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Climate-change Effects on the Epidemiology of Infectious Diseases and the Impacts on Northern Societies

CLINF Data and Methods for Inferring Future CSI Scenarios

Tomas Thierfelder, Birgitta Evengård, Ann Albihn,
Gia Destouni, Shaun Quegan, Grete Hovelsrud, et al.

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Roadmap towards Inferring Future CSI Scenarios

1. Identify relevant northern climate sensitive infections
   - And acquire empirical reference materials
2. Infer the 30-year reference CSI scenario
   - With respect to how diseases natural foci change with climate characteristics
3. Model and depict future climate/landscape characteristics
   - In accordance with IPCC scenarios
3. Infer future CSI scenarios
   - By exchanging the reference climate/landscape information with future projections
4. Study how Northern societal infrastructures are situated in the inferred future CSI scenario (see the workshop programme for tomorrow morning)
   - Including the associated risks

Photo: Carl-Johan Utsi

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CLINF data – zoonotic diseases data

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 avialble 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

- CLINF has acquired data regarding approximately 35 zoonotic infectious diseases of the North, the above table provides an example of the, perhaps, most important.
- 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

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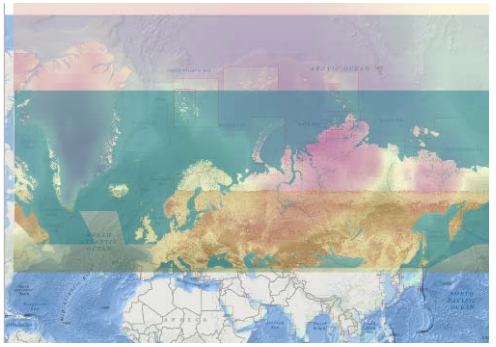
CLINF data – landscape and climate data

Primary variables	Primary variables	Derived variables
Land cover	Air temp	Plant functional type
Photosynthesis	Precipitation	Soil moisture
Leaf area index	Topograhy	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	



MODIS-FPAR MCD15A2H 20016-01-09 and ERA-Interim 2T 1979-01-01 semi-transparently overlaid the contours of the CLINF study region.

- CLINF ”landscape and climate data” are provided at generally high spatial and temporal resolutions, where the time-period covered with CLINF diseases data is matched as far as possible (varies a lot from one data product to another).
- Consider the CLINF study area, “from Nuuk to Yakutsk”, to be overlaid with a digital subdivision of diseases report districts (counties everywhere except in Russia, where oblasts and/or autonomous republics are used).
- Based on the remotely sensed raster representations of landscape/climate variables, every diseases report district is represented with an annual central value together with an annual measure of dispersion.
    - With annual measures of centrality (like the mean) and dispersion (like standard deviation) calculated across the annual raster cell representations that cover the respective digital delineation of diseases report districts.

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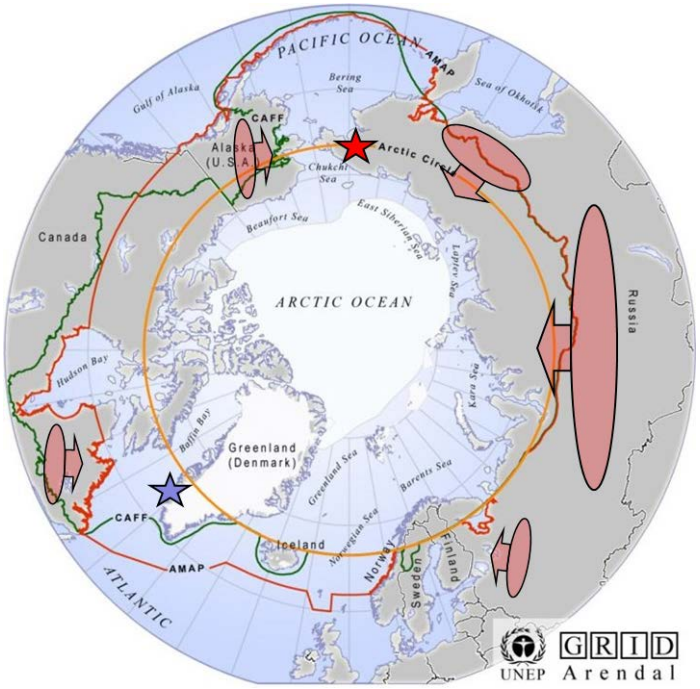
CLINF inferential methods – expected results

By deploying a range of biometric and modelling methods, the following main results are expected:

- Spatiotemporal CSI change during the 30-year climate reference period
  - CSI geography – the notion of a CSI climate
  - Including the (eventually changing) balance across categories of age and gender
- Effects of landscape and climate characteristics
  - How climate and landscape characteristics regulate the natural foci of northern infectious diseases
  - Facilitates the identification of Climate Sensitive Infections
- Future CSI scenarios
  - What climate-change effects to expect regarding the natural foci of northern infectious diseases
    - Like the eventual northward expansion of diseases populations
    - In accordance with IPCC climate scenarios
    - Huge uncertainty involved, which by itself constitutes an interesting topic of CLINF research



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Questions for break-out discussions

i. Have you sensed an increasing trend in the variability of weather in the region of your livelihood, and hence a notion that weather isn't as reliable and/or predictable as it used to be (for example in comparison from one generation to another)?

ii. If you feel that weather is changing, are you aware of any related effects on enterprises such as agriculture, animal husbandry, hunting/fishing, tourism, or any other branch of entrepreneurship?

iii. If you feel that the possibilities of conducting enterprises are changing as a result of changing weather, are you aware of any cases that may be related to a changing exposure towards infectious diseases?

- Please break out into groups and discuss the above questions.
- You have 40 minutes for discussions, and thereafter 20 minutes for reporting back in-plenum.
- Notes will be taken for panel discussions at the end of the afternoon

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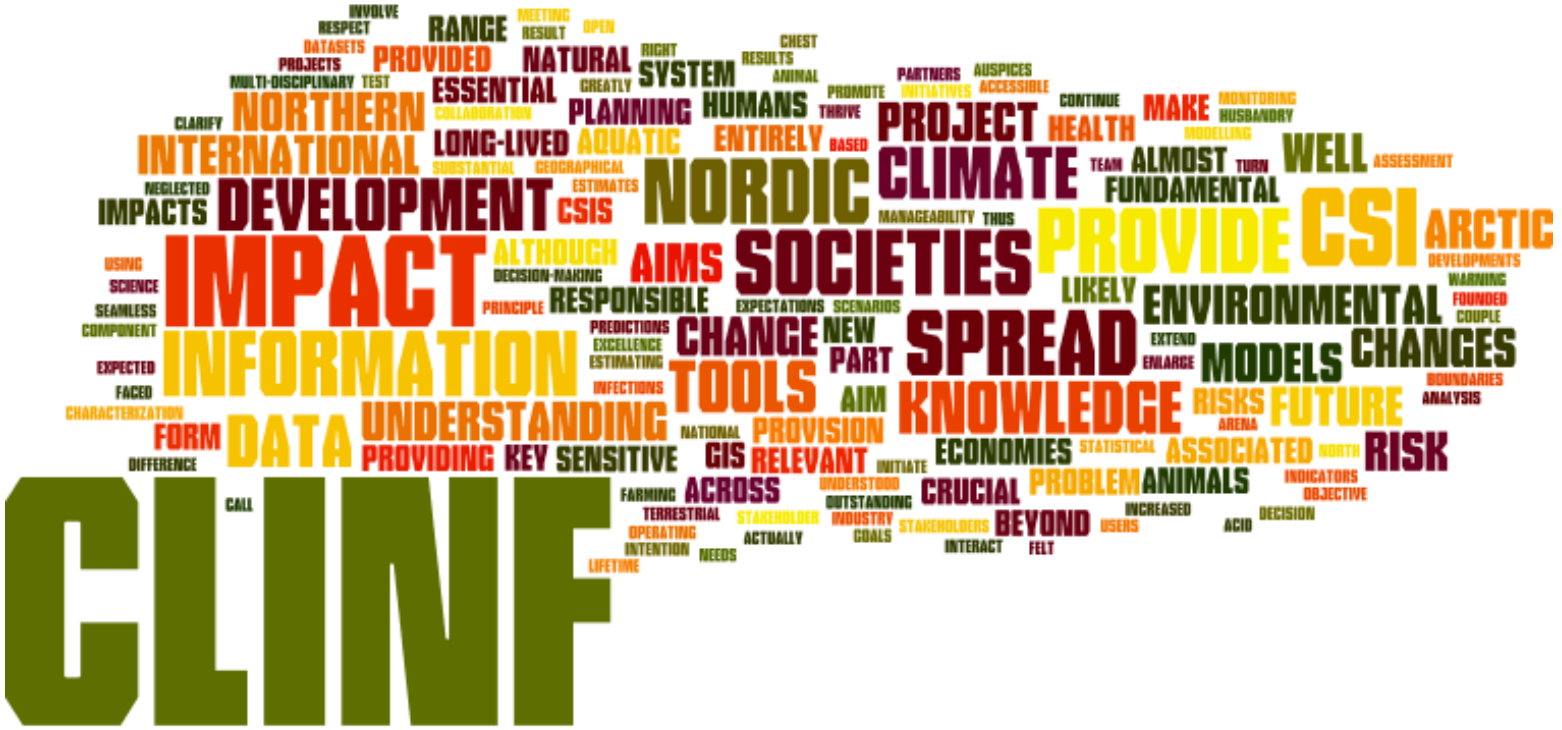
Thanks' for your attention!!



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Examples of climate/weather effects on climate-sensitive infections

Climate Sensitive Infections (CSI) in the north- Examples

Soil- and Water-borne
Anthrax

Feed-, Food- and Water-borne
Salmonellosis,
Cryptosporidiosis,
Giardiasis

Arthropod vector borne

Mosquito-borne
West Nile fever,
Sinbis fever

Tick-borne
Anaplasmosis,
Babesiosis,
TBE,
Borreliosis/Lyme diseases

Midges-borne
Bluetongue,
Schmallenberg

Midges-borne diseases

- Schmallenberg virus (ortobunya) affect ruminants
- Infection during first half of gestation causes dead or malformed offspring

Culicoides spp

- In 2011 in central EC
- Swedish survey 2012 of farm based milk containers (Chenais et al., 2013)
  - May, 1/ 723 farms pos.
  - Nov, 521/ 723 pos. (72%)

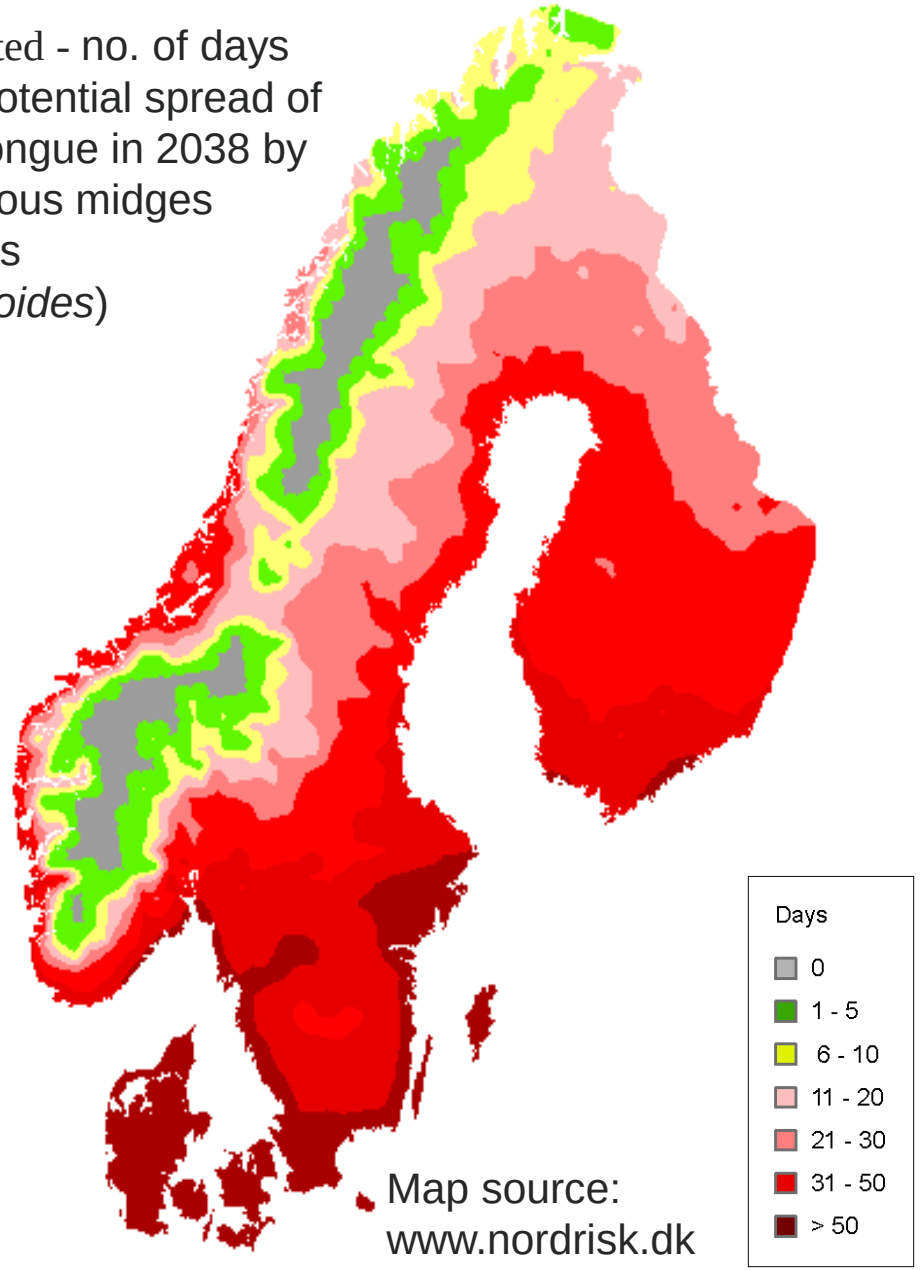
- May spread quick!

White _ most samples positive
Yellow – some positive
Green – no positive

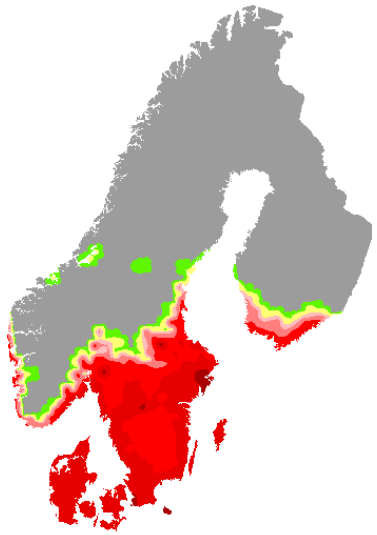
Identification of ”epidemiological hotspots” - to predict VBD outbreaks

Decrease the cost for vector surveillance
Increase the success of handling of an outbreak
A process-based model includes temp, precipitation, vector abundance, biology/distribution, traits of pathogen
Prediction models - foresight of a disease outbreak by modeling the potential transmission intensity
Good models need good data, but a model will never be perfect

Predicted - no. of days with potential spread of Bluetongue in 2038 by infectious midges vectors (*Culicoides*)



Map source: www.nordrisk.dk



Observed Bluetongue infection in 2008

Tick-borne diseases

Citizen science study by SVA 2018
Norden half of Sweden
From animals and humans

Ixodes ricinus

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Tick-borne diseases

We also recievd a new species
Hyalomma ssp
Comes here as larvae on migrating birds
Prefer to feed from big animals like cattle and horses.
Is quick, agressive and "hunts"
From the south known to spread diseases as piroplasmosis and Crim Congo Hemorragic fever

Mediabevakning

SUNDSVALL | 18 aug

Fästingar undersöks i stort projekt – flest har skickats in från Sundsvall: "Vi är överväldigade"

Rekordmånga fästingar upphittade i norra Sverige

Statens veterinärmedicinska anstalt (SVA) uppmanade privatpersoner att skicka in upphittade fästingar. Och nog har folk skickat fästingar; omkring 2000 kryp bara från norra Sverige har hamnat i SVAs postlåda.
– Vi förväntade oss kanske 200-300, säger Anna Omazic, forskare på SVA.

I början a… d en uppmaning till alla n…

Orsaken … verige är att fästingar… en går fortare i norr än i …

SVA vill ha in fästingar från norra halvan av Sverige.

Fästingarna i norr ska kartläggas

UPPSALA (TT) Nu ska fästingarnas utbredning och spridning av sjukdomar norrut i Sverige kartläggas. SVA vill att människor norr om Dalälven skickar in fästingar.

– Ju längre norrut, desto mer intressanta är fästingarna för oss. Men vi hoppas samtidigt på att få in fästingfynd från hela norra Sverige, säger Ann Albihn, forskare på Statens veterinärmedicinska anstalt, SVA, till Svenska Dagbladet, SvD.

Man ska undersöka hur klimatet påverkat fästingens utbredningsområde. Samtidigt ska man kartlägga om de tar med sig de infektionssjukdomar de kan bära på.

– Där har vi inte full koll. Men vi vet att följderna kan bli tråkiga om nya smittor dyker upp i en population som inte är vana vid dem sedan tidigare, säger Anna Albihn till SvD.

Den som vill hjälpa till med undersökningen och skicka in fästingar, döda eller levande, till SVA, ska först fylla i ett formulär på Internet.

Fästingarna kan skickas med vanlig post men önskemålet är att de lägga i en ordentligt tillsluten påse.

Jättefästing hittad på häst i Enköping

HIPPSON | Artiklar | Ridövningar | Bloggar | Böcker | Tidningen | Shop | ···

Artikelarkivet | Nyheter | Hippson-TV | Forskningskollen | Fråga experterna | Evenemang

VETERINÄR & HÄSTVÅRD Publicerad: 2018-09-05

Foto: Adobe Stock, SVA och Privat

Så ser du skillnad på fästingarna – Hyalomma springer och är dubbelt så stor

I sommar har fästingar av den aggressiva arten Hyalomma för första gången påträffats i Sverige. Arten är känd för att kunna bära skadliga smittämnen. Här delar Statens veterinärmedicinska anstalt, SVA, med sig av bilder och film som visar hur den ovanliga arten ser ut.

Ny jättefästing i Sverige - "Uppåt tre centimeter - blodfyllda"

KLIPP – LÖRDAG 25/8 KL 10:18
LÄNGD 5:11

Giulio Grandi, forskare vid Statens veterinärmedicinska anstalt, berättar om fyndet av jättefästingen Hyalomma, som för första gången upptäckts på tre olika ställen i Sverige.

Dela
Tweeta

Gilla oss på Facebook

Soil- and Water-borne

Antrax

- 13000 Russian burial grounds, more than half in permafrost (Revich & Podolnaya, 2011; Glob Health Action)
- 2016 several 1000 reindeer dead in Yamal and 1 or 2 humans. Thawing tundra and over grasing.
- 2016 Sweden some 20 dead animals both domestic and Wildlife in Östergötland. Drought, cracks in the ground thereafter heavy rainfall.

Anthrax

Country	Year	Cases
FIN	1974	1
FIN	1988	1
FIN	2014	1
NO	1990	1
NO	1993	1
SWE	2013	1
SWE	2016	8

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Inclusion of CSI's into Ongoing Programmes of Environmental Survey

Tomas Thierfelder, Birgitta Evengård, Ann Albihn,
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Red-alert In-field CSI Monitoring

CLINF sets out to recommend how to include the monitoring of climate sensitive infections as part of on-going programs of environmental survey performed at northern field-stations

- CLINF members are also affiliated with field-station organisations such as INTERACT and SITES
- Collaborative initiatives regarding in-field CSI monitoring and reporting have already been initiated in collaboration with the INTERACT Red-phone initiative (www.eu-interact.org)
- In-fact, INTERACT and SITES field-station representatives, representing Russia, Svalbard, and Sweden, are present as we speak

Instead of engaging in costly laboratory analyses of captured vector organisms, we believe that a constant societal CSI lookout needs to be implemented in the surroundings of individual stations, in order to rapidly communicate diseases outbreaks as they occur.

- Via communication with local healthcare and veterinary resources, as well as with farmers, reindeer herding communities, hunters and fishers, schools, etc., etc.
- And via active engagement as part of field-stations everyday activities

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Red-alert Real-time Reporting of CSI's

With CSI outbreaks being potentially serious, there may be a need for rapid societal response in order to undertake necessary safety measures. This requires communicative infrastructures as part of the red-alert monitoring and report system.

- That connect stations bilaterally with adequate authorities at real-time pace
- Such an infrastructure is most likely digital, and may host many functionalities in support of a CSI monitoring and reporting system
- In-fact, the local "societal sensors" that surround individual stations may be part of such a system

CLINF is not commissioned to develop a digital infrastructure for red-alert monitoring and reporting of CSI's, but to include it in its recommendations.

- Perhaps CLINF GIS may be utilised, or INTERACT GIS? Or any other existing digital infrastructure that may be further developed for the benefit of rapid diseases detection and reporting?
- Do you know of any such infrastructure (see the break-out questions)?
- See the demonstration and official launch of CLINF GIS later this very afternoon!

In-field CSI sampling of reindeer

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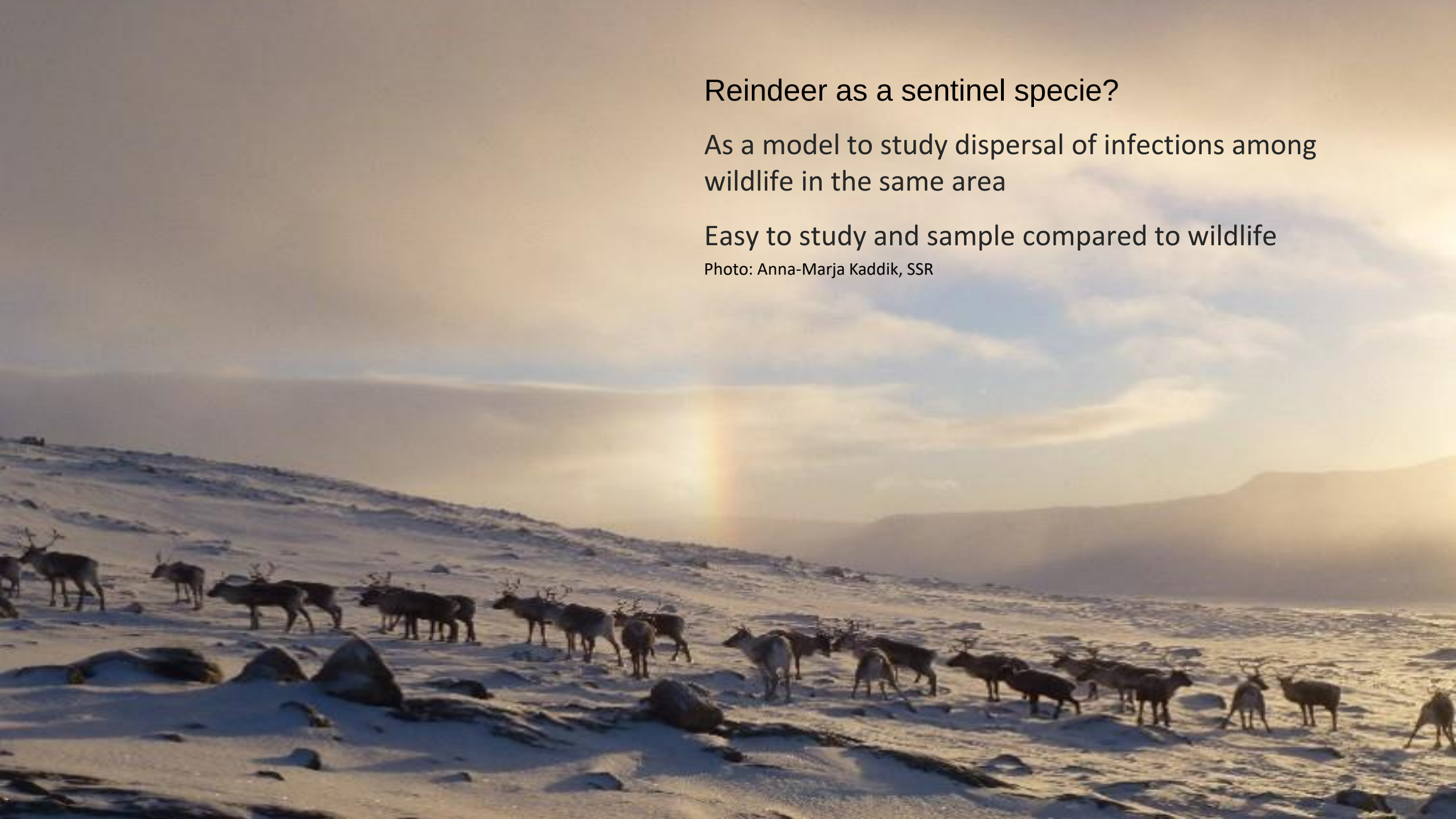

Reindeer as a sentinel specie?

As a model to study dispersal of infections among wildlife in the same area

Easy to study and sample compared to wildlife

Photo: Anna-Marja Kaddik, SSR

Screening of Infectious Microorganisms in Reindeer

Photo: Tiina Reilas, LUKE, Finland

- Three semi-domesticated herds, from south to north, sampled in SWE, NO, FIN and on ISL one wild herd. All two times.
- One heard sampled once in Russia
- Twenty animals, 10 calves and 10 senior reindeer cows/herd
- In total 60 samples (rectal- and nose swab and blood samples) are collected from each country both 2 years
- Analysis: Next Generation Sequencing, PCR and serology

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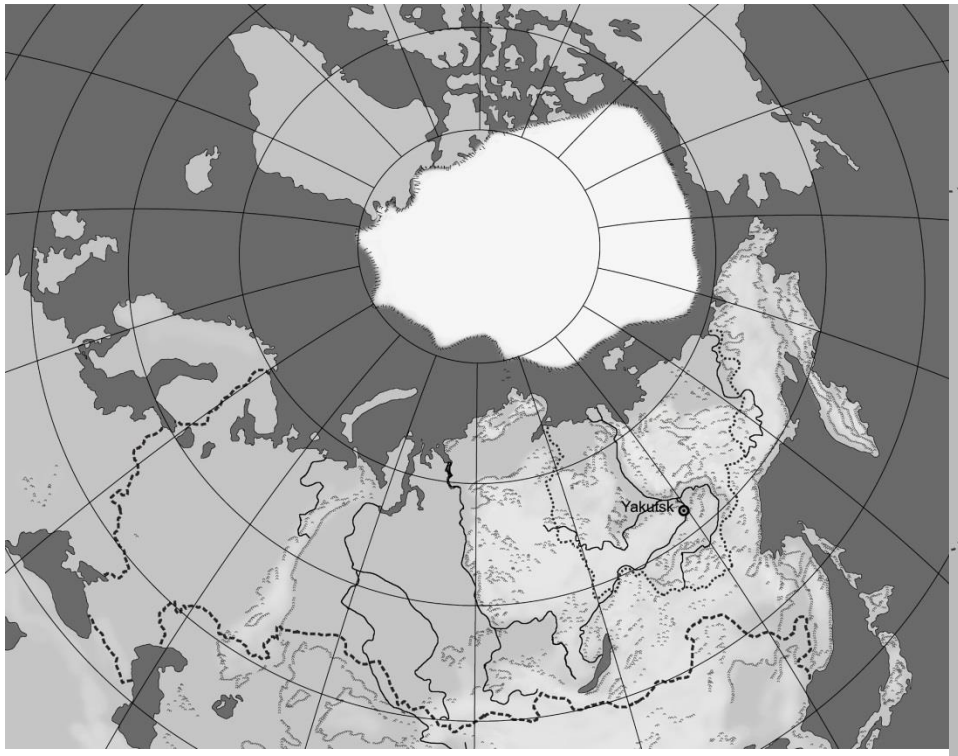
Sampling in Sweden were done by Anna Omazic, SVA and Ulrika Rockström, Farm and Animal Health

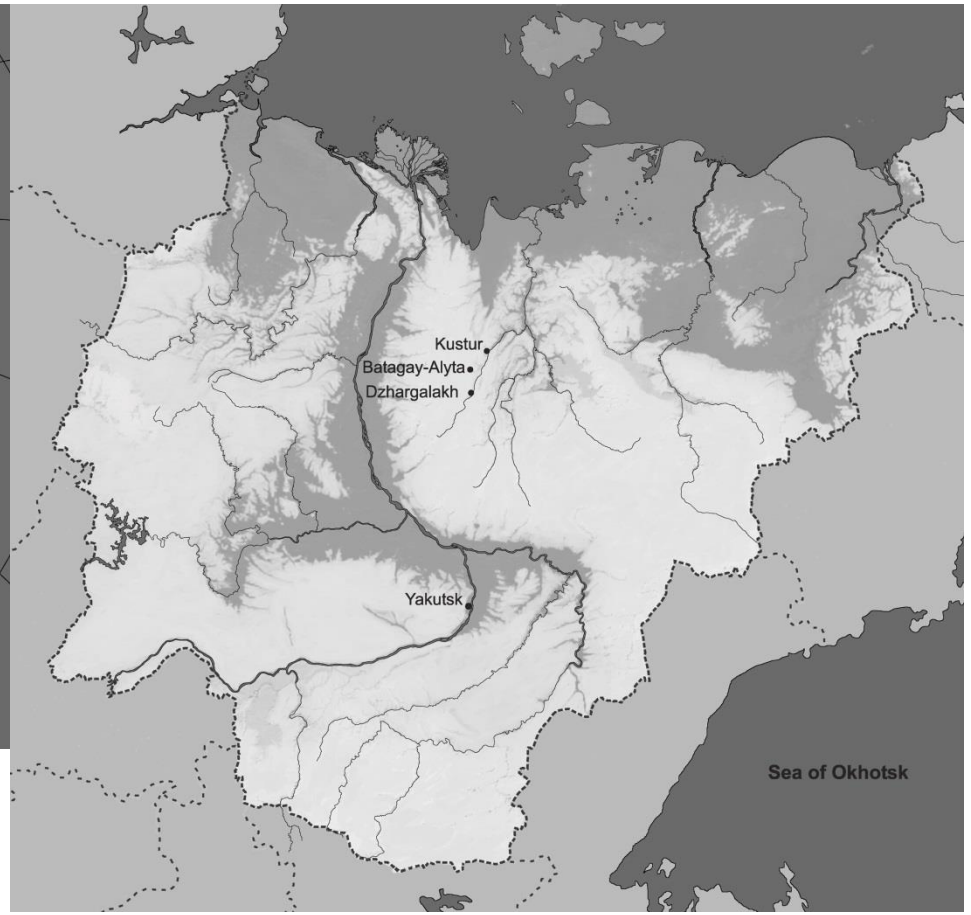
Photos: Ulrika Rockström,, Sweden

SAMPLING IN SLAUGHTERED ANIMALS

Photos: Anna Omazic, SVA and
Ulrika Rockström, Farm and Animal Health

Sakha Republic (Yakutia)





My record -52^{o}C

Sampling in Russia were done by Juha Kantanen, Natural Research Inst., (Luke), Finland and Valeri Federov, Yakutian Inst. Of Agriculture, Russia

With help from reindeer herders and local veterinarians


Акционерное общество
«Таб

NGS-data Indicate the presence of the following viruses

Finland	Norway	Sweden
Macavirus (gammaherpesvirales)	”Betaherpesviridae” (normally not found in ungulates)	Bovine adenovirus 3
Sheep feces associated smacovirus	Bovine respirovirus 3	Reindeer papillomavirus
		Equine pegivirus 1
		Bos taurus papillomavirus 7
		Rangifer tarandus granti papillomavirus
		Other papillomaviruses
		Bovine parvovirus 3
		Macavirus

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Aspects on Reindeer Herding and on their Important Infectious Diseases

Welcome to a Research seminar arranged by the Graduate School for Veterinary Medicine and Animal Sciences (GS-VMAS)

Date: September 24, 2018, 13.00-16.00

Location: Ratatosk, VHC, Uppsala

Conclusion

- CC may disrupt food security
- Diseased animals may reduce earnings and production and cause negative impact on animal welfare
- Healthy animals also reduce the mitigation effect from animal production.
- Human health may be affected by zoonotic diseases

Photo Camilla Risvoll, Nord Univ., Norway

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THANK YOU FOR YOUR ATTENTION!

Photo: Carl-Johan Utsi

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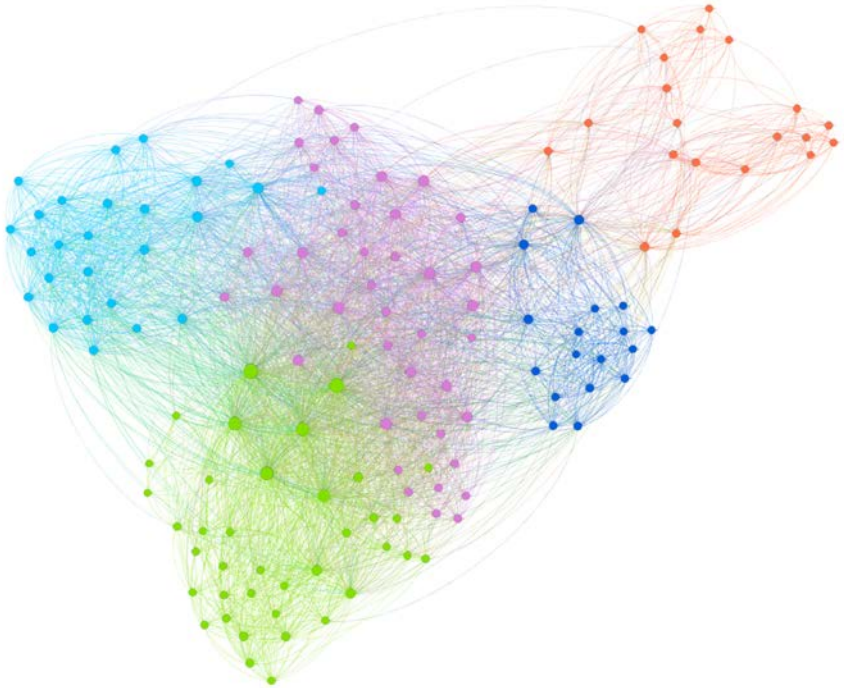
Introduction to CLINF GIS - an International Hub for Communicating CSI



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Specification of CLINF GIS - an International Hub for Communicating CSI

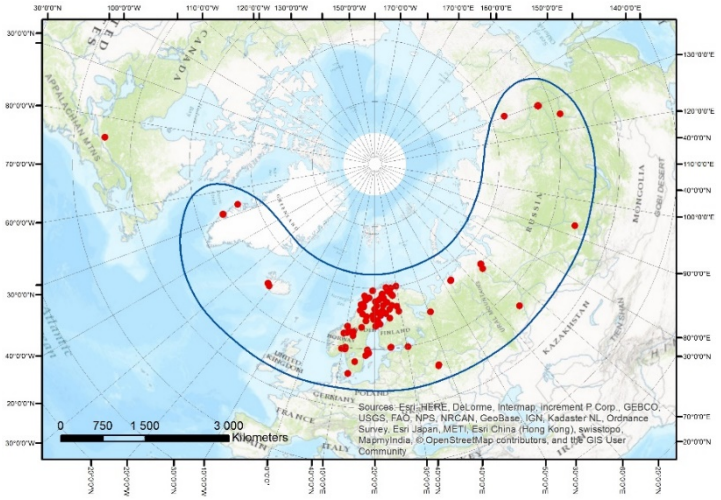
Specification of CLINF GIS

In order to design a digital communicative infrastructure, the first thing to do is identifying its potential users and estimate how they communicate.

Based on the resulting "associative network of CLINF stakeholders", a blueprint outline of a digital infrastructure (CLINF GIS) may be constructed and provided with information and supportive functionalities.

CLINF has just received new complementary funding for expanding its ties with Russian stakeholder organisations.

Geographic coordinates



The CLINF network of stakeholder organisations

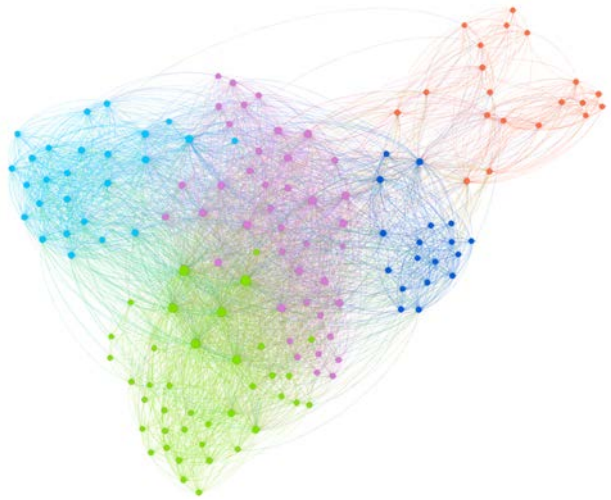
The observed network of stakeholders appears to be country dependent by multiple criteria. Even though clusters generally indicate international communication, nation-specific associations dominate.

The CLINF sample of approximately 150 organisations, from Nuuk to Yakutsk, contains 5 relatively independent associative clusters, each containing unique communicative characteristics. We assume a total number of 500 potential CLINF stakeholder organisations, and hypothesise that they have similar clustering characteristics.

With "cluster analysis", organisations are ranked with respect to their "communicative strength" within and across clusters, which facilitates the identification of the organisations that best represent the entire network. These relatively well-connected organisations are the main target for CLINF GIS.

Böhme S., et al. 2017

Associative coordinates



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Our focus is on societal aspects:

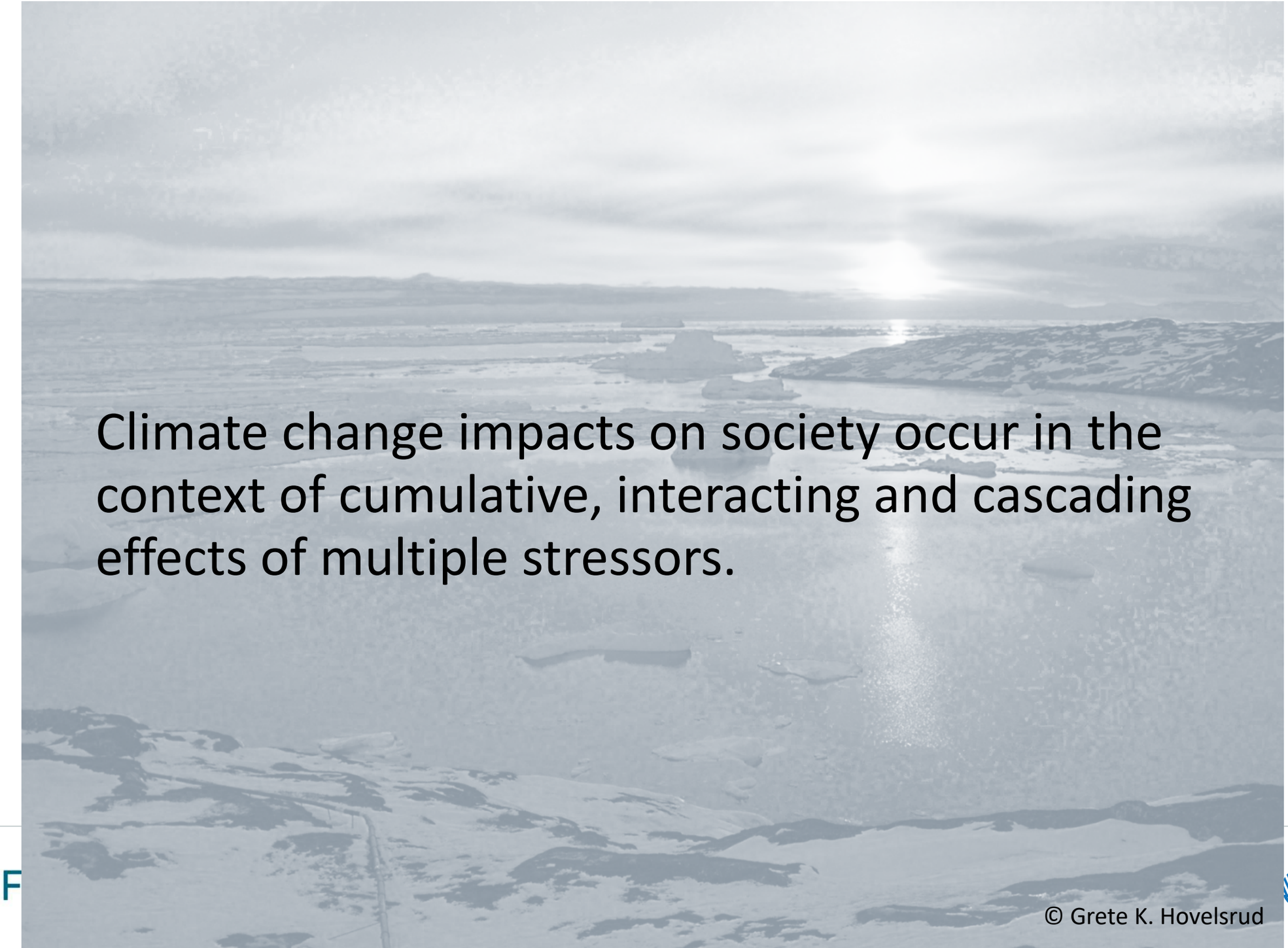
Understand how the spread of climate sensitive infections CSI will affect societal and individual well-being, sense of personal and community security (ontological security) and adaptive capacity.

Three-pronged approach for analyzing the linkages between increasing CSI and health and well-being:

1. The significance for ontological security of destabilizing health
2. Impacts on animal husbandry – health effects of CSI on both animals and humans
3. Adaptation strategies and adaptive capacity across societal scales
4. Traditional knowledge is critical for adaptation to climate change/ CSIs, but it is under pressure

Grete K. Hovelsrud, Camilla Risvoll,

Jan Åge Riseth and Hans Tømmervik



Climate change impacts on society occur in the context of cumulative, interacting and cascading effects of multiple stressors.

© Grete K. Hovelsrud

Interdisciplinary approach needed for addressing CSIs:

- What are the consequences of climate change and CSIs for social, economic and biophysical conditions?
- How do projected changes in climate and CSIs interact with changes in social and natural conditions and how will such interactions shape vulnerability, resilience and adaptation to climate change?
- To what degree can climate change research in local communities contribute to local adaptation strategies and increase adaptive capacities and resilience?
- How can we connect knowledge about the local socioeconomic consequences of climate change ad CSIs with regional, national and international decision making and resource management policies?

© Camilla Risvoll

Examples of multiple stressors in reindeer herding:

- Climate change causes locked pastures
- Increased encroachment (human activities; infrastructural developments, outdoor recreation and tourism)
- Predators (wolverine, Lynx, brown bears, golden eagle)
- Societal infrastructure and framework conditions (management, policy, governance)

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Adaptation strategies

- Move the herd to coastal pastures
  - A result of inaccessible inland pastures
  - Not all reindeer herding districts have access to coastal pastures
- Supplementary feeding
  - When not possible to move herd to alternative pastures (e.g. due to locked pastures, predator pressure, encroachments)
  - Enables easier control of herd

Photos: C. Risvoll

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Adaptation linkages to CSIs

- Moving herds to coastal pastures increases exposure to ticks
  - Warmer and wetter climate increase spreading of vectors for infections (such as ticks)
- Supplementary feeding in fenced and smaller areas increases stress in animals and thereby exposures to diseases (many animals together on relatively small areas)
  - Risk of affecting traditional knowledge?

Photos: C. Risvoll

Photo: C. Risvoll

What is Traditional Knowledge (TK)?

Defined: *"a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes et al. 1993)*

TK is

- *culture-* and *experience-based,*
- *transferred across generations,* and *includes*
  - *empirical facts,*
  - *social institutions* and *management,* as well as
  - *inherited world views*;
- It is often focused on *practical application* and provides *a basis for cultural and community continuity*.

Foot rot *Necrobacillosis* (*Slubb/Glubbie*)

Milking of reindeer, usual in wide parts of Sápmi up to early 1900s; in some areas practised up to 1950s-1960s

Female reindeer gathered in small corrals, from early summer to August

If wet and muddy soil, excellent conditions for a bacteria (*Fuscobactericum necrophorum*),

- attacks via small wounds/cracks in hoofs
- Contagious via mud and shit

Inflammation, necrosis, subcutanous, (Tryland 2014)

Photo: Helgeland Museum (1936)

Prevention praxis (I)

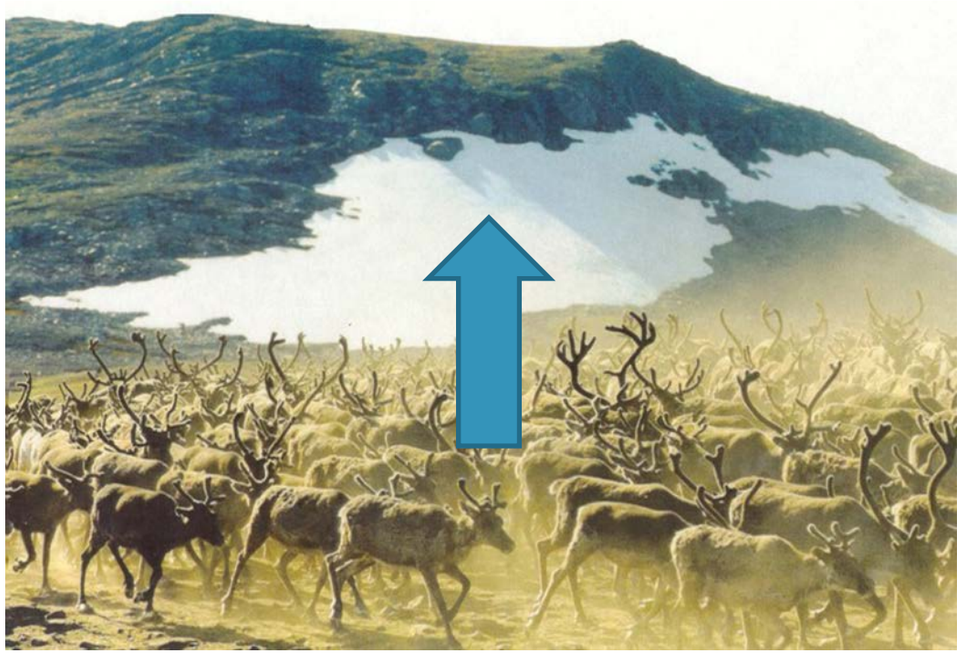
In early summer; move reindeer to unused grazing land, avoid staying to long in trampled and dirty grazing land (N.N.Skum 1955)

«The Elders knew that the animals should not be kept too close» (embodied knowledge). Interviewee (born 1944) in Gabna:

No observation of **foot rot** (Interviewee born 1947) in Troms by following milking practices

- *Relatively small herds*
- *dry hills as milking sites*
- *milking site rotation: 3 weeks*
- *Next year: new milking sites*
- Old ones , well fertilized used for growing of potatoes

Prevention praxis (II)



Moving the reindeer uphill in the high mountains. Use of small glaciers or snow patches for milking and ear marking purposes (Thomas Renberg to HT in 1978). Also mentioned by Interw. born 1944. Also described by Drake (1918).

Coproduction of knowledge

- If scientific climate change/ CSI knowledge is to motivate action and change in society, it has to be framed and conveyed in ways that resonates with people's livelihoods, world views and cultural bias (Dannevig and Hovelsrud 2016, Meadow et al. 2015).
- Local contexts and risk perceptions matter and are critical components of deliberate coproduction processes because they ensure inclusion of particularities. This increases the relevance of the knowledge produced.

S. Rybråten


Next group discussion coming up
– but first a break
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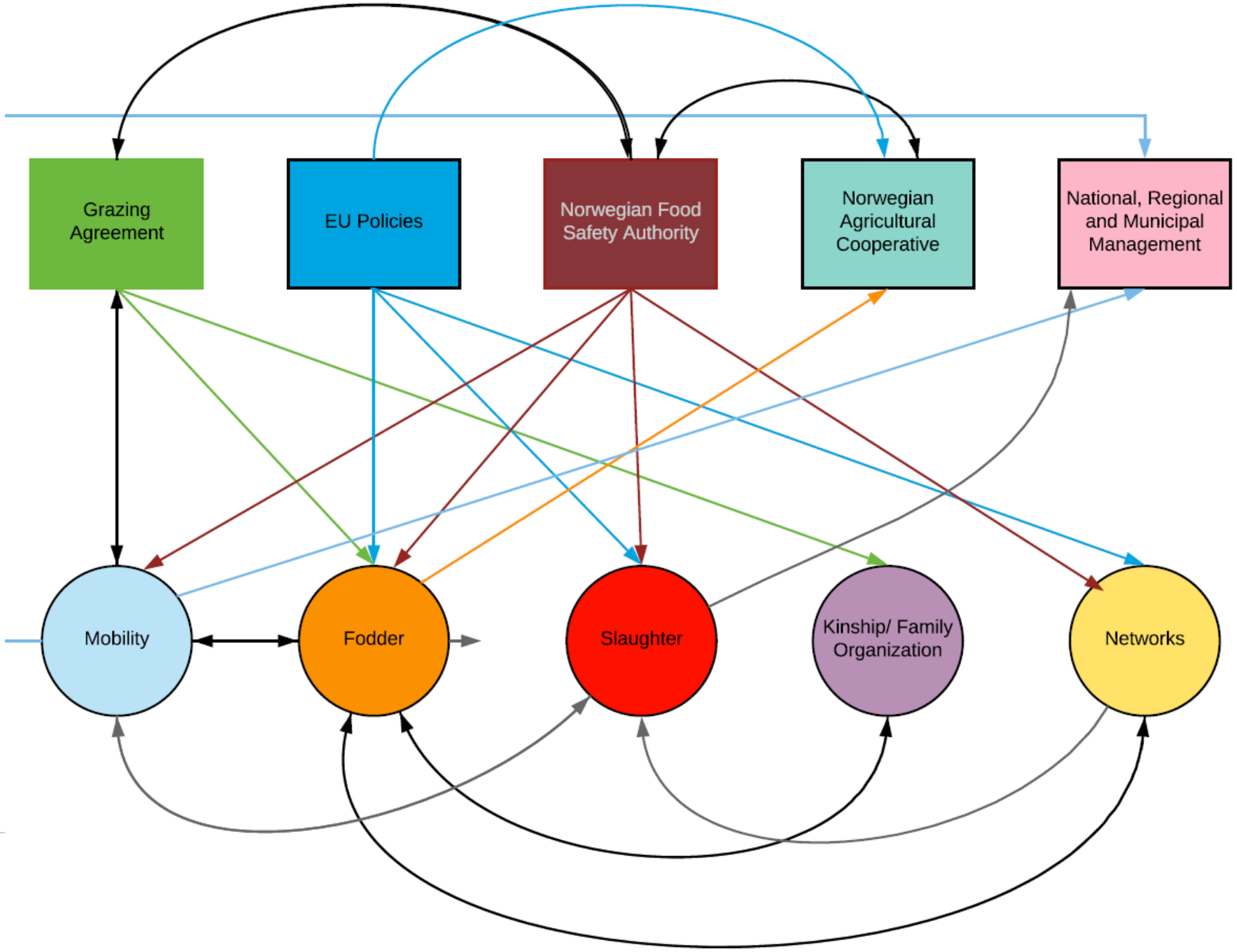
Linkages between societal infrastructure and spreading of CSIs



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