NORECOPA - Harmonisation of the Care and Use of Wild and Domestic Mammals and Birds in Field Research
Oslo Airport Gardermoen, 26-27 October 2017

Disease as a confounding problem and the need for surveillance

Bjørnar Ytrehus
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medical vs. ecological approach

- individual
- syndromes
  - a set of medical signs and symptoms that are correlated with each other and, often, with a specific disease.
- diagnose – intervene – cure
- next patient, please!

- population
- parameters and variables
- collect data – analyse – describe – increase knowledge
- apply (?)

Avicenna = Ibn-Sīnā (980-1037 e.Kr) – bilde fra Wikipedia

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- mutual feeling between professions that «they are working with something that is totally different from what we are dealing with»?

- competition and arrogance between departments, directorates, public services, scientific institutions, professions and individuals...SECTORIZATION

Mother Jones

momondo.no
stay curious

HOME POLITICS ENVIRONMENT CULTURE PHOTO ESSAYS BLOGS

Must Reads: Inside the Mammoth Backlash to Common Core | What It's Like to Be an NFL Wife

POLITICS
→ *Health, International, Top Stories*

This Map Shows Why People Are Freaking Out About Ebola's Arrival in Senegal

Deadly contagion + international transit hub = bad news.

—By **Alex Park** | Thu Sep. 4, 2014 6:15 AM EDT

Like Share 3.5k Tweet 1,237 Email 121

The ongoing outbreaks of Ebola in West Africa continue to devastate Liberia, Sierra Leone, and Guinea, and recently caused a national emergency in Nigeria—as of August 28, the Centers for Disease Control was putting the suspected and confirmed case count at 3,069, including 1,552 deaths. But in the last few days, with the virus entering Senegal and health workers discovering a fresh outbreak in Nigeria, global health groups such as the World Health Organization are getting increasingly strident with their concerns. On Sunday, WHO officials called Ebola's arrival in Senegal "a top priority emergency." On Tuesday, Joanne Liu, international president of the global health organization Doctors Without Borders, warned the United Nations that the world was "losing the battle to contain" the disease. "Leaders are failing to come to grips with this transnational threat," she said.

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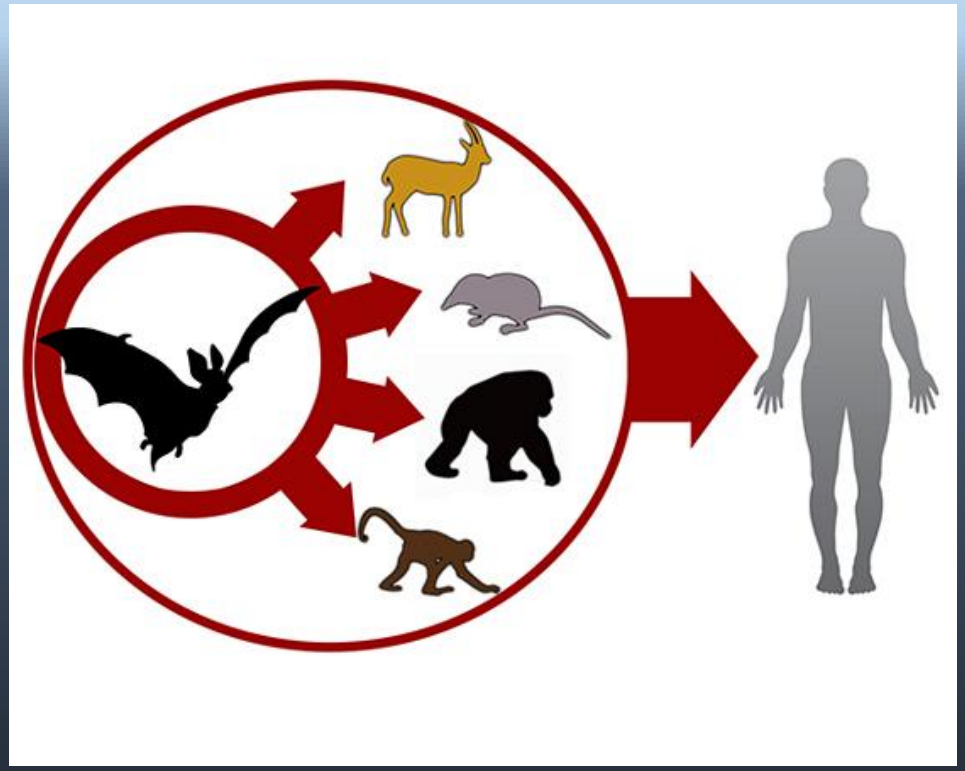

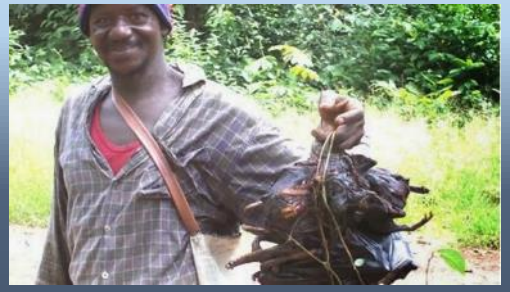

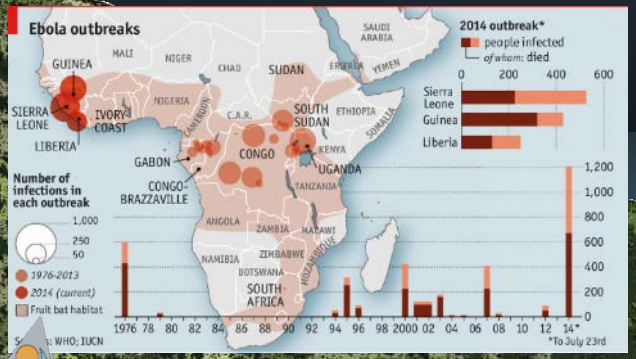

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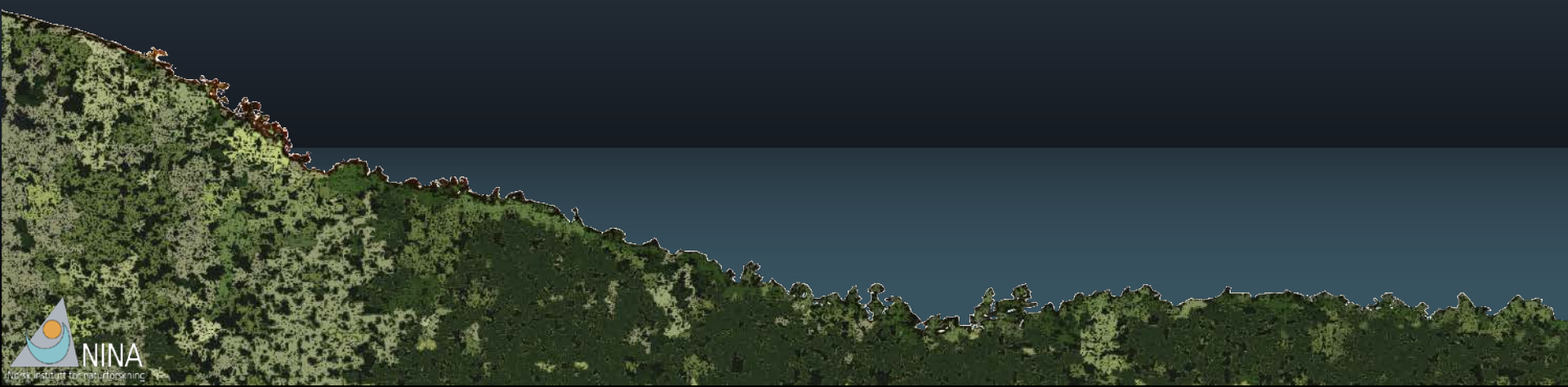
OneHealth

- Recognizing the inadequacy of a purely «medical» scientific approach to emerging diseases and other «new» health problems



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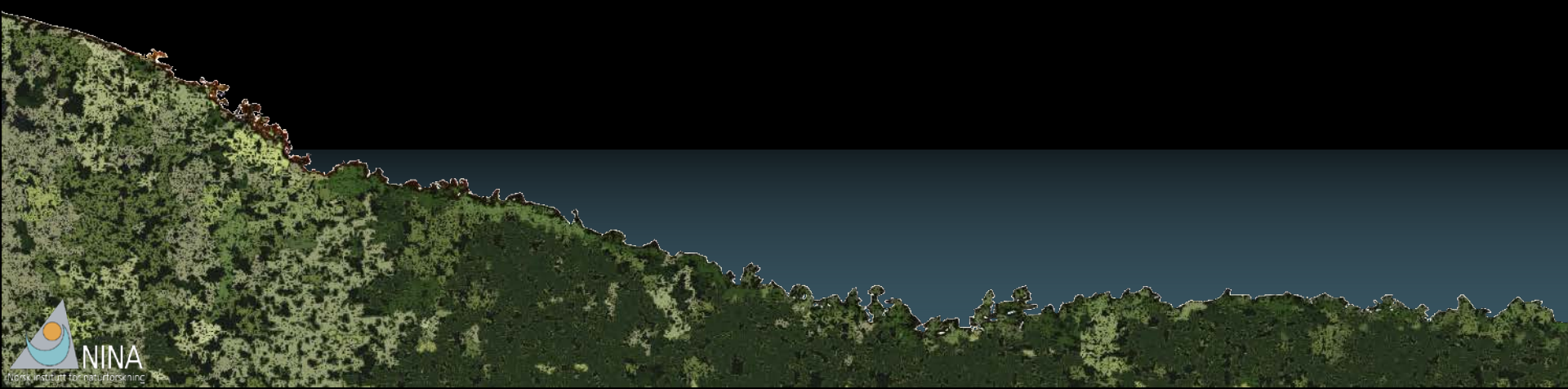
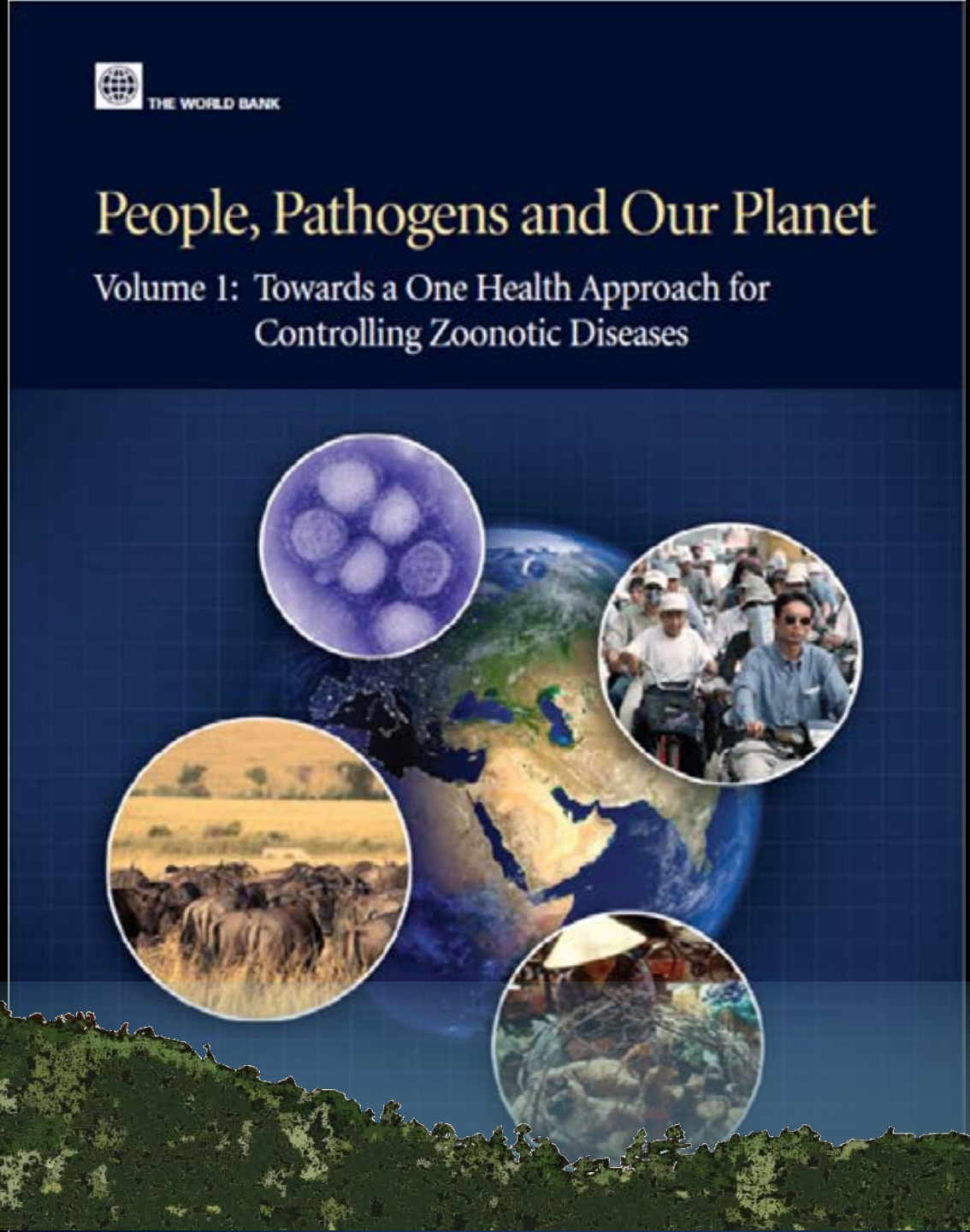
Human health, welfare and quality of life is inextricably linked to the health of the animals and the ecosystems we share.





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Where are the biologists?

Need for Enhanced Environmental Representation in the Implementation of One Health

Meredith A. Barrett[1,2,4] and Timothy A. Bouley[3]

[1]*Robert Wood Johnson Foundation Health and Society Scholars Program, University of California San Francisco, San Francisco, CA*
[2]*University of California Berkeley, School of Public Health, Berkeley, CA*
[3]*Environment and Natural Resources, World Bank Group, 1818 H St. NW, Washington, DC 20433*
[4]*Propeller Health, San Francisco, CA*

Abstract: Issues of global environmental change, global health, emerging disease, and sustainability present some of the most complex challenges of the twenty-first century. Individual disciplines cannot address these issues in isolation. Proactive, innovative, and trans-disciplinary solutions are required. Recognizing the inherent connectedness of humans, animals, plants, and their shared environment, One Health encourages the collaboration of many disciplines—including human and veterinary medicine, public health, social science, public policy, environmental science, and others—to address global and local health challenges. Despite great progress in this shift toward transdisciplinarity, the environmental component of the One Health paradigm mains underrepresented in One Health discourse. Human and animal health issues are commonly discussed the umbrella of the One Health paradigm, while upstream environmental drivers and solutions are less the current integration of environmental issues in One Health publications and integration of environmental knowledge in the implementation of One fits from the collaboration between One Health and eco- vement.

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Is health and disease important in an ecological context?

- neglected in Scandinavia?
- very difficult to objectively measure impacts of disease…
- Nordic biologists' approach to disease…?
  - something that happens in exotic places and is visible as rare, devastating outbreaks with mass mortality
  - something that occurs in artificially dense populations, i.e. in livestock, zoos and captive populations, but very rarely in Nordic nature
  - no important impact on Nordic wildlife populations

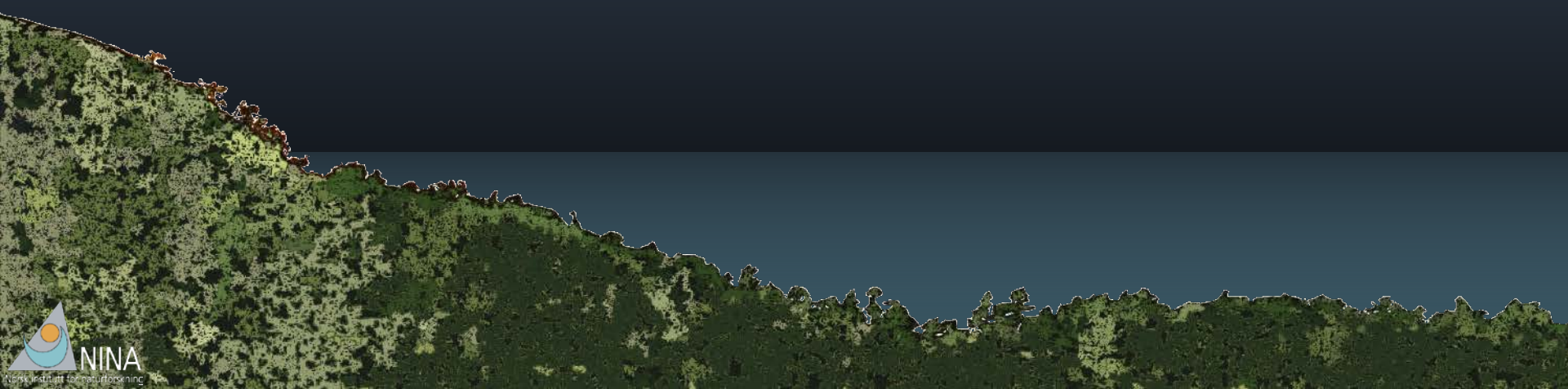

Image: Dep. of Environment and Natural Resources, North-West Territories, Canada

Bilde: www.cbc.ca, Canada

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Image: Albert Salemgarayev, Kazakhstan, mai 2015

Bilde: Sergei Khomenko/Food and Agriculture Organization of the United Nations, Kazakhstan, mai 2015

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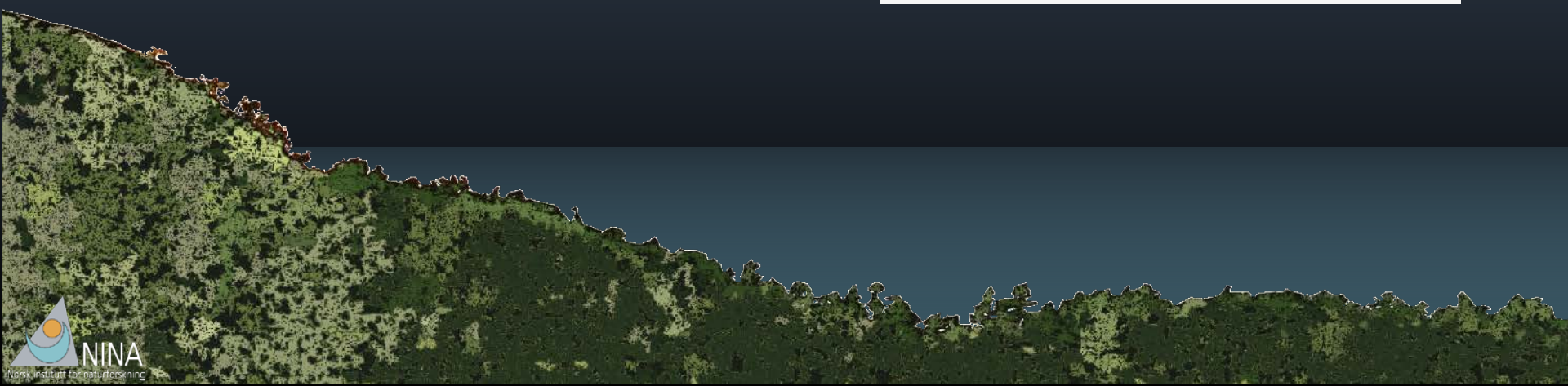
But new currents are coming

- EcoHealth
- Conservation medicine
- Ecosystem health



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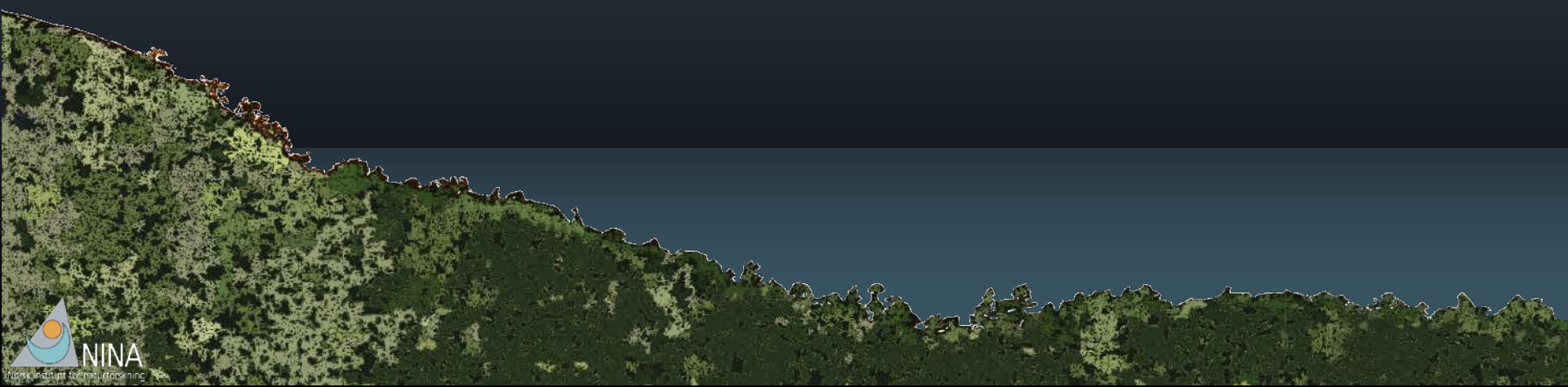
But – what do we actually mean by saying

”I’m ill today!”



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”I have fallen ill.

I can’t participate.”

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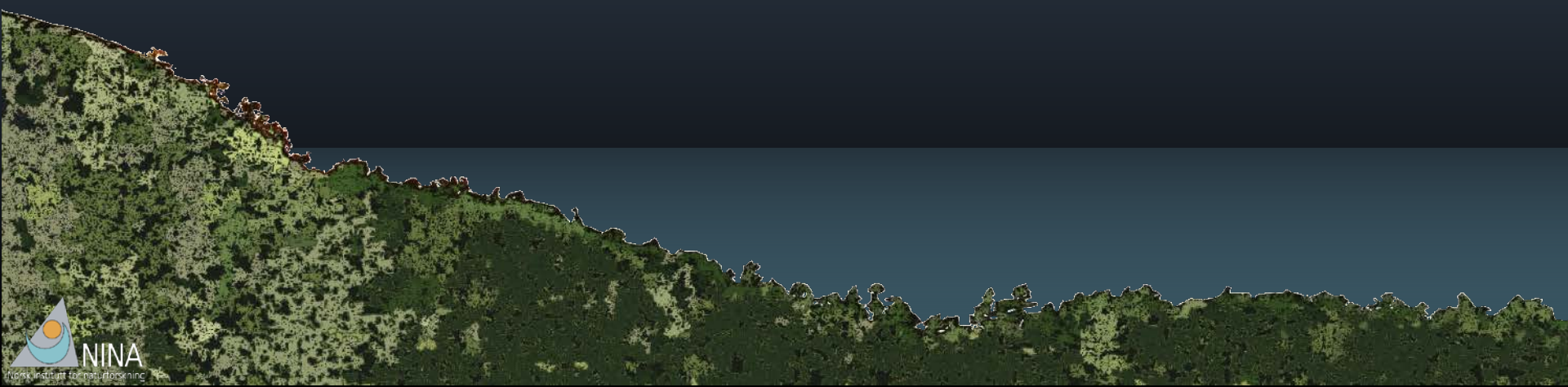
What do we actually mean by saying «I'm ill!»

- very difficult to define!
  - abscence of health?

World Health Organization

  - "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."

Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948.



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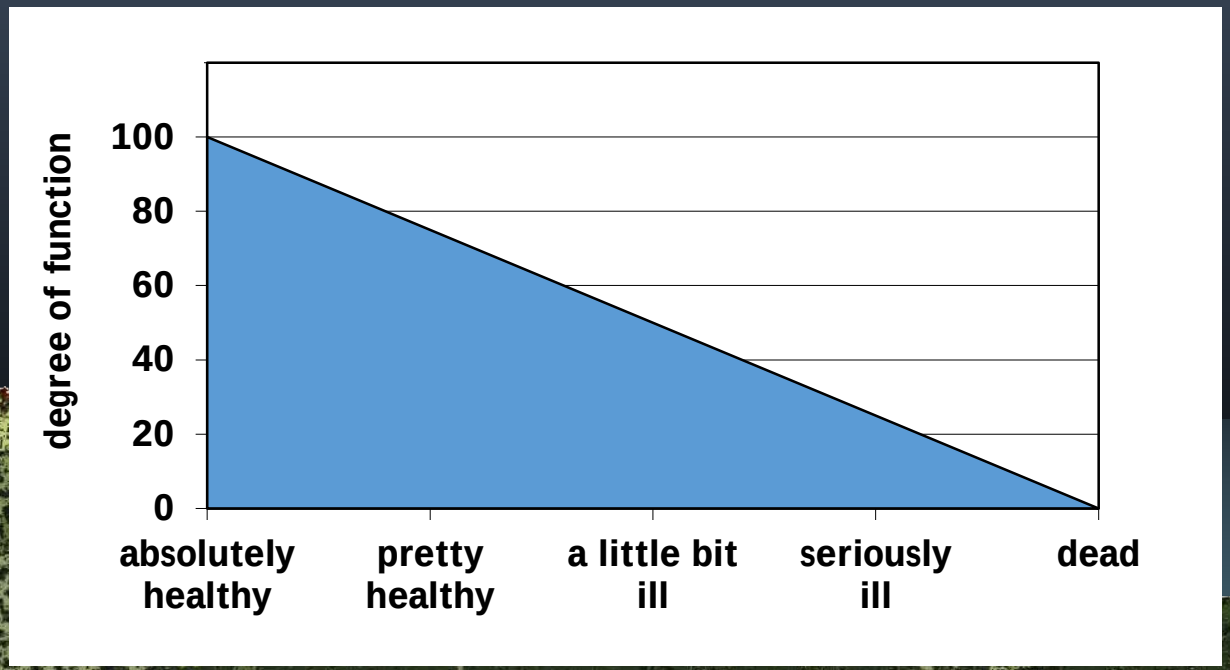
What do we actually mean by saying «I'm ill!»

- very difficult to define!
  - not merely abscence of health
  - a continuous scale from absolutely healthy to state of death - a condition where the functions of the body are so disturbed that vital organs are irreversibly damaged
  - "pretty healthy" sliding into "a little bit ill"



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…attempt on definition (Wobeser, 1997)…

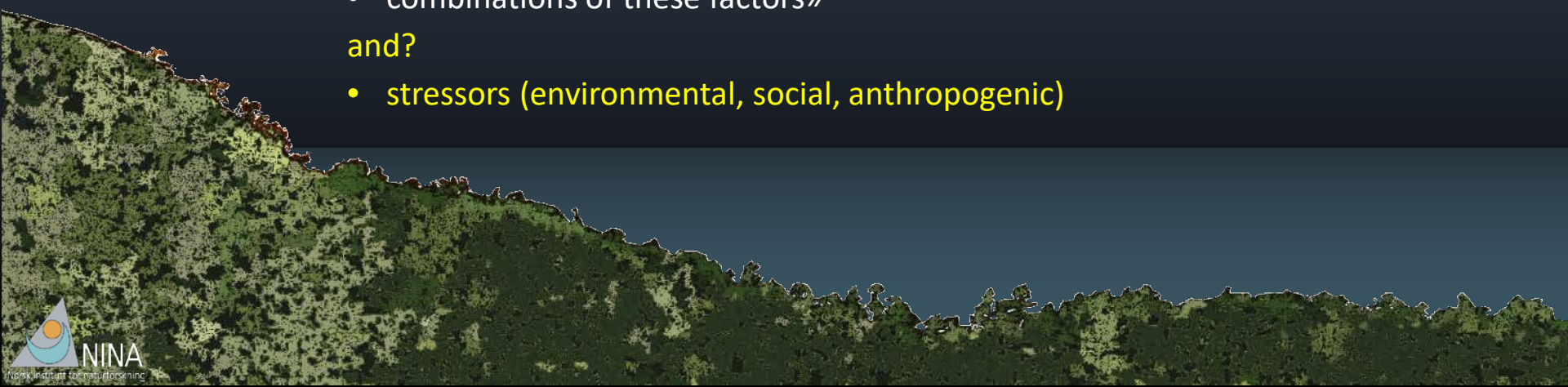
- ***«any impairment that interferes with or modifies the performance of normal functions***

- including responses to
  - environmental factors
    - nutrition
    - toxicants
    - climate
  - infectious agents
  - inherent or congenital defects
  - combinations of these factors»

…attempt on definition (Wobeser, 1997)…

- ***«any impairment that interferes with or modifies the performance of normal functions and/or length of life***
- including responses to
  - environmental factors
    - nutrition
    - toxicants
    - climate
  - infectious agents
  - inherent or congenital defects
  - combinations of these factors»

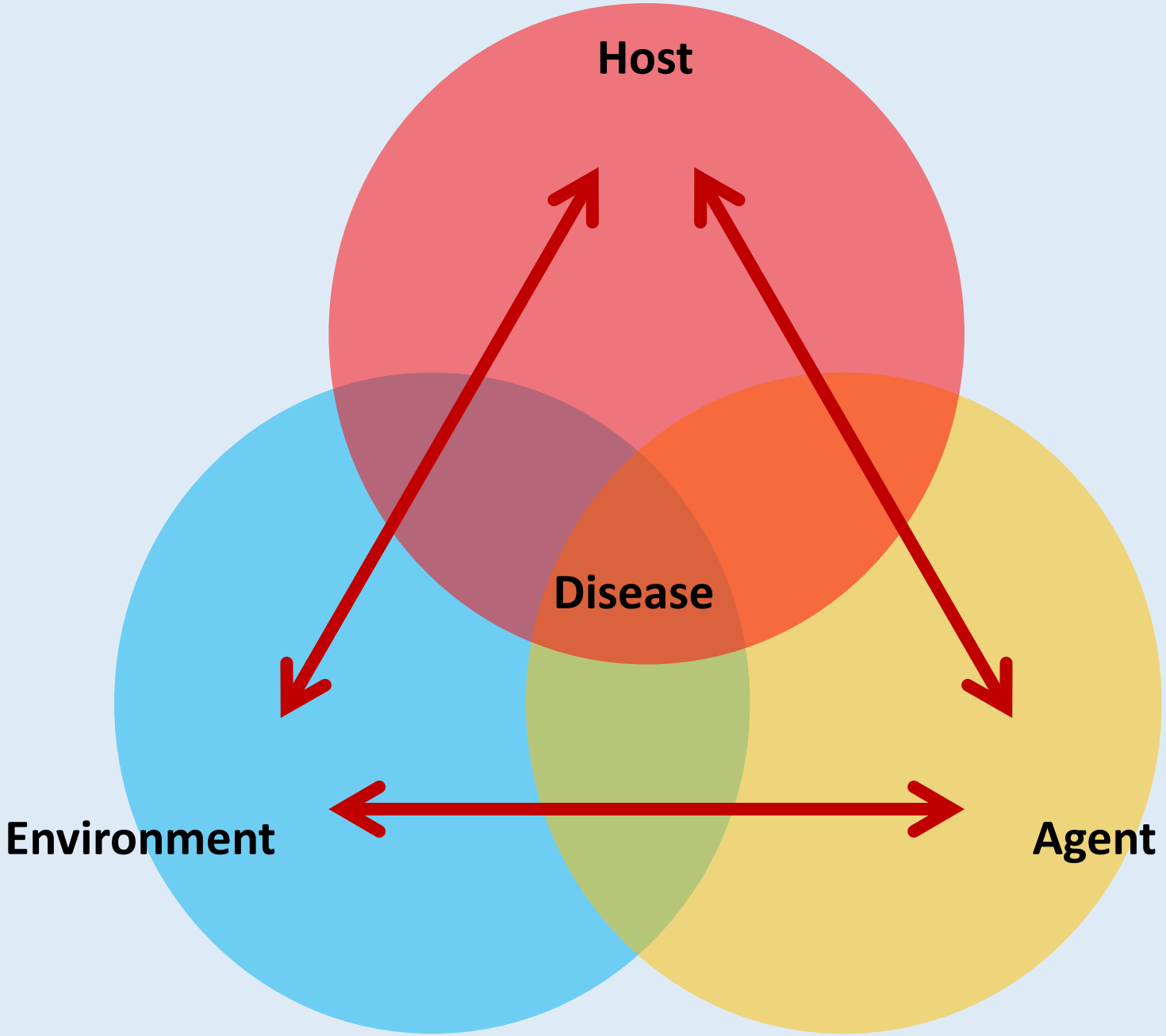
  and?
  - stressors (environmental, social, anthropogenic)



The least spectacular is as always the most common

- low degree (subclinical) disease is most prevalent
- many disease factors are often at play at the same time
- and work in interplay with other factors
- often not visible at «typical disase»
- but rather lowered condition, reproduction or long-term survival
- clinical disease and death are often the result of an interplay of multiple factors

Images: B. Ytrehus



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absolutely healthy

pretty healthy

average

disease

death

deer image from www.openclipart.org

seesaw from Søve Leke-miljø, www.sove.no

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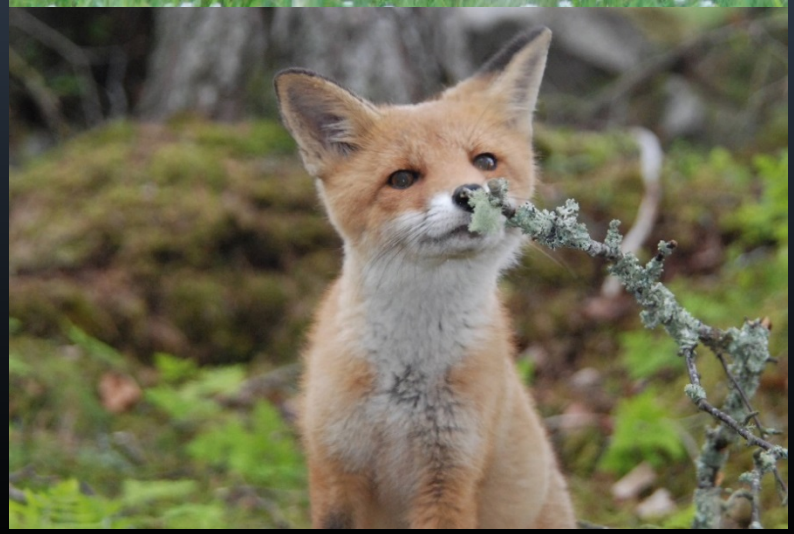
What I meant to say…

- disease is a response in animals caused by (most oftenly) the combined effect of multiple interacting factors, both abiotic and biotic, natural and anthropogenic
- this condition in an animal and/or an animal population may again affect its interaction with other species, its abiotic environment and humans
- a wildlife researcher need to take this into account…

Hypothetical examples:

Roe deer and red foxes: A study of how predation mortality rate is a consequence of topography and vegetation



Bilder: B. Ytrehus

Journal of Animal Ecology

Journal of Animal Ecology 2009, **78**, 1124–1133 doi: 10.1111/j.1365-2656.2009.01584.x

Habitat and roe deer fawn vulnerability to red fox predation

[redacted]

[1]*Norwegian Institute for Nature Research, NO-7485 Trondheim, Norway; and* [2]*Norwegian University of Life Sciences, Department of Ecology and Natural Resource Management, NO-1432 Ås, Norway*

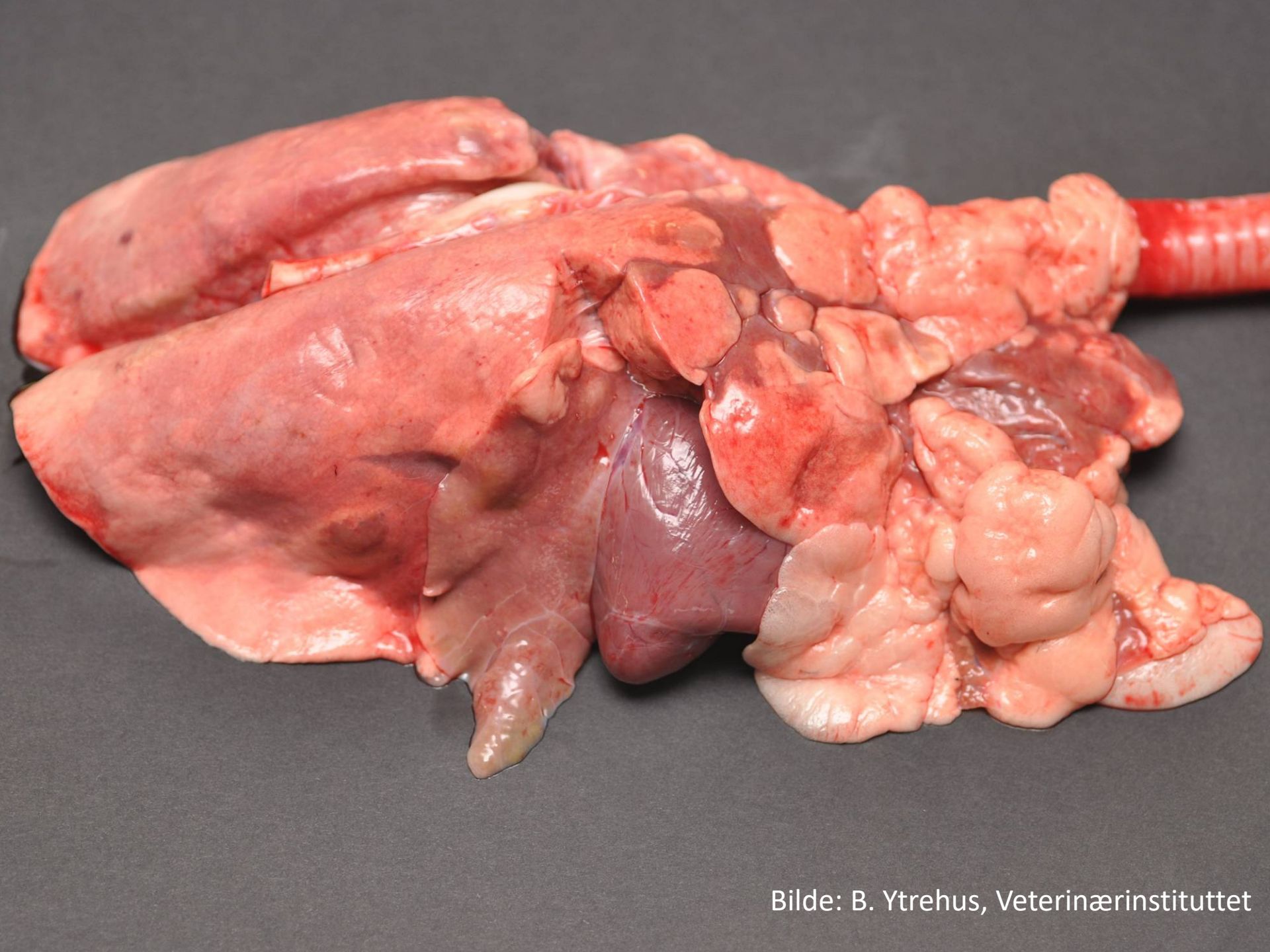
Summary

1. Notwithstanding the growing amount of literature emphasizing the link between habitat, life-history traits and behaviour, few empirical studies investigated the combined effect of these parameters on individual predation risk. We investigated direct and indirect consequences of habitat composition at multiple spatial scales on predation risk by red foxes on 151 radio-monitored roe deer fawns. We hypothesized that the higher resource availability in fragmented agricultural areas increased predation risk because of: (i) shorter prey movements, which may increase predictability; (ii) larger litter size and faster growth rates, which may increase detectability in species adopting a hiding neonatal anti-predator strategy. The sharing of risky habitat among littermates was expected to promote whole-litter losses as a result of predation.

2. The landscape-scale availability of agricultural areas negatively affected pre-weaning movements, but did not influence growth rates or litter size. Predation risk was best described by the interplay between movements and fine-scale habitat fragmentation: a higher mobility increased the encounter rate and predation risk in highly fragmented home ranges, while it reduced predation risk in forest-dominated areas with clumped resources because of decreased predictability. This is one of the first demonstrations that movement patterns can be an efficient anti-predator strategy when adjusted to local conditions.

3. In accordance with previous studies documenting the existence of family effects (i.e. non-independence among siblings) in survival, littermates survived or died together more often than expected by chance. In addition, our study specifically demonstrated the occurrence of behaviourally mediated family effects in predation risk: after a fox killed one fawn the probability of a sibling being killed within a few days rose from 20% to 47%, likely because of the win-stay strategy (i.e. return to a previously rewarding site) adopted by the predator. Hence, the predator's hunting strategy has the potential to raise fawn mortality disproportionately to predator abundance.

4. There is increasing evidence that fawns inhabiting highly productive predator-free habitats are granted lifetime fitness benefits; these potential advantages, however, can be cancelled out when predation risk increases in the very same high-productivity areas, which might thus turn into attractive sinks.



Bilde: B. Ytrehus, Veterinærinstituttet


Bilde: B. Ytrehus, Veterinærinstituttet

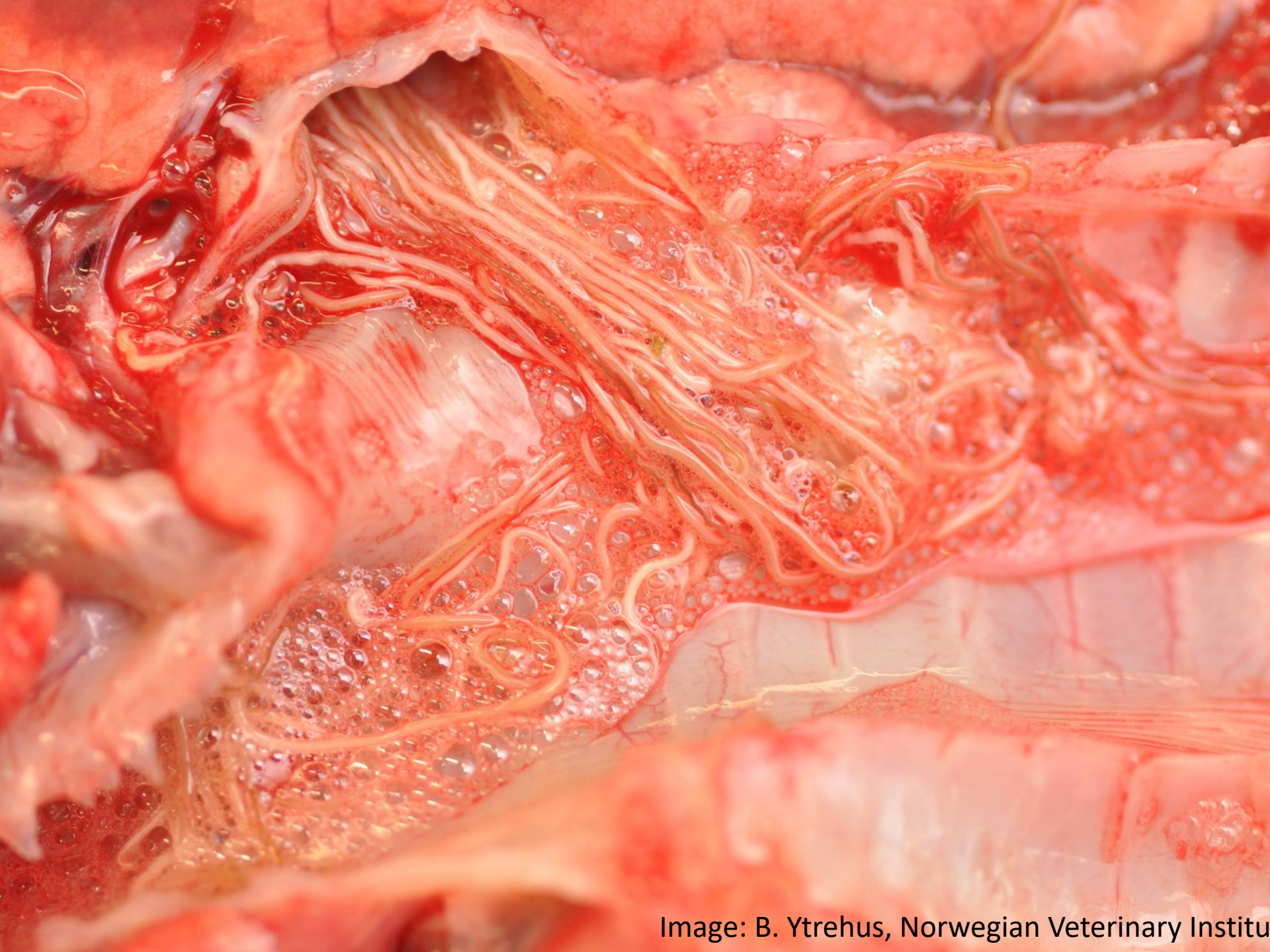


Image: B. Ytrehus, Norwegian Veterinary Institu

Archive photograph from Norwegian Veterinary Institute

Another highly hypotethical study:

”Effect of pollution and climate in breeding areas on the survival of juvenile cormorants (*Phalocrocax carbo*) in Skagerak»

Image from Wikimedia commons. «great cormorant in Gothenburg, Sweden» by Gegik.

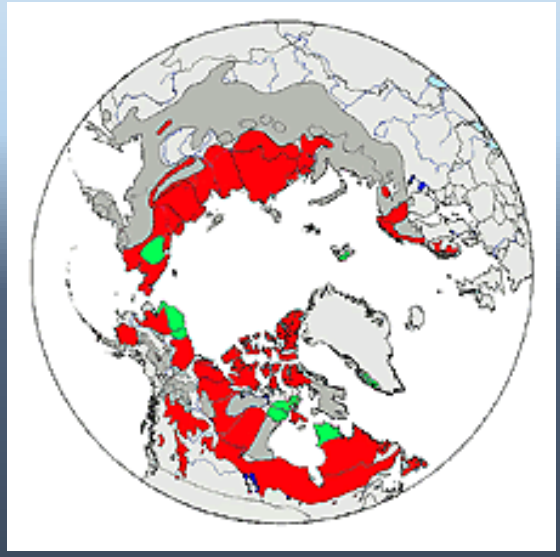
Bilde: B. Ytrehus, Veterinærinstitutte

«Global declines of caribou and reindeer»

- Global change
- Changes in phenology
- Insect harassment
- Extreme weather events

BUT

- What about….?



Global Change Biology

Global Change Biology (2009) **15**, 2626–2633, doi: 10.1111/j.1365-2486.2009.01974.x

Global declines of caribou and reindeer

LIV SOLVEIG VORS and MARK STEPHEN BOYCE
Department of Biological Sciences, University of Alberta, Edmonton, Alberta, T6G 2E9, Canada

Abstract

Caribou and reindeer herds are declining across their circumpolar range, coincident with increasing arctic temperatures and precipitation, and anthropogenic landscape change. Here, we examine the mechanisms by which climate warming and anthropogenic landscape change influence caribou and reindeer population dynamics, namely changes in phenology, spatiotemporal changes in species overlap, and increased frequency of extreme weather events, and demonstrate that many caribou and reindeer herds show demographic signals consistent with these changes. While many caribou and reindeer populations historically fluctuated, the current, synchronous population declines emphasize the species' vulnerability to global change. Loss of caribou and reindeer will have significant, negative socioeconomic consequences for northern indigenous cultures.

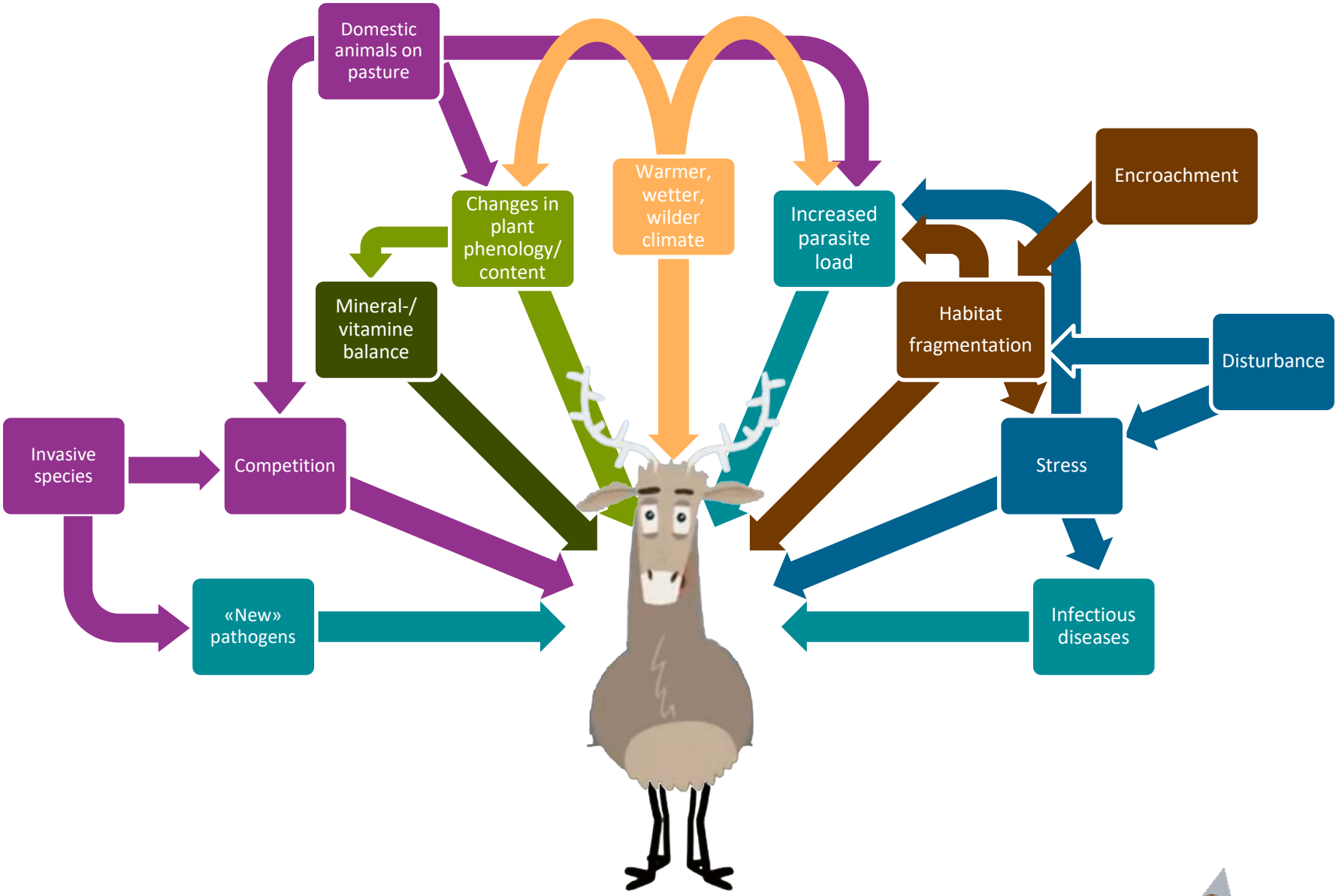
Keywords: climate change, landscape disturbance, population dynamics, *Rangifer tarandus*, zoology

Received 10 January 2009 and accepted 13 April 2009

Introduction

The persistence of caribou and reindeer (*Rangifer taran-*

Rangifer forms the socioecological cornerstone of circumpolar indigenous cultures, from subsistence hunting of caribou by Aboriginal peoples in Canada,



A bewildered Willy the Wild Reindeer

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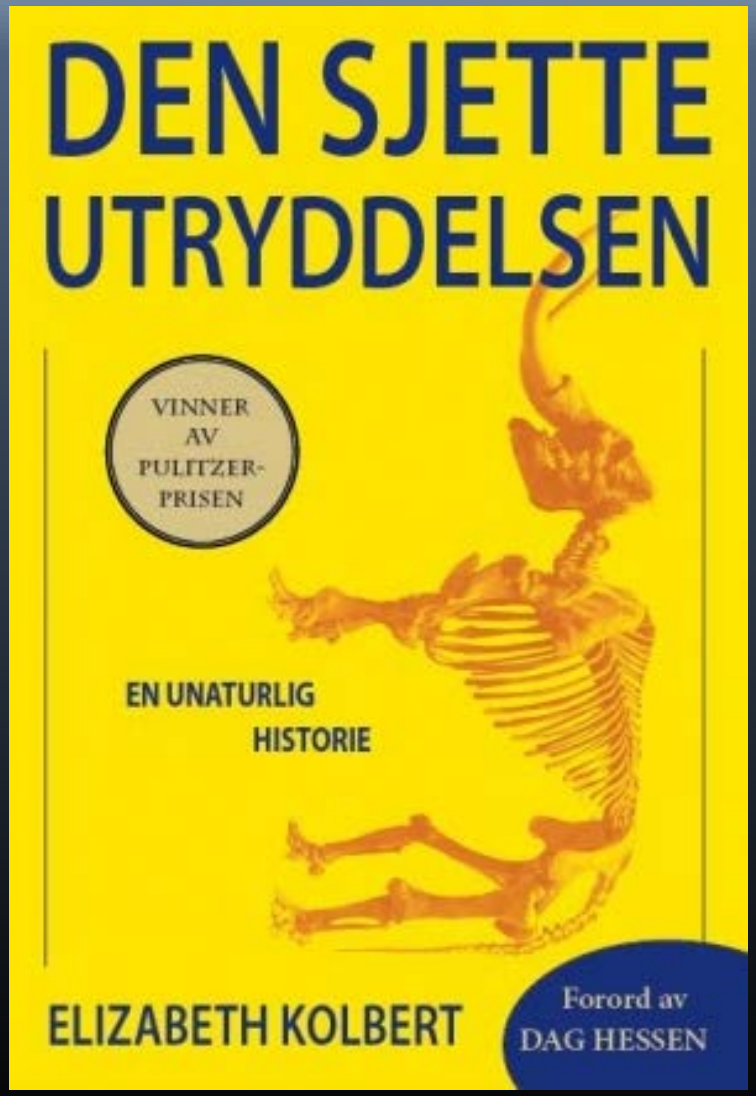
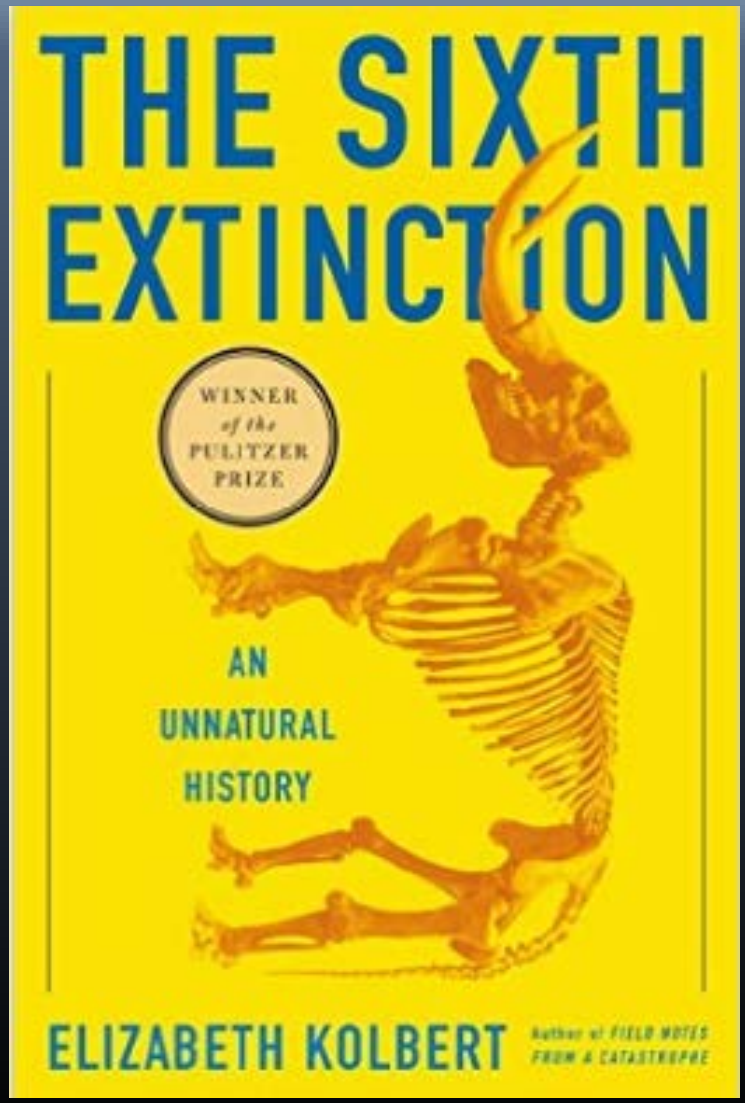
Living in an exciting period of time…





Ecological tipping points?

- Enormous growth of human population
- Urbanization
- Movement of industrial production
- Increased transport
  - of people
  - of animals
  - of goods -> connectivity
- Changes in agricultural landscapes
  - developing countries - enchroachment
  - Western and Northern – forest regrowth
- Changed area use – fragmentation
- Managment that increases wildlife population densities
- Global warming – climate change
- Medical treatment – immunosuppression, antibiotic resistance

A message from the frogs...

- chytridiomycosis (*Batrachochytrium*
- spread from South Africa with Africa (*Xenopus laevis*)
- acting together with

Vol 439|12 January 2006 nature

NEWS & VIEWS

EXTINCTIONS

A message from the frogs

Andrew R. Blaustein and Andy Dobson

The harlequin frogs of tropical America are at the sharp end of climate change. About two-thirds of their species have died out, and altered patterns of infection because of changes in temperature seem to be the cause.

One of the worries about global climate change is that it will raise the transmission rates of infectious diseases[1]. On page 161 of this issue, Pounds and colleagues[2] provide compelling evidence that anthropogenic climate change has already altered transmission of a pathogen that affects amphibians, leading to widespread population declines and extinctions.

According to the Global Amphibian Assessment (GAA)[3], around a third of amphibian species (1,856) are classified globally as 'threatened'. The tenuous hold these animals have on life is especially evident in tropical America, where, for example, 67% of the 110 species of harlequin frog (*Atelopus*; Fig. 1) endemic to the region have died out in the past 20 years[3]. A pathogenic chytrid fungus, *Batrachochytrium dendrobatidis*, is implicated as the primary cause of *Atelopus* population crashes and species extinctions[4,5]. Now, Pounds *et al.* offer a mechanistic explanation of how climate change encourages outbreaks of *B. dendrobatidis* in the mountainous regions of Central and South America: night-time temperatures in these areas are shifting closer to the thermal optimum of *B. dendrobatidis*, and increased daytime cloudiness prevents frogs from finding 'thermal refuges' from the pathogen.

The authors defined an 'extinction' as the time when a frog species was last

Figure 1| Amphibian alarm call. The Panamanian golden frog is one of roughly 110 species of harlequin frog (*Atelopus*), many of which are dying out. Although this species still survives, its numbers have fallen significantly.

optimal growth of the pathogen. Mid-elevation *Atelopus* communities are not only the hardest hit by extinction, but they also harbour the most species, so biodiversity in these areas is in double jeopardy. These results corroborate the GAA findings[3] for a broad array of amphibians that the percentage of extinct or threatened species is largest at middle elevations. This is contrary to the expectation that higher-elevation species would be more prone

change had been stymied by the so-called 'climate–chytrid paradox', because the climatic conditions favouring chytrid growth seemed to be the very opposite of those created by current climate trends.

Pounds and colleagues' work[2] is a breakthrough as it resolves the paradox and offers a theory to explain the widespread 'enigmatic' declines of *Atelopus* and other amphibians[3]. The authors combine two disparate approaches into one unifying theory, simultaneously explaining how shifting temperatures are the ultimate trigger for the expansion of a pathogenic fungus, and that this infection is the direct cause of *Atelopus* extinctions.

There may be a tragic irony here. The oldest-known hosts of *Batrachochytrium* are African-clawed frogs (*Xenopus*)[7], first recorded in South Africa in 1938. Global trade in these frogs burgeoned in the 1950s following the development of pregnancy tests that used *Xenopus* tissue[7,8]. Museum records suggest that the pathogen achieved a worldwide distribution in the 1960s. So it seems that the expansion in one frog species through trade may have led to the extinction of other amphibian species — a totally unexpected, indirect consequence of human ingenuity.

Frogs and *Batrachochytrium* fungi are

Vol 439|12 January 2006|doi:10.1038/nature04246 nature

ARTICLES

Widespread amphibian extinctions from epidemic disease driven by global warming

J. Alan Pounds[1], Martín R. Bustamante[2], Luis A. Coloma[2], Jamie A. Consuegra[3], Michael P. L. Fogden[1], Pru N. Foster[4]†, Enrique La Marca[5], Karen L. Masters[6], Andrés Merino-Viteri[2], Robert Puschendorf[7], Santiago R. Ron[2,8], G. Arturo Sánchez-Azofeifa[9], Christopher J. Still[10] & Bruce E. Young[11]

As the Earth warms, many species are likely to disappear, often because of changing disease dynamics. Here we show that a recent mass extinction associated with pathogen outbreaks is tied to global warming. Seventeen years ago, in the mountains of Costa Rica, the Monteverde harlequin frog (*Atelopus* sp.) vanished along with the golden toad (*Bufo periglenes*). An estimated 67% of the 110 or so species of *Atelopus*, which are endemic to the American tropics, have met the same fate, and a pathogenic chytrid fungus (*Batrachochytrium dendrobatidis*) is implicated. Analysing the timing of losses in relation to changes in sea surface and air temperatures, we conclude with 'very high confidence' (>99%, following the Intergovernmental Panel on Climate Change, IPCC) that large-scale warming is a key factor in the disappearances. We propose that temperatures at many highland localities are shifting towards the growth optimum of *Batrachochytrium*, thus encouraging outbreaks. With climate change promoting infectious disease and eroding biodiversity, the urgency of reducing greenhouse-gas concentrations is now undeniable.

Humans are altering the Earth's climate[1–4] and thus the workings of

these members of the toad family (Bufonidae)[16]. Brightly coloured

Proc. Natl. Acad. Sci. USA
Vol. 95, pp. 9031–9036, July 1998
Population Biology

Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America

LEE BERGER[a,b,c], RICK SPEARE[a], PETER DASZAK[d], D. EARL GREEN[e], ANDREW A. CUNNINGHAM[f], C. LOUISE GOGGIN[g], RON SLOCOMBE[h], MARK A. RAGAN[i], ALEX D. HYATT[b], KEITH R. MCDONALD[j], HARRY B. HINES[k], KAREN R. LIPS[l], GERRY MARANTELLI[m], AND HELEN PARKES[b]

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Edited by Robert May, University of Oxford, Oxford, United Kingdom, and approved May 18, 1998 (received for review March 9, 1998)

ABSTRACT Epidermal changes caused by a chytridiomycete fungus (Chytridiomycota; Chytridiales) were found in sick and dead adult anurans collected from montane rain forests in Queensland (Australia) and Panama during mass mortality events associated with significant population declines. We also have found this new disease associated with morbidity and mortality in wild and captive anurans from additional locations in Australia and Central America. This is the first report of parasitism of a vertebrate by a member of the phylum Chytridiomycota. Experimental data support the conclusion that cutaneous chytridiomycosis is a fatal disease of anurans, and we hypothesize that it is the proximate cause of these recent amphibian declines.

Amphibian population declines in protected habitats are a serious global concern (1–3), and although several etiologies

primary degraders or saprobes, using substrates such as chitin, plant detritus, and keratin. Some genera are facultative or obligate anaerobes, and many are obligate parasites of fungi, algae, vascular plants, rotifers, nematodes, or insects. The chytrid reported here is the first member of the phylum Chytridiomycota to be recognized as a parasite of the phylum Vertebrata (18). A similar discovery of a chytrid fungus in dying captive dendrobatids in the United States made independently and contemporaneously (19) demonstrates that chytridiomycosis is widespread in amphibians in the Americas as well as Australia.

MATERIALS AND METHODS

Collection of Specimens. Large numbers of ill and dead anurans were found during monitoring programs of amphibian populations in decline in Big Tableland, Queensland, Australia

Same message from bats in North-America…

- White-nose syndrome
- Discovered in 2007
- *Geomyces destructans*
- Common in European bats

U.S. Fish & Wildlife Service

News Release

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North American bat death toll exceeds 5.5 million from white-nose syndrome

On the verge of another season of winter hibernating bat surveys, U.S. Fish and Wildlife Service biologists and partners estimate that at least 5.7 million to 6.7 million bats have now died from white-nose syndrome. Biologists expect the disease to continue to spread.

White-nose syndrome (WNS) is decimating bat populations across eastern North America, with mortality rates reaching up to 100 percent at many sites. First documented in New York in 2006, the disease has spread quickly into 16 states and four Canadian provinces. Bats with WNS exhibit unusual behavior during cold winter months, including flying outside during the day and clustering near the entrances of caves and mines where they hibernate. Bats have been found sick and dying in unprecedented numbers near these hibernacula.

"This startling new information illustrates the severity of the threat that white-nose syndrome poses for bats, as well as the scope of the problem facing our nation. Bats provide tremendous value to the U.S. economy as natural pest control for American farms and forests every year, while playing an essential role in helping to

Image credit to Martin Moriarty, USFWS

and a word from the snakes, too…

- snake fungal disease
- *Ophidiomyces ophiodiicola*
- found first in 2006
- spreading
- isolated populations plummet

USGS
science for a changing world

National Wildlife Health Center
Wildlife Health Bulletin 2013-02

Snake Fungal Disease in the United States

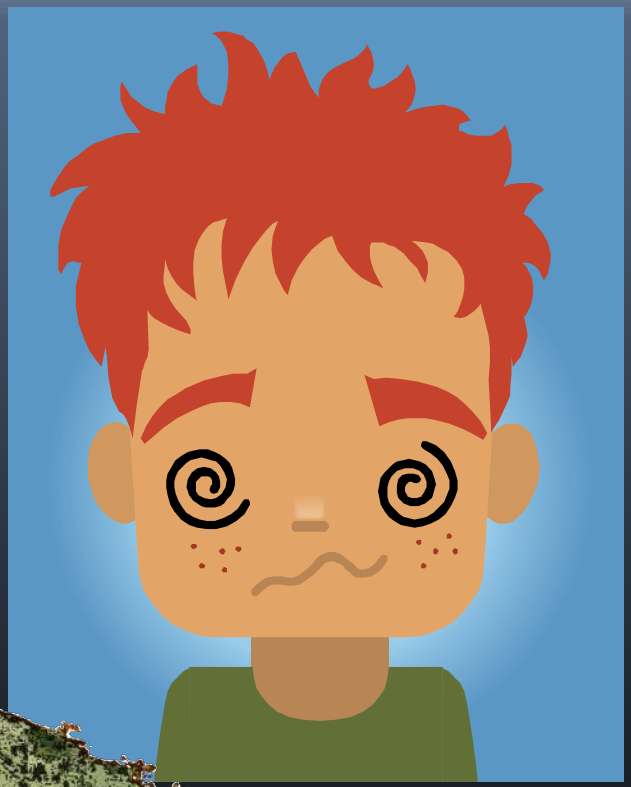
To: **Natural Resource/Conservation Managers**
From: Dr. Jonathan Sleeman, Center Director, USGS National Wildlife Health Center
Date: April 22, 2013 (revised genus name, May 2, 2013)

Snake Fungal Disease (SFD) is an emerging disease in certain populations of wild snakes in the eastern and midwestern United States. While fungal infections were occasionally reported in wild snakes prior to 2006, recently the number of free-ranging snakes with fungal dermatitis submitted to the USGS National Wildlife Health Center (NWHC) and other diagnostic laboratories has been increasing. Laboratory analyses have demonstrated that the fungus *Ophidiomyces* (formerly *Chrysosporium*) *ophiodiicola* is consistently associated with SFD, but often, additional fungi are isolated from affected snakes. At this time, definitive evidence that *O. ophiodiicola* causes SFD is inconclusive. As its name implies, SFD is only known to afflict snakes.

To date, the NWHC has confirmed fungal dermatitis (or the suspected fungal pathogen in association with skin lesions) in wild snakes from nine states, including Illinois, Florida, Massachusetts, Minnesota, New Jersey, New York, Ohio, Tennessee, and Wisconsin. However, it is suspected that SFD is more widespread in the United States than is currently documented. Multiple species of snakes have been diagnosed with SFD at the NWHC (see attached figures; view additional photographs at http://www.nwhc.usgs.gov/disease_information/other_diseases/snake_fungal_disease.jsp), including northern water snake (*Nerodia sipedon*), eastern racer (*Coluber constrictor*), rat snake (*Pantherophis obsoletus* species complex), timber rattlesnake (*Crotalus horridus*), massasauga (*Sistrurus catenatus*), pygmy rattlesnake (*Sistrurus miliarius*), and milk snake (*Lampropeltis triangulum*).

The most consistent clinical signs of SFD include scabs or crusty scales, subcutaneous nodules, premature separation of the outermost layer of the skin (*stratum corneum*) from the underlying skin (or

What I am trying to say…



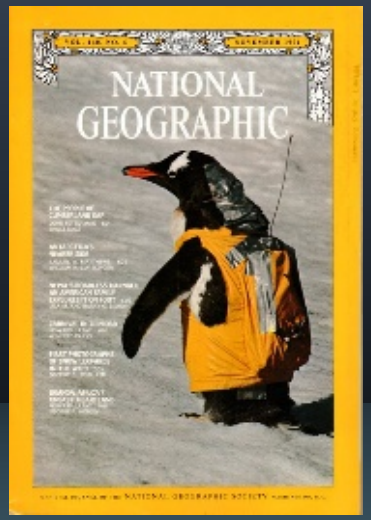
- there are a lot of «invisible» bugs around - what we observe may not be descriptive for what really happens
- a lot of things are currently happening that may increase the exposure to and impact of diseases that hitherto has been negligible
- a wildlife researcher need to take this into account…

Acting responsibly

- Formal duty
  - Food Act § 19

    Anybody shall exercise necessary caution, so that there not will arise danger for development or spread of transmissible animal disease.

- Avoid confounding ourselves by transmitting disease, causing disease or increasing impacts
  - not transmit diseases
    - from yourself and your food
    - from domestic animals
    - from other populations of the same or similar species
    - between individual animals
  - not force study animals into «unnatural situations»
  - minimalize stress



Stress & disease

- Term with different meanings in different scientific disciplines
- Not only an attribute of the stressor (the environmental component), but also an attribute of the stressed (the biological component)
- In psychology, ethology and welfare science often restricted to situations where the stress response fails to return the organism to homeostasis
- Definitions of «environmental stress» put forward by Bijlsma and Loesche (2005) (evolutionary context)
  - An environmental condition that, when first applied, impairs Darwinian fitness (Sibly & Calow, 1989)
  - Any environmental change that acts to reduce the fitness of organisms (Koehn & Bayne 1989)
  - An environmental factor causing a change in the biological system which is potentially injurious. (Hoffmann & Parsons, 1991).

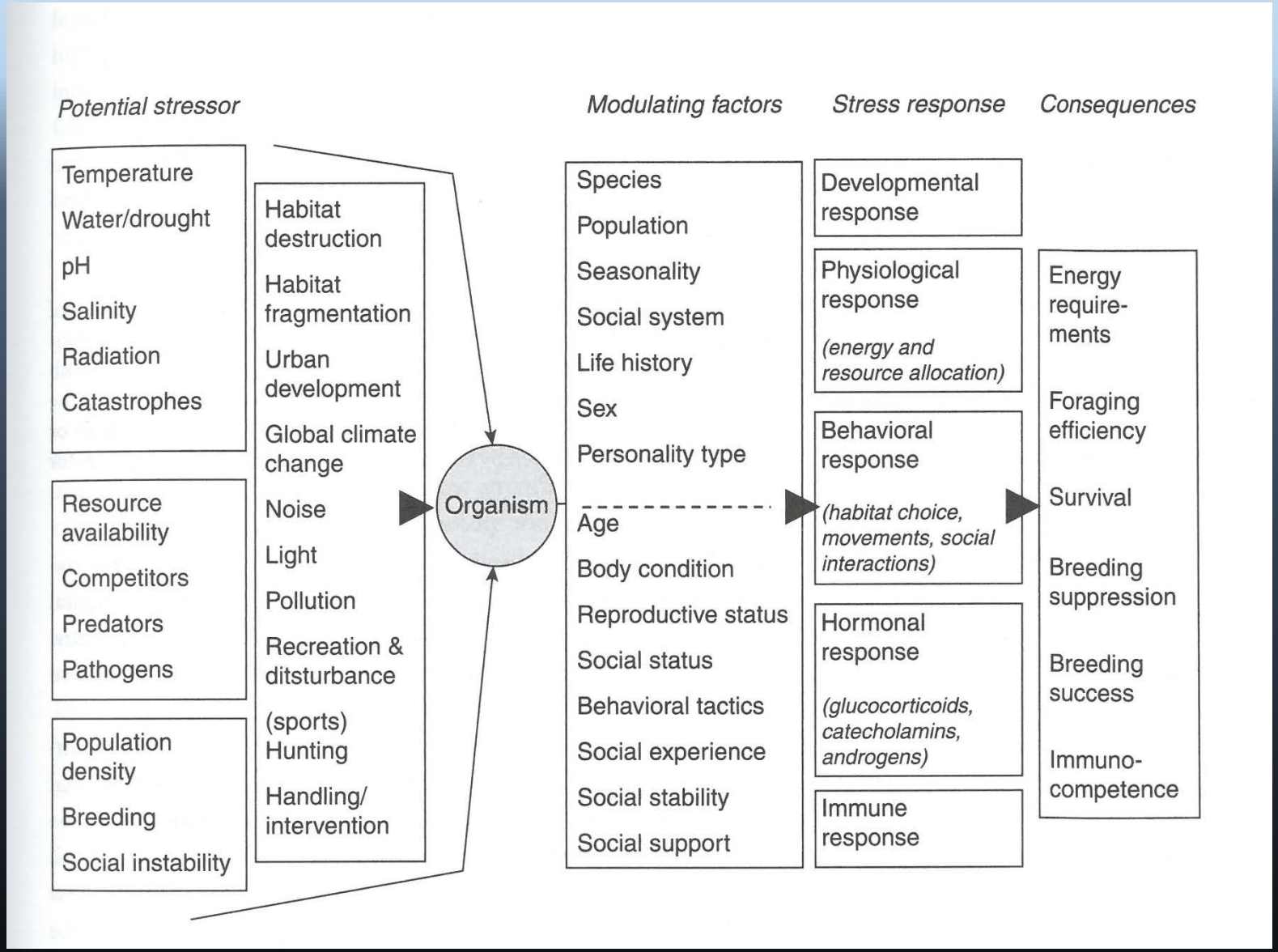


Figure from: Hofer & East, 2012, Chapter 7 in «New directions of conservation medicine – applied cases of ecological health»

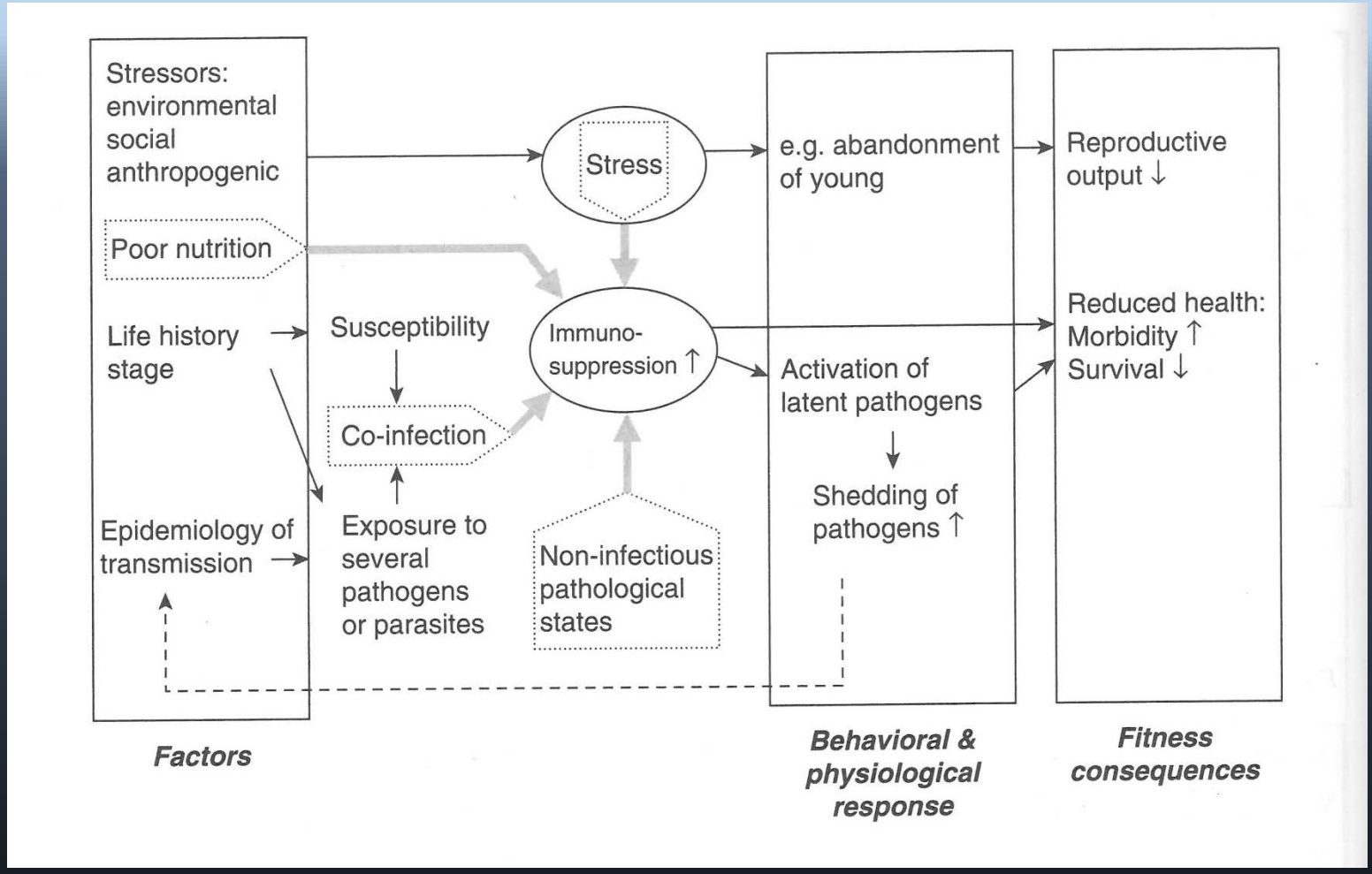


Figure from: Hofer & East, 2012, Chapter 7 in «New directions of conservation medicine – applied cases of ecological health»

Measuring stress…?

- Not necessarily easy
- Behavioural responses
- Corticosteroids
  - *which ones?*
  - *in which tissues or excretions?*
  - *interpretation???!*
- Cathecholamines
- Pheromones
- Heat-shock proteins and other proteins
- Body temperature
- Heart rate and contraction
- Leucocyte coping activity
- Neutrophil/heterophil to lymphocyte ratio in peripheral blood

Samples to (routinely) take when handling animals to enable health examination

- Serum samples
  - *serology*
  - *blood chemistry*
- Blood (with anticoagulant)
  - *pathogens in blood*
  - *haematology*
- Faeces
  - *parasites*
  - *some viruses and bacteria*
  - *corticosteroids (?!)*
- Hair/feathers
  - *corticosteroids*
- Check disease status in your study area
- Contact somebody that may know
- DON'T WAIT UNTIL YOU GO OUT IN THE FIELD

Things to look out for

- Dead animals
  - *thorough necropsy done by veterinary pathologist*
  - *if not possible – take samples of all vital organs according to premade necropsy protocol (!)*
  - *if associated with the study – film!*
  - *DON'T PUT IT IN THE FREEZER!*
- Also in individuals and species that not are studied

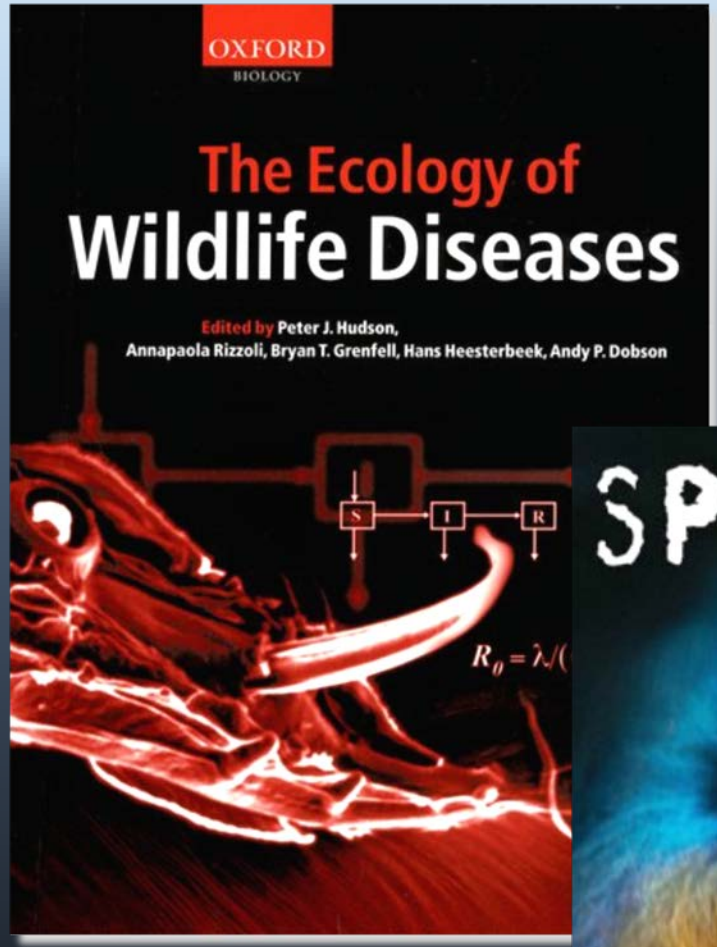
- Live animals
  - *behaviour*
  - *walk/flight*
  - *fur and skin*
  - *secretions*
  - *lesions*
  - *ectoparasites*
- Contact somebody that may know
- DON'T WAIT UNTIL YOU COME HOME

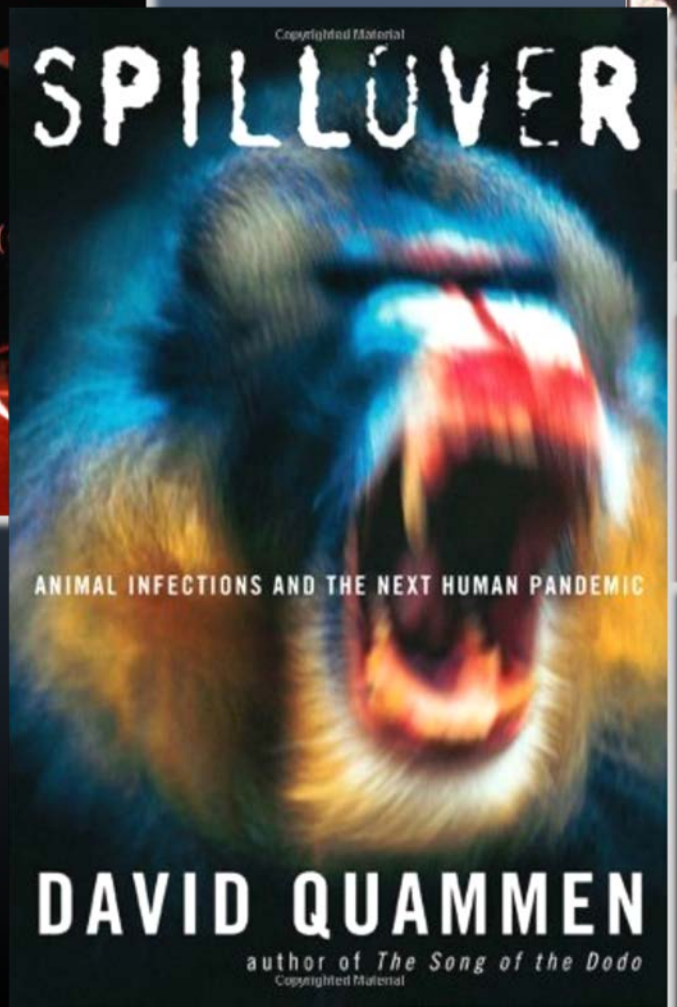
So…

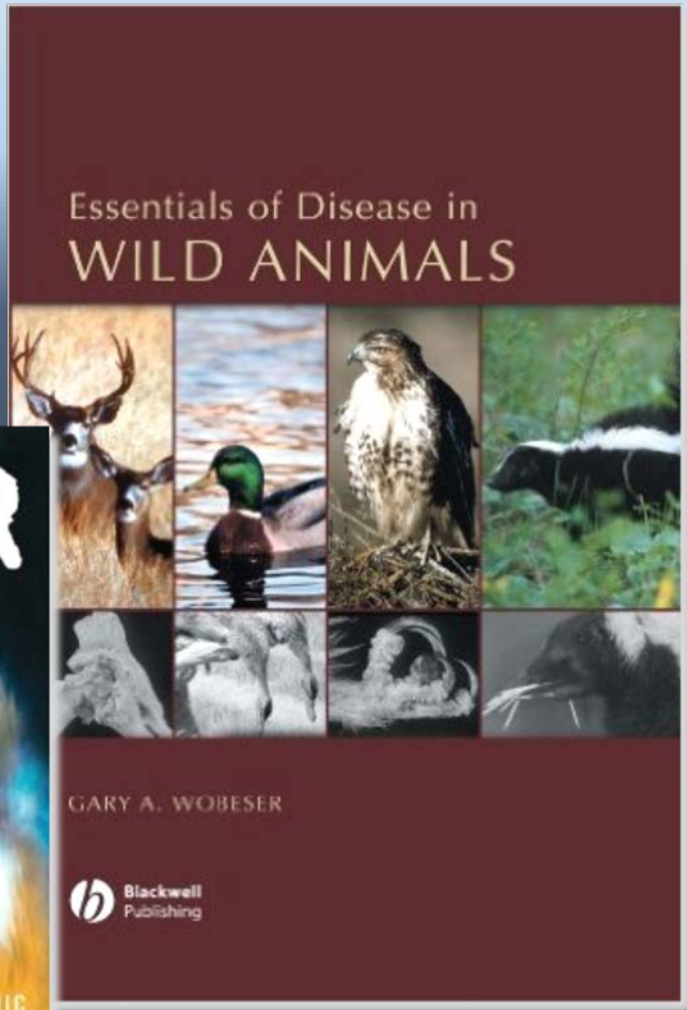
- *what is disease*
  - *an ecological factor among many others*
  - *may be obscure, but although important*
  - *may be the reason behind other phenomena*
    - *lowered condition, reproduction or long-term survival*
    - *changed behaviour*
  - *may strike rapidly and hard – but that's not common*
- *One Health, EcoHealth, Conservation Medicine*
- *why bother*
- *responsibility to not increase disease load and impacts*
- *avoid confounding results*
- *some things that can be done*

May turn exciting

- holistic approach – more valuable knowledge
- un-anticipated results
- may be both important and interesting
- and even fun







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