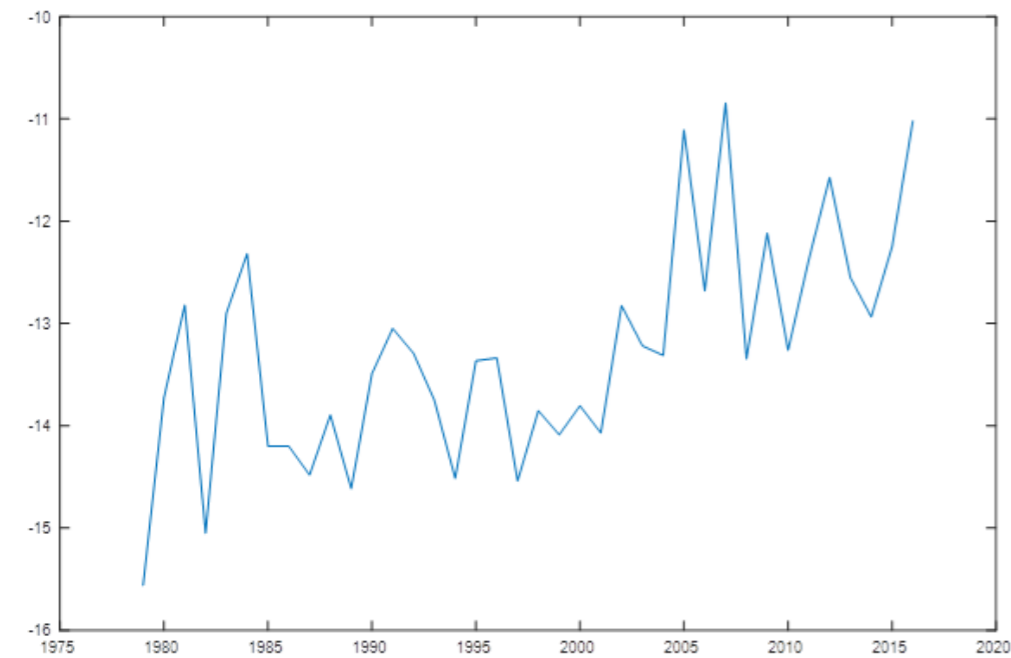
## Leptospirosis incidence 1972 - 2016 around the Eurasian Arctic 1972



# The CLINF OPEN Data Repository

which is **OPENLY available** for all stakeholders

- CLINF is collating a rather unprecedented **database** covering the Eurasian Arctic with data concerning human and animal **zoonotic infections**, and with corresponding **landscape and climate data**.
  - All possible relevant **satellite products**
    - through their entire time-span of production
      - intended to cover the **30-year climate reference period**
    - from “Nuuk to Yakutsk”
      - and from lat. 60 to lat. 80 degrees north
    - many products highly resolved in space and time
  - Primary data concerning the **incidences of zoonotic infections**
    - including visualisations via maps and animations
    - resolved across **gender and age** (where applicable)
    - through the past **30-year climate reference period**
  - Complete **GIS materials**
    - PDF, AVI, Shape and ArcGIS package formats
  - Still due for completion with respect to:
    - **Russian** in-depth data, also including factors gender and age
    - data concerning zoonotic infections observed on **animals**



ERA Interim [surface temperatures](#) averaging from western Greenland to the Russian Pacific, 60 to 80 degrees north. [Greening and wetness](#) indices display similar patterns.

Primary variables	Primary variables	Derived variables
Land cover	Air temp	Plant functional type
Photosynthesis	Precipitation	Soil moisture
Leaf area index	Topography	Length of vegetation period
Soil moisture	Evaporation	Air temp extremes
Snow water equivalent	Soil properties	Precipitation extremes
Snow extent	Solar radiation	Land-cover change
Snow depth	U/W wind components	Start of spring-flood
Snow melt	Air pressure	Geostrophic wind
Soil freeze/thaw	Sea-ice cover	
Soil temp	Runoff	

CLINF landscape and climate data products

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## CLINF [human diseases](#) data products

**Data available through the period of:**

Nation	BOR	BRU	CRY	LEP	PUU	QFE	TBE	TUL
Finland	1995 - 2016	1995 - 2014	1995 - 2016	1995 - 2016	1995 - 2016	1998 - 2016	1995 - 2016	1995 - 2016
Greenland	n/a	n/a	n/a	n/a	n/a	2007 - 2007 *	n/a	n/a
Iceland	n/a	n/a	2013 - 2016	n/a	n/a	n/a	n/a	n/a
Norway	1990 - 2016	2004 - 2016	2012 - 2016	n/a	1991 - 2016	n/a	1998 - 2016	1985 - 2016
Russia	1992 - 2015	1970 - 2015	n/a	1975 - 2015	1975 - 2015	1998 - 2015	1969 - 2015	1970 - 2015
Sweden	1985 - 1994	2011 - 2013	2004 - 2016	1972 - 2013	1985 - 2016	2007 - 2013	1978 - 2016	1969 - 2016

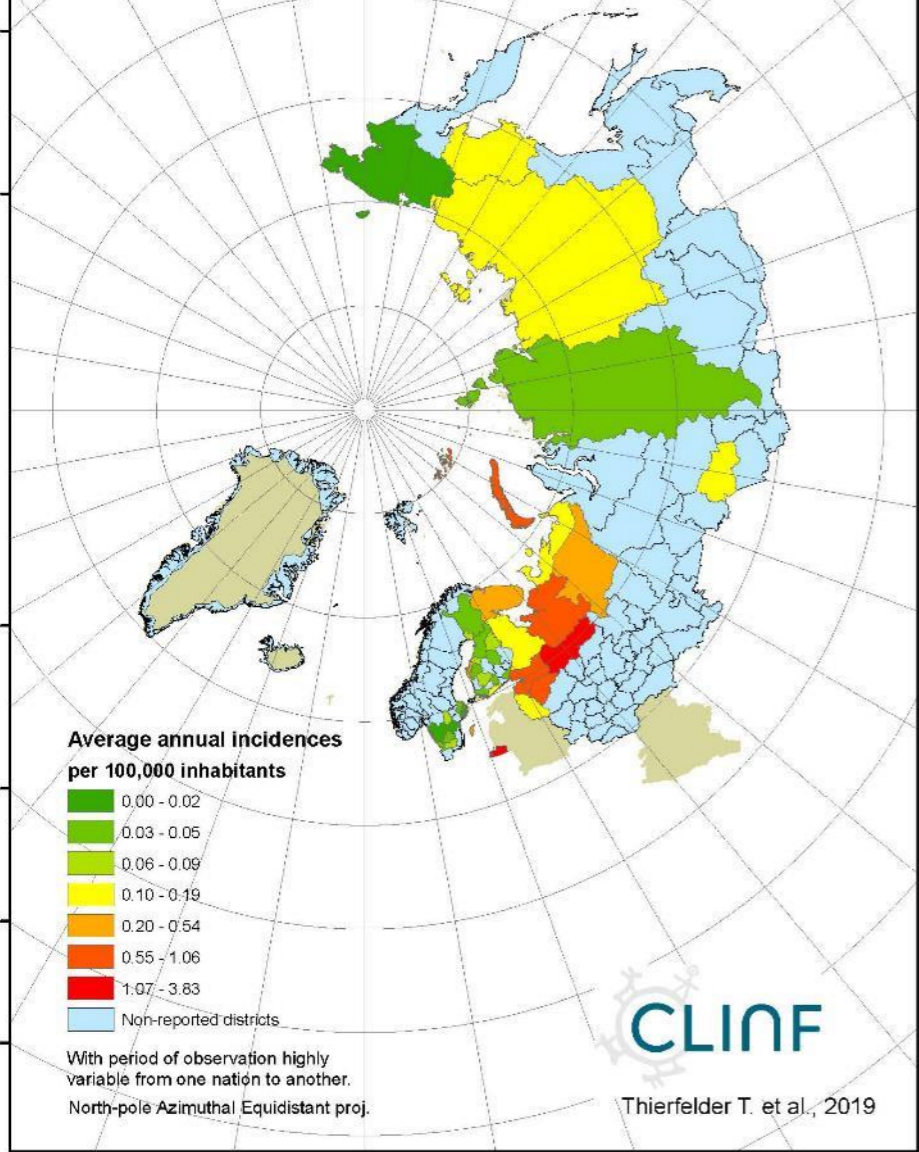
**Information concerning gender and age available through the period of:**

Nation	BOR	BRU	CRY	LEP	PUU	QFE	TBE	TUL
Finland	1995 - 2016	1995 - 2014	1995 - 2016	1995 - 2016	1995 - 2016	1998 - 2016	1995 - 2016	1995 - 2016
Greenland	n/a	n/a	n/a	n/a	n/a	2007 - 2007 *	n/a	n/a
Iceland	n/a	n/a	-	n/a	n/a	n/a	n/a	n/a
Norway	1990 - 2016	2004 - 2016	2012 - 2016	n/a	1991 - 2016	n/a	1998 - 2016	1985 - 2016
Russia	-	-	n/a	-	-	-	-	-
Sweden	-	-	2004 - 2016	-	1985 - 2016	-	1978 - 2016	1969 - 2016

\* = A single case of QFE in Greenland 2007

- Since reported case-by-case, human diseases data are (in many cases) provided with information regarding **gender and age**.
- Spatial resolution = **county-wise** report districts from western Greenland to the Russian Pacific
- Temporal resolution = unlimited (primary data case-wise reported, day-by-day), but **annually** collated

## Leptospirosis incidence 1972 - 2016 around the Eurasian Arctic



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CLINF **animal diseases** data products

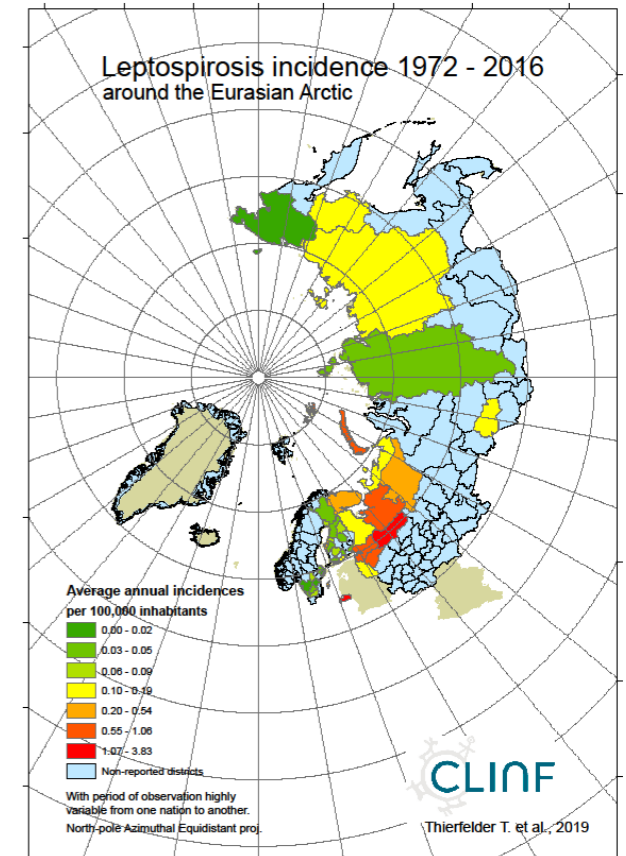
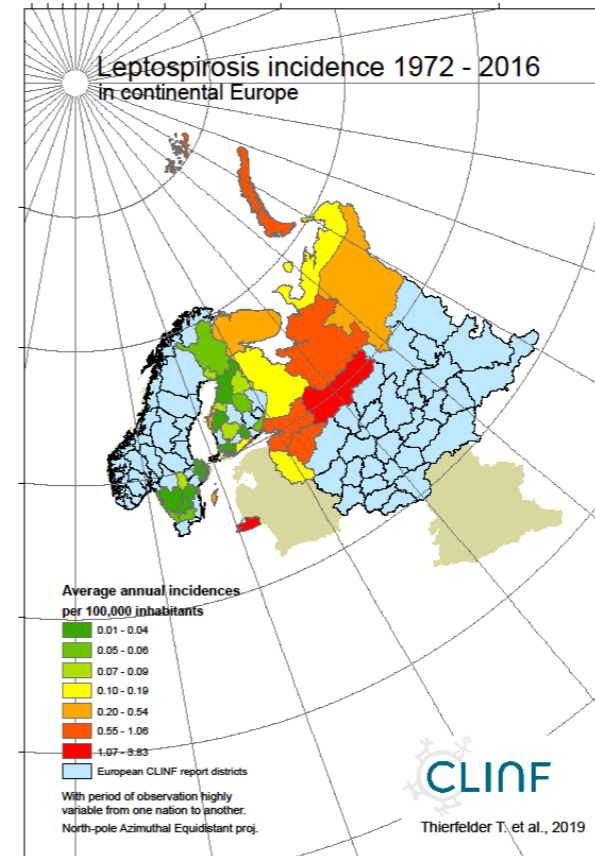
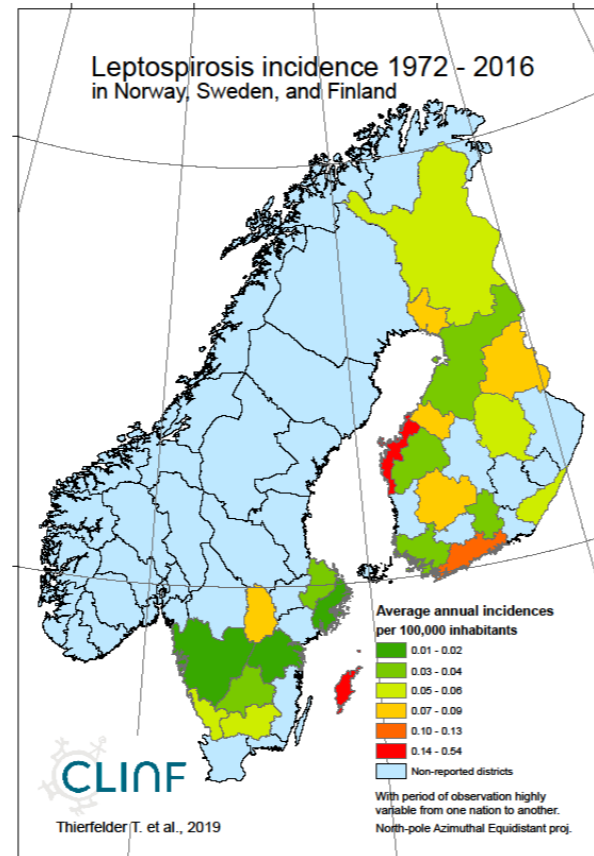
Anthrax	Listerios
Babesios	Necrobacillose
Bluetongue virus (BTV)	Q-fever
Botulism	Rabies
Brucellos	Salmonellos
Campylobacter infection	Toxoplasmosis
Clostridios	Trichinellosis
Echinococcosis	Tularemia
Erysipelothrix	Vtec/EHEC
Leptospiros	

- Animal diseases data cover the same 30-year reference period as in the case of human data, although much more **scattered and heterogenous**
- Spatial resolution = **county-wise** report districts from western Greenland to the Russian Pacific
- Temporal resolution = unlimited (primary data case-wise reported, day-by-day), but **annually** collated

# The CLINF OPEN Data Repository

which is **OPENLY available** for all stakeholders

- ✓ Each dataset is **mapped** through Scandinavia, through Europe, and from Nuuk to Yakutsk
  - With incidences **averaged** through the observed period of time





# Climate-change Effects on the Geographic Distribution of Infectious Diseases in the Arctic

- Based on the **combined data** collated through the 30-year climate reference period, CLINF is in the process of:
  - Exploring, mapping, and documenting the **geography** of Arctic infectious diseases
    - with a particular focus on **patterns and trends**
      - also regarding proportions across categories of **age and gender**
      - perhaps caused by the northward **migration of vector organisms**
    - defining a "**diseases climate**"
  - **Infer** correlations across changing diseases, landscapes, and climate
    - regarding the landscape and climate factors that **regulate** the migration patterns/trends of diseases, and hence of their **vector/reservoir organisms**
    - and hence identifying **Climate Sensitive Infections (CSI's)**
    - and their eventual migratory paths towards Arctic **societal infrastructures**
  - Providing **CSI decision support**
    - to CLINF societal and economical scientists
    - to CLINF modellers of **future CSI scenarios**
    - to local stakeholder organisations
    - and to administrative and legislative stakeholder organisations

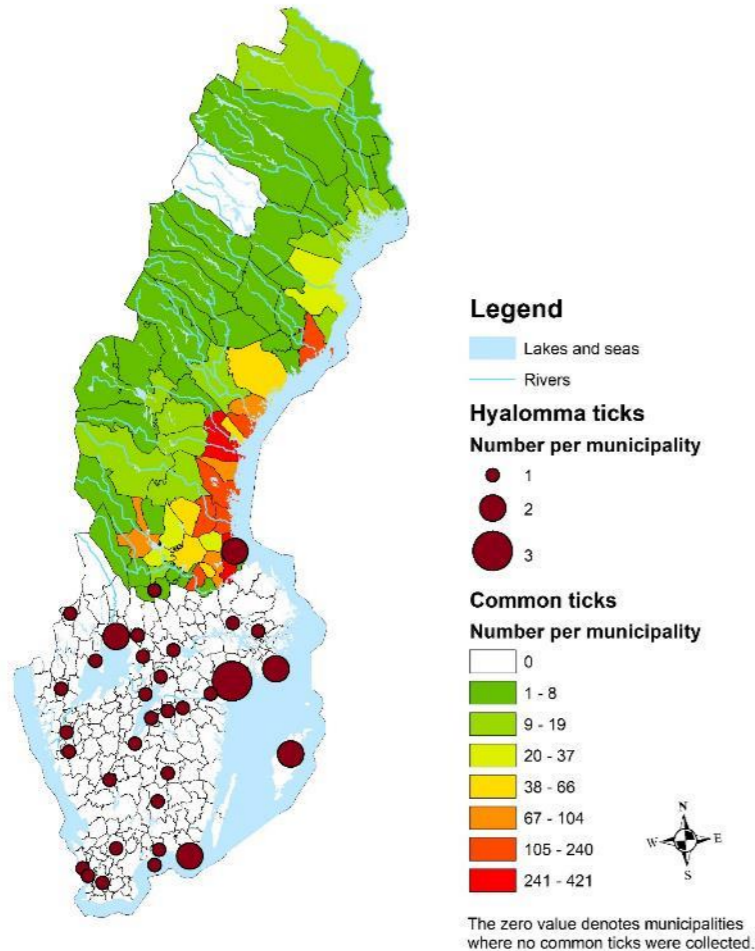
$$Inc = \alpha + \beta \square Year \square Long + \delta \square Year \square Lat + \varepsilon(0, \delta_R^2)$$

$$Inc = \alpha + \beta \square Year \square Age + \delta \square Year \square Gender + \varepsilon(0, \delta_R^2)$$

$$Inc = \alpha + \beta \square Long \square Age + \delta \square Lat \square Age + \varepsilon(0, \delta_R^2)$$

$$Inc = \alpha + \beta \square Long \square Gender + \delta \square Lat \square Gender + \varepsilon(0, \delta_R^2)$$

Collection of ticks north of river Dalälven 2018  
with genus *Hyalomma* assessed across the entire nation



Principal investigator: Anna Omazic, SVA  
Cartographer: Tomas Thierfelder, SLU  
Source: Sverige 1000 Plus, Lantmäteriet

## Examples of CLINF activities

### Citizen-science and case studies

- Through a **citizen-science** study performed in 2018, CLINF partner SVA received around 4500 ticks found on animals or humans in Sweden:
  - 35 specimen of adult *Hyalomma* ticks were found
    - first ever** on non-imported animals in Sweden
    - potentially carrying "Mediterranean pathogens"
      - including Crimean-Congo haemorrhagic fever and rickettsia.
  - Common ticks **on the move**
    - with their vector and reservoir organisms
      - along the Swedish climate gradient**
    - transmitting borrelia and TBE in new territories
      - just like anticipated** in the basic CLINF hypotheses
- CLINF has chosen tularaemia as a **case study** for detailed analysis of climate sensitivity and projective model testing, in order to:
  - Utilize the substantial **expertise** on tularaemia that is kept in the CLINF consortium
  - Develop strategies and methods** that may be applied in the study of other diseases
    - particularly the regulating links to **biotic** landscape characteristics





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# Thank you!

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