Dark Nature
Rapid natural change and human response

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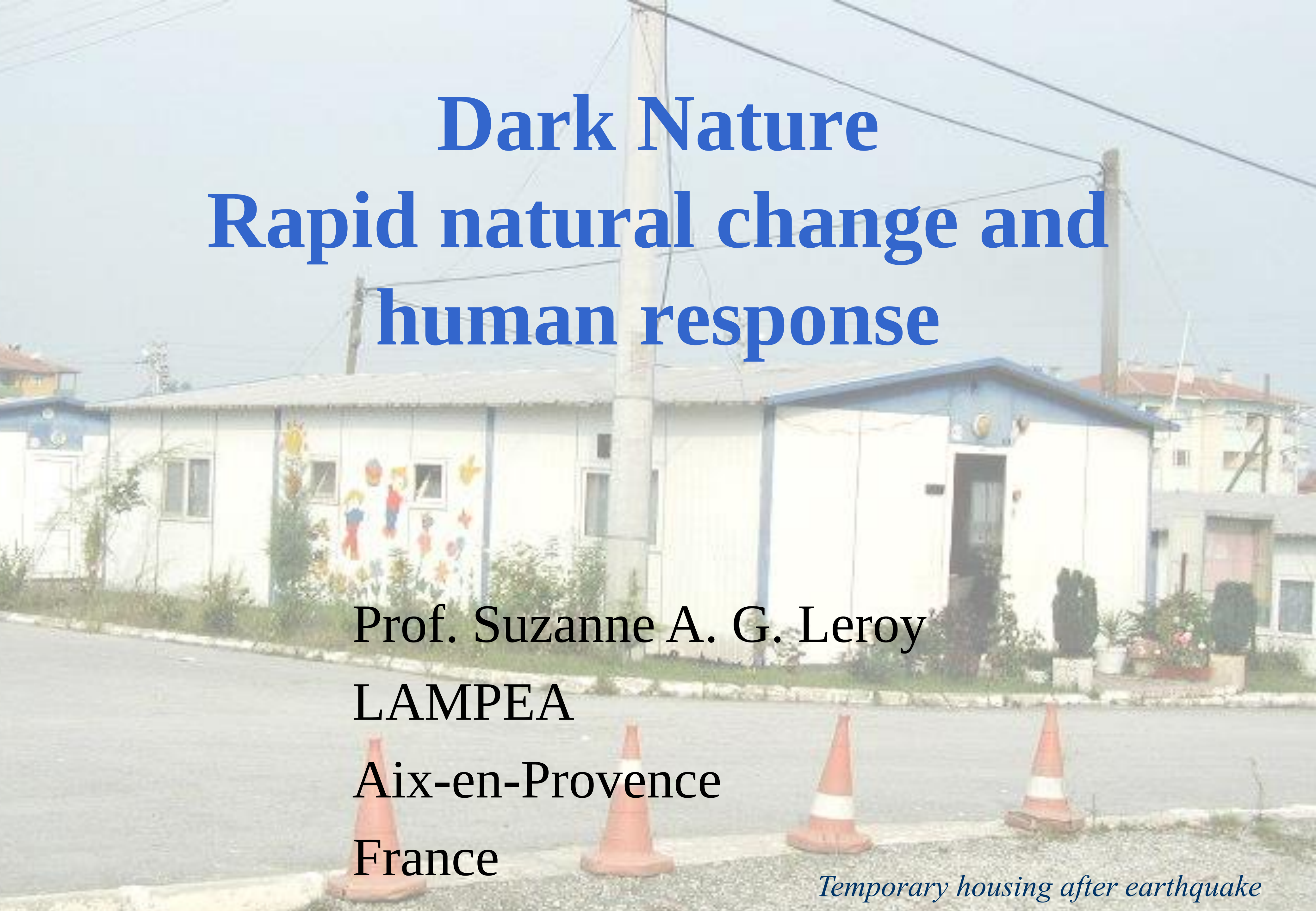


Temporary housing after earthquake

Structure of the talk

Part 1 What makes a catastrophe?

- Theory and examples

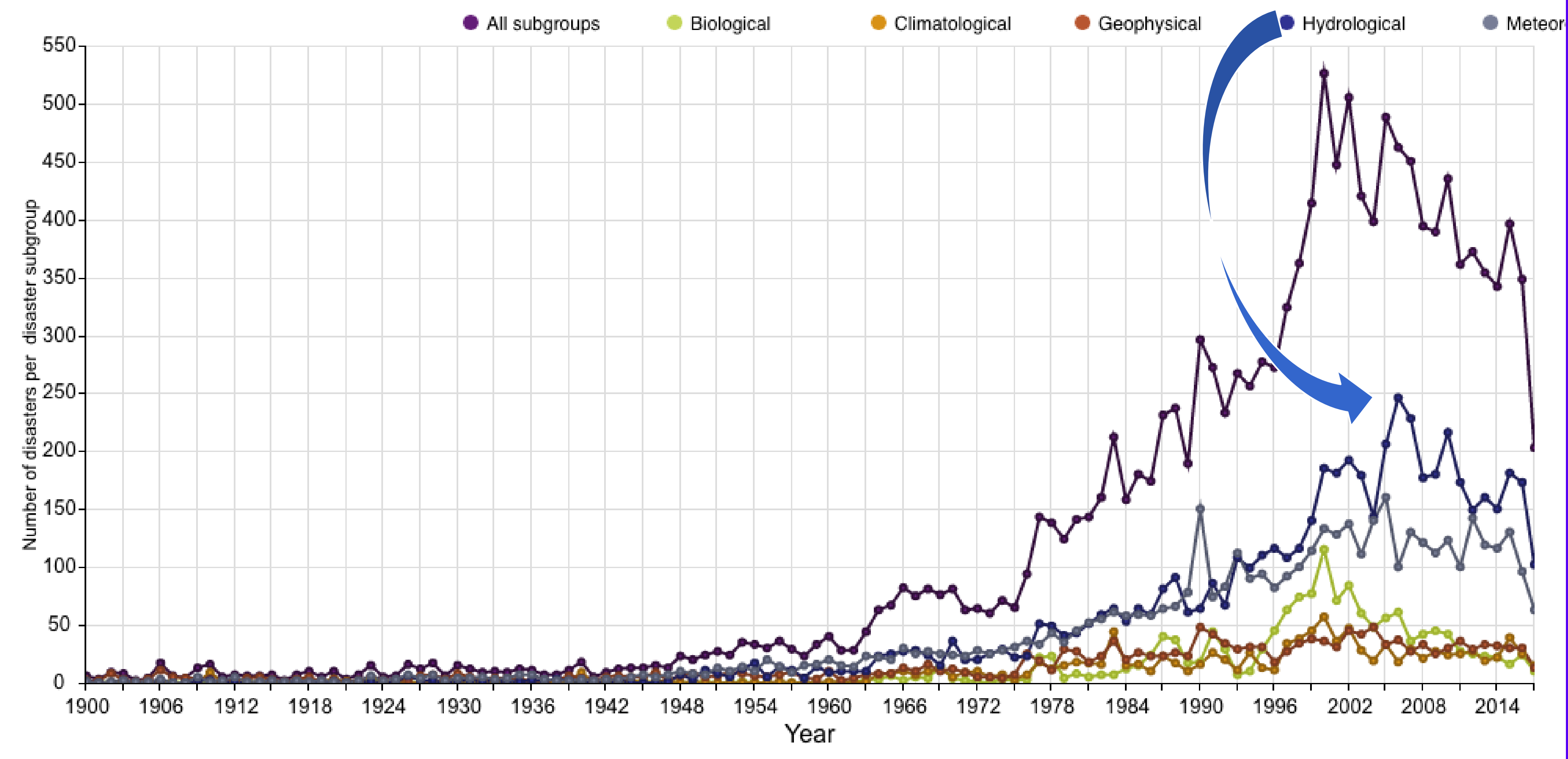
Part 2 Human answer

- Theory and examples

Part 3 Relevance & future

Part 1
What makes catastrophe?

- Natural disasters
  - increase in hydrometeorological
  - but slight only for biological and geological



Source: EM-DAT: The Emergency Events Database - Université catholique de Louvain (UCL) - CRED, D. Guha-Sapir - www.emdat.be, Brussels, Belgium

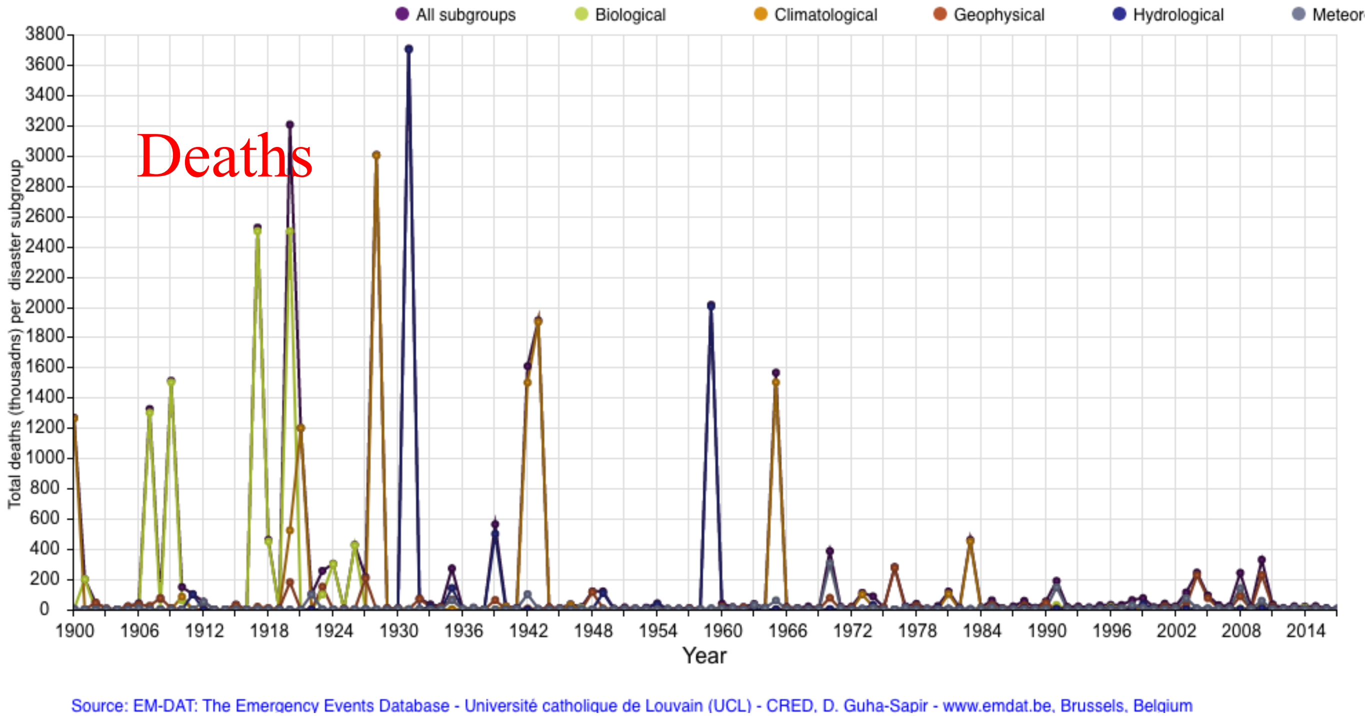
- Disaster: escalating
  - world population grows and
  - people settle in marginal areas

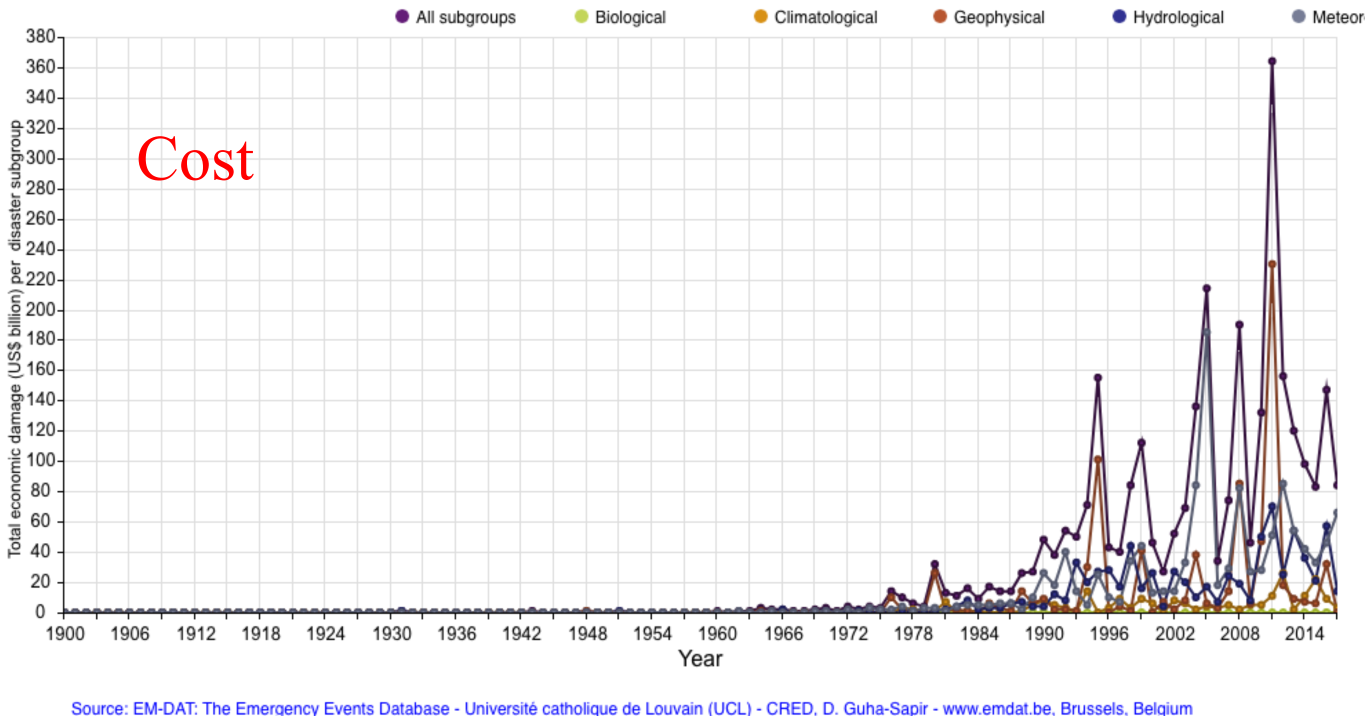
- Catastrophe: yes at larger scale and on a larger area

- Any global ones?
  - 4.2 ka, linked to global climatic change
  - 2.2 ka, linked to global climatic change

Caveats

- Non linearity in the assumption of causality
- No scale to measure it
  - Deaths?
  - Costs?





China

Disaster type	Date	Total deaths
Flood	00-07-1931	3700000
Drought	00--1928	3000000
Flood	00-07-1959	2000000
Epidemic	00--1909	1500000
Drought	00--1920	500000
Flood	00-07-1939	500000
Earthquake	27-07-1976	242000
Earthquake	22-05-1927	200000
Earthquake	16-12-1920	180000
Flood	00--1935	142000

Disaster type	Date	Total affected
Flood	01-07-1998	238973000
Flood	01-06-1991	210232227
Flood	30-06-1996	154634000
Flood	23-06-2003	150146000
Flood	29-05-2010	134000000
Flood	15-05-1995	114470249
Flood	15-06-2007	105004000
Flood	23-06-1999	101024000
Flood	14-07-1989	100010000
Storm	14-03-2002	100000000

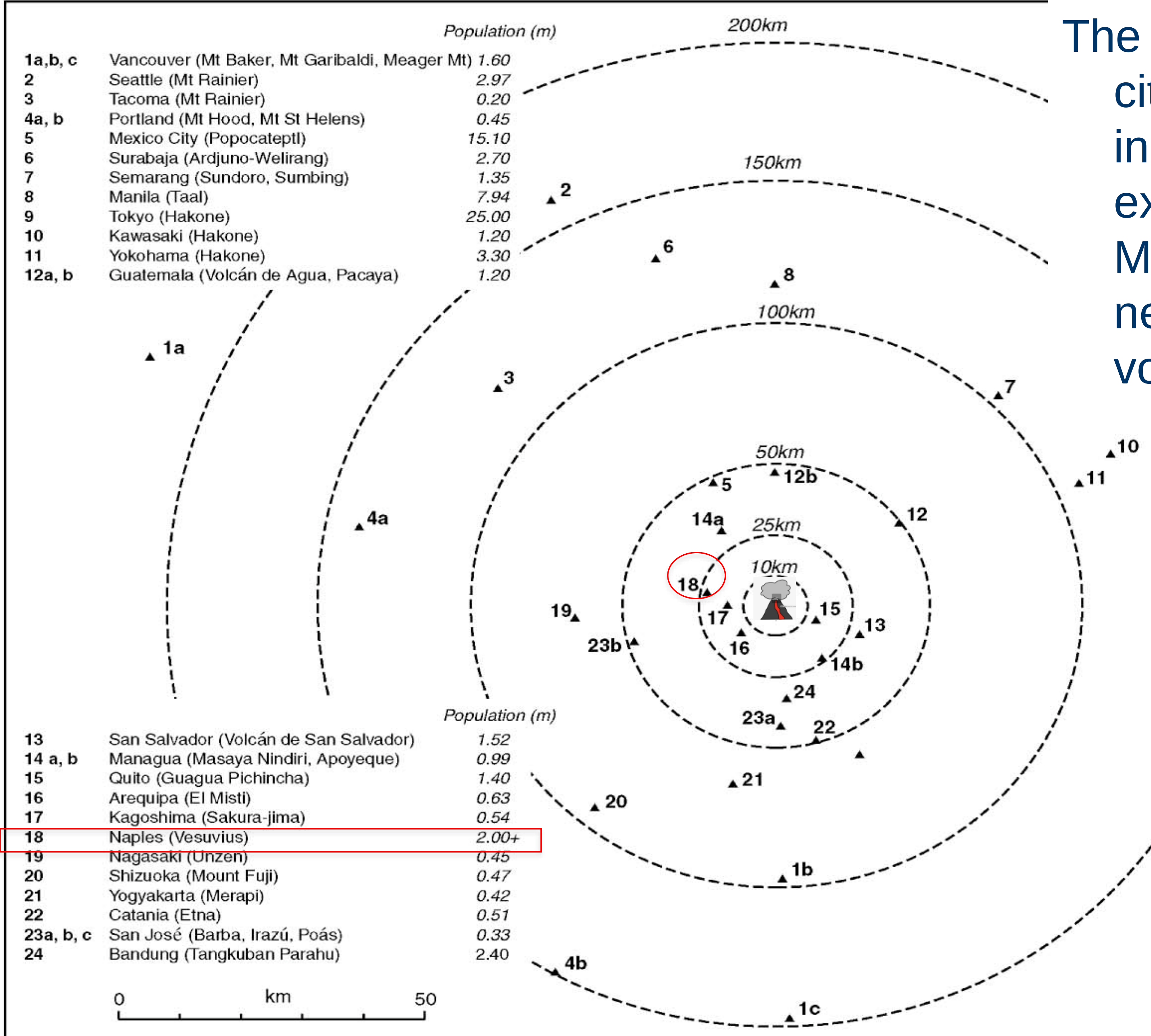
Disaster type	Date	Damage ('000 US$)
Earthquake	12-05-2008	85000000
Flood	01-07-1998	30000000
Flood	28-06-2016	22000000
Extreme temperature	10-01-2008	21100000
Flood	29-05-2010	18000000
Drought	00-01-1994	13755200
Flood	30-06-1996	12600000
Flood	23-06-1999	8100000
Flood	21-07-2012	8000000

Em-dat

Turkey

- In em-dat
- 195 cases since AD1900
- Deaths:
  - Earthquake 1999 in Izmit and 1939 in Erzincan, highest number of deaths: >17,000 and 33,000
- Number affected:
  - 1998 earthquake in Adana: 1.5 millions
  - 1999 earthquake in Izmit : 20 millions

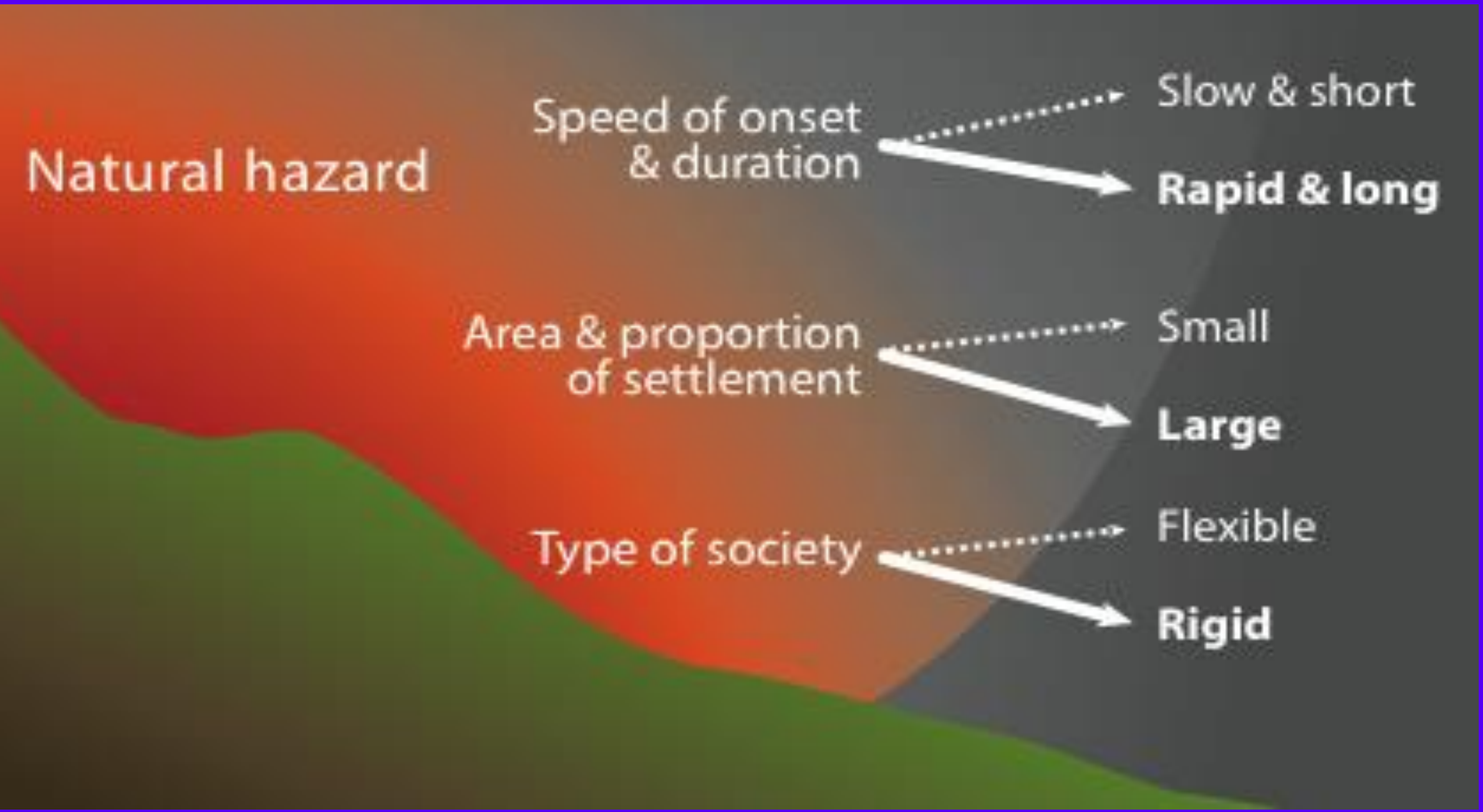
Vesuvius Supervolcano waking up signs



The number of large cities is increasing exponentially. Many of them are near active volcanoes.

Chester et al. 2001

Three factors for the amplitude of change



longer than the food storage capacity

nowhere to escape

lack of freedom to innovate

Leroy 2006

World food reserves

- 74 days according to a 2012 estimation by the United Nations

(McGuire)

- UK

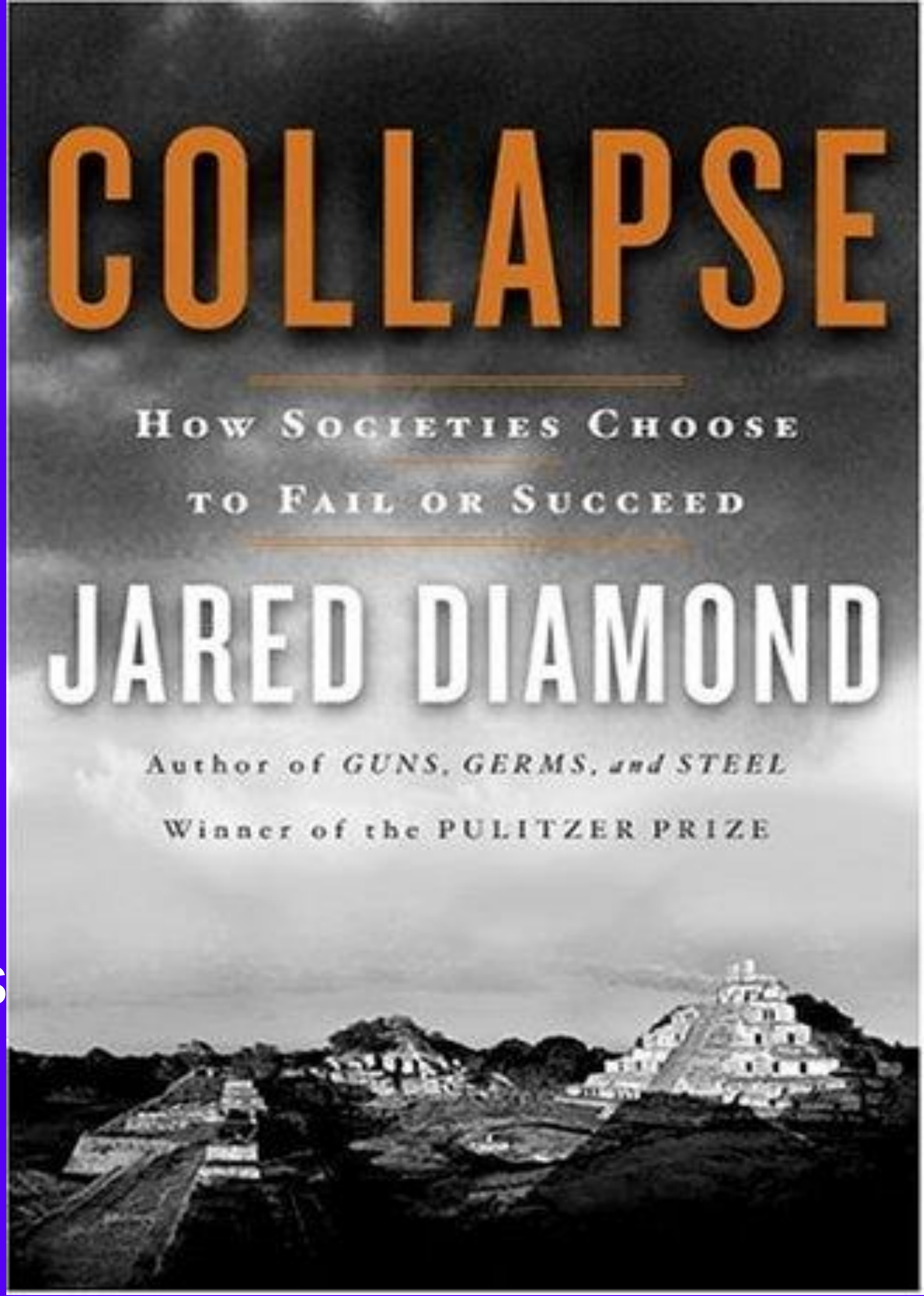
10 days

(The Telegraph in 2012)

- Very large reserves in China, but not for sharing?!

5 major causes of societal collapse:

- **environmental damage**
- **climate change**
- relation with hostile neighbours
- relation with friendly partners
- people's cultural response



J. Diamond 2005

Example 1

- The Anasazi indians, Chaco Canyon, AD 1200
  - 4: drought, deforestation, exchanges between friendly groups, culture

Example 1: Usual situation

- Cut trees for firewood and buildings
- Cultivation of corn, squash and bean
- Relatively dry area, irregular rainfall
- Nutrient-poor soils

=> move to another area until depleted too

Collapse

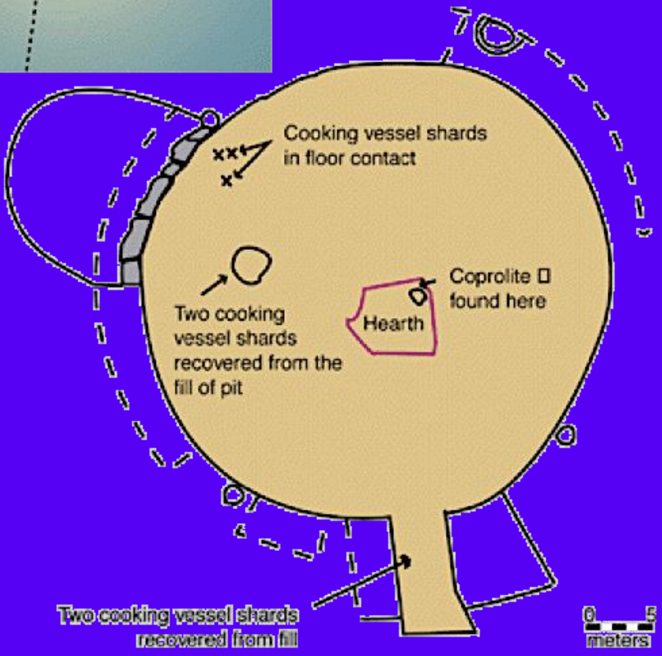
- Complete and rapid abandonment
- No where else to migrate
- Malnutrition, shorter life spans
- Increased infant mortality

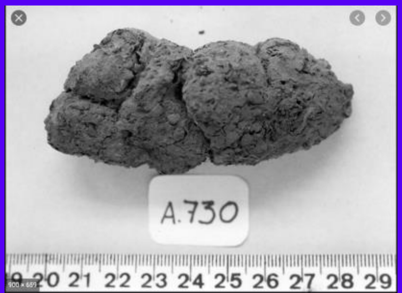
- Fights between groups

Cannibalism

before abandonment during drought, between 1130 and mid-XIII c.

human myoglobin, a protein common in muscle cells, in Anasazi faecal matter





Example 1: Conclusion

- Collapse of a society that is adapted to marginal land
- caused by
  – Environmental change
  – Climatic change (warm and dry).

- This scenario is re-occurring in the last decades?

Example 1

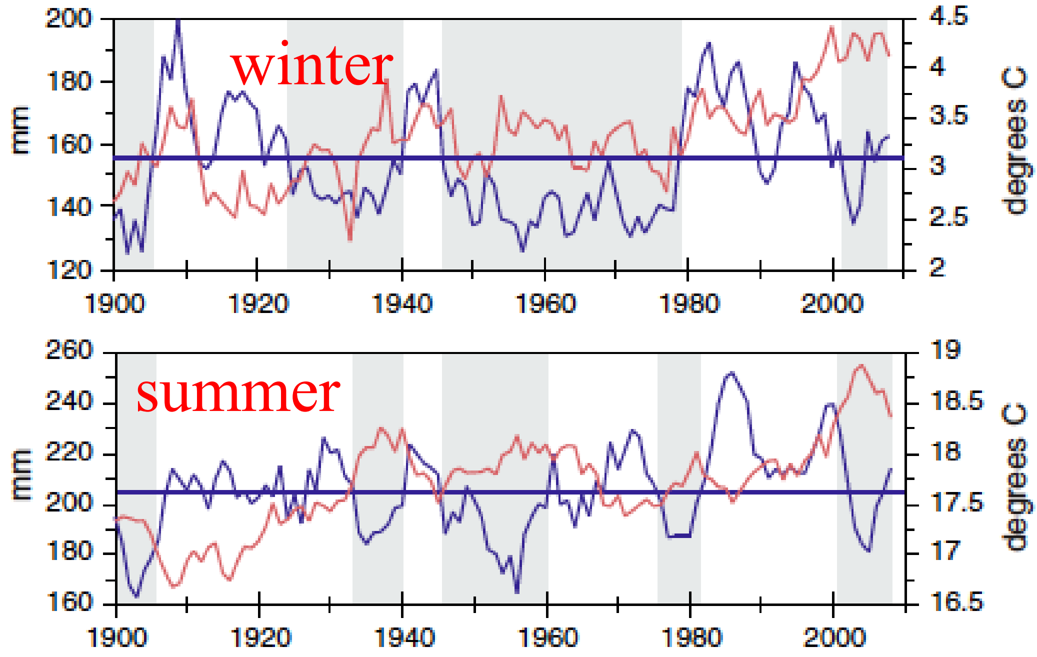


Fig. 1. Total seasonal precipitation and mean seasonal temperature averaged over Colorado, Utah, New Mexico, and Arizona (17); five-year running means, 1900–2008. Precipitation in *Blue Line* (*Horizontal Line* is the average), temperature in *Brown*. Cool season (November–March), *Top*. Warm season (May–October), *Bottom*. *Shading* indicates periods of below average precipitation.

in blue: Precipitation drop
in red: Temperature rise

Woodhouse et al., 2010 PNAS

Colorado River flow drop

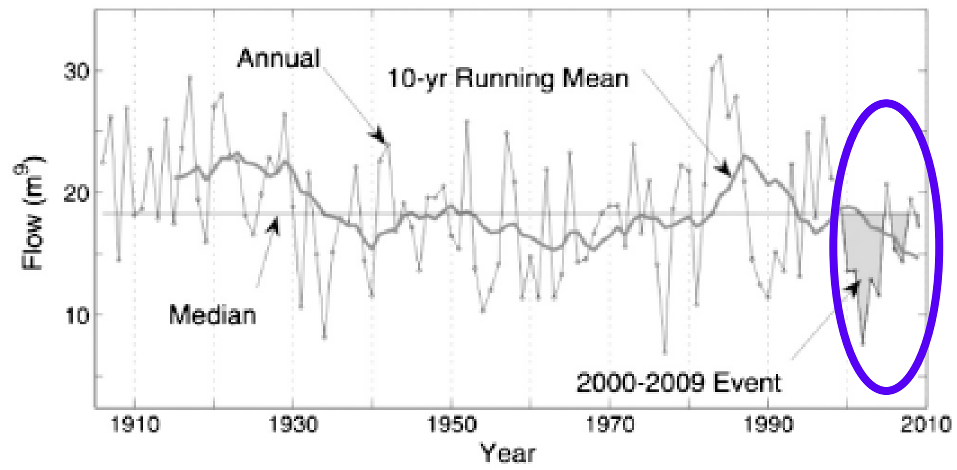
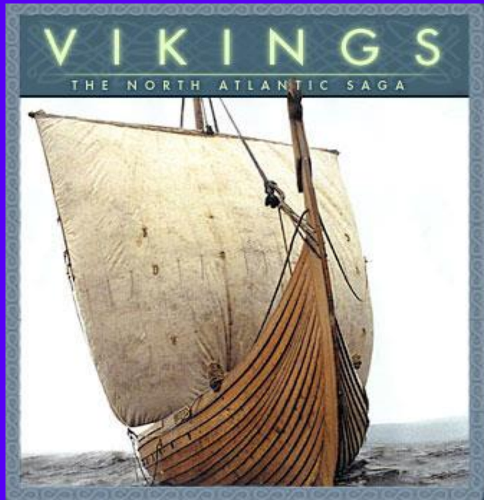


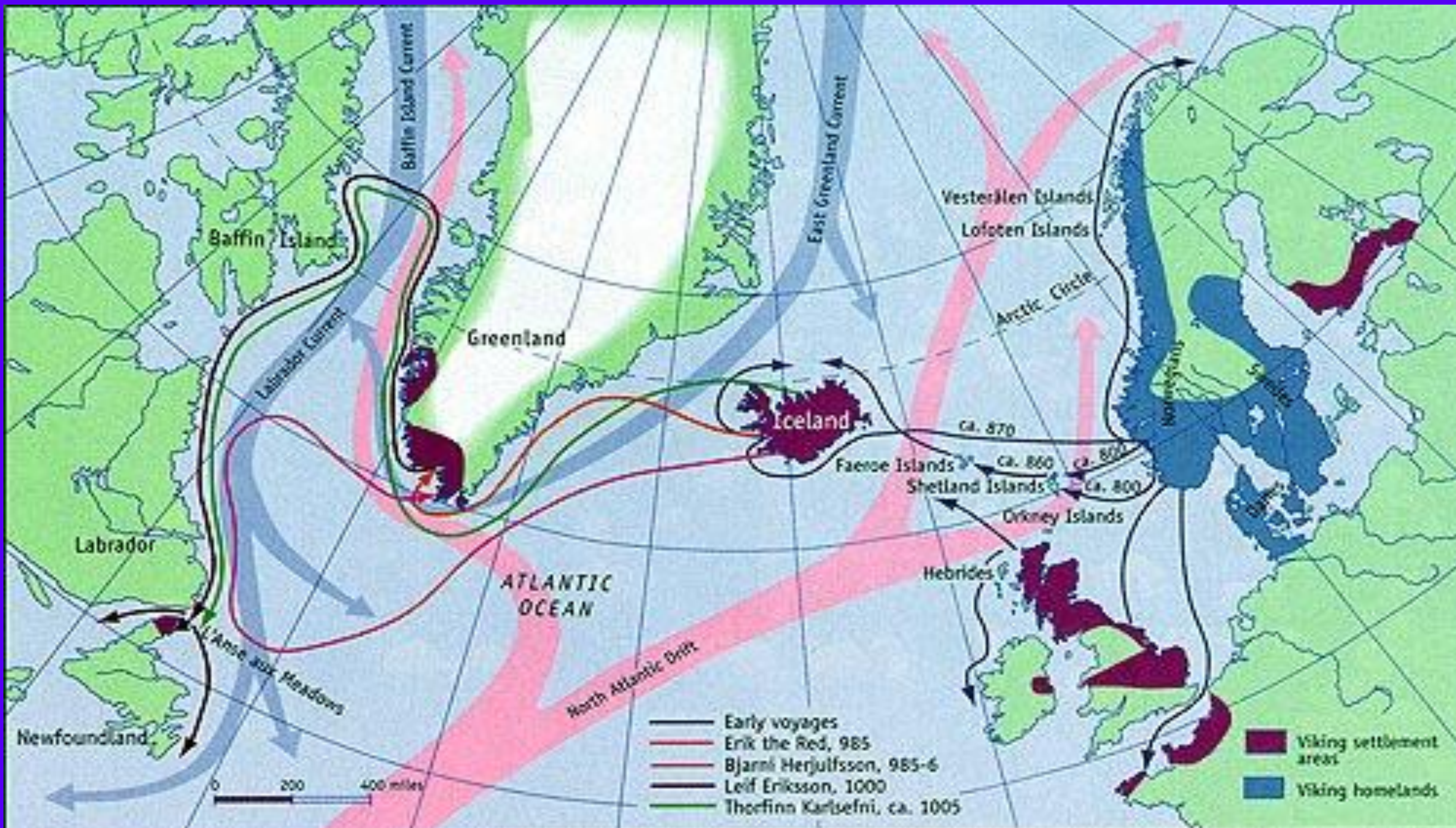
Fig. 4. Observed annual flow of the Colorado River at Lees Ferry. *Horizontal Line* is the median of the 1906–2006 observed flows (18.32 billion cubic meters). *Light Gray* line is the 10-year running average. Observed flows are version 6.18.08 of the natural flows from the U.S. Bureau of Reclamation (http://www.usbr.gov/lc/riverops.html), appended with provisional flows for water years 2007–09 that were estimated by the Bureau of Reclamation with data currently available.

Example 2

- The Norse Greenland, AD c. 1450
  - 5: LIA, damage to environment, hostilities with Inuit, cessation of trade, culture



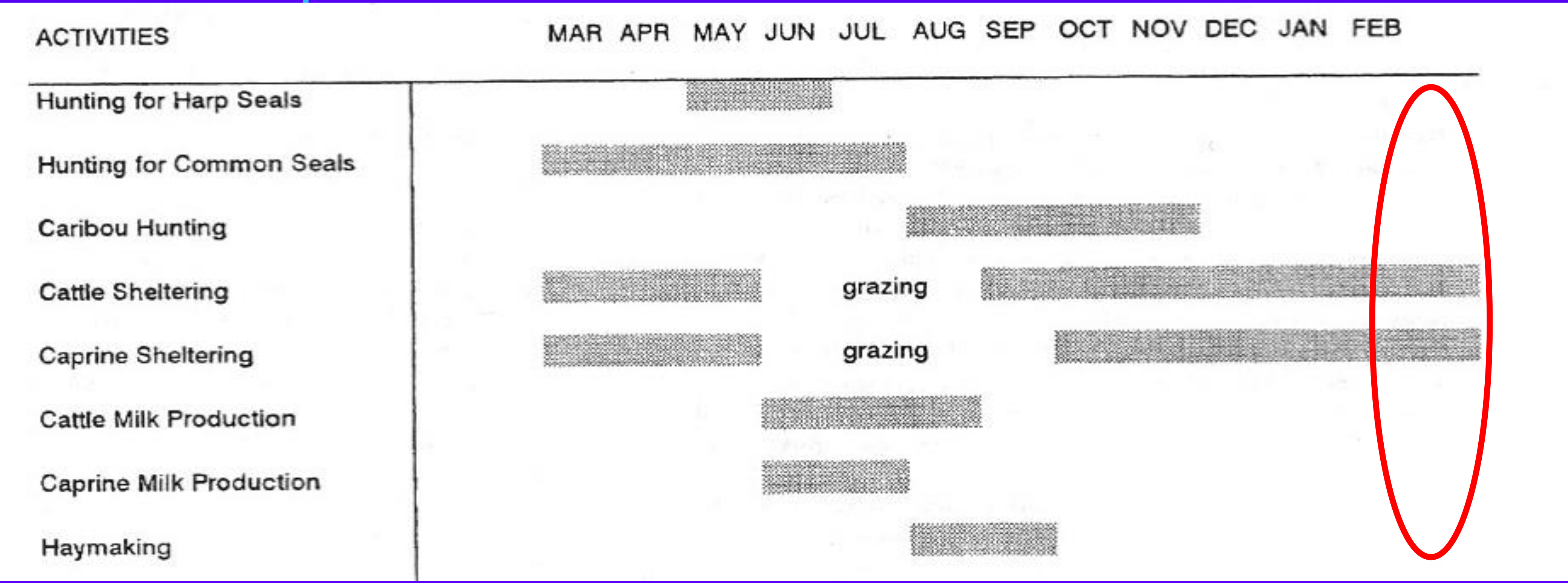
Example 2: How did they come: currents



Routes various Vikings travelled

McGovern and Perdikaris, 2000

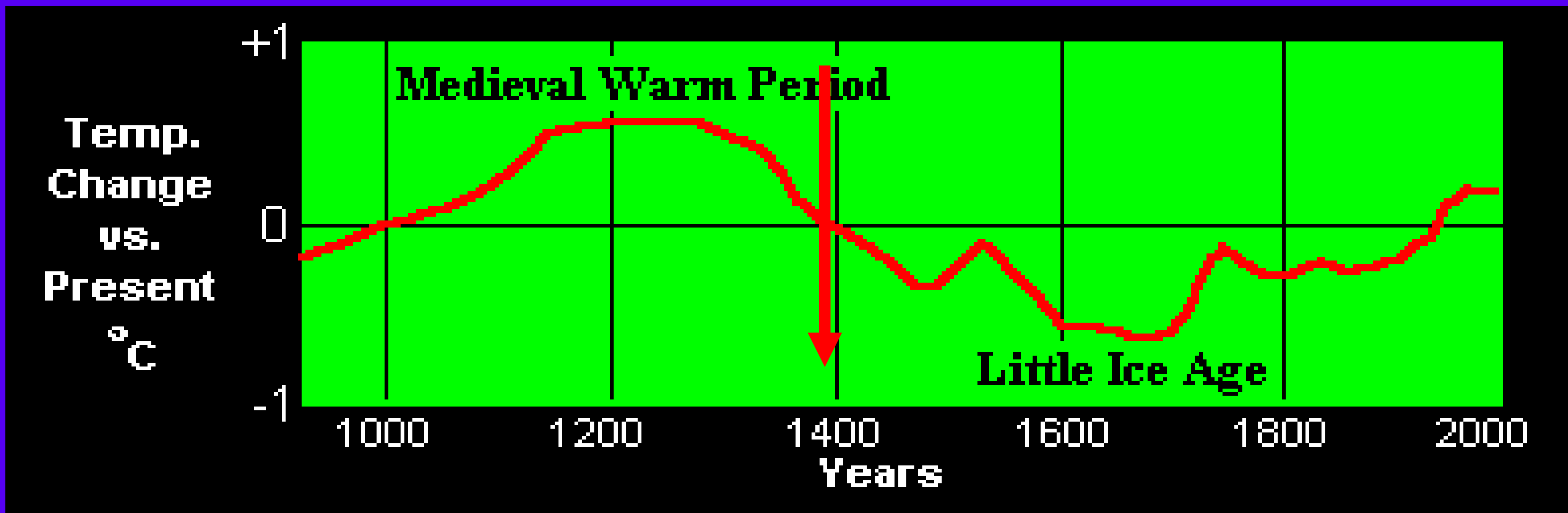
Example 2: Seasonal activities: short summer



Late winter subsistence gap between
the exhaustion of stored meat and dairy produce and
the beginnings of the spring sealing

Barlow et al. 1997 fig. 10

End of Medieval Warm period beginning of Little Ice Age



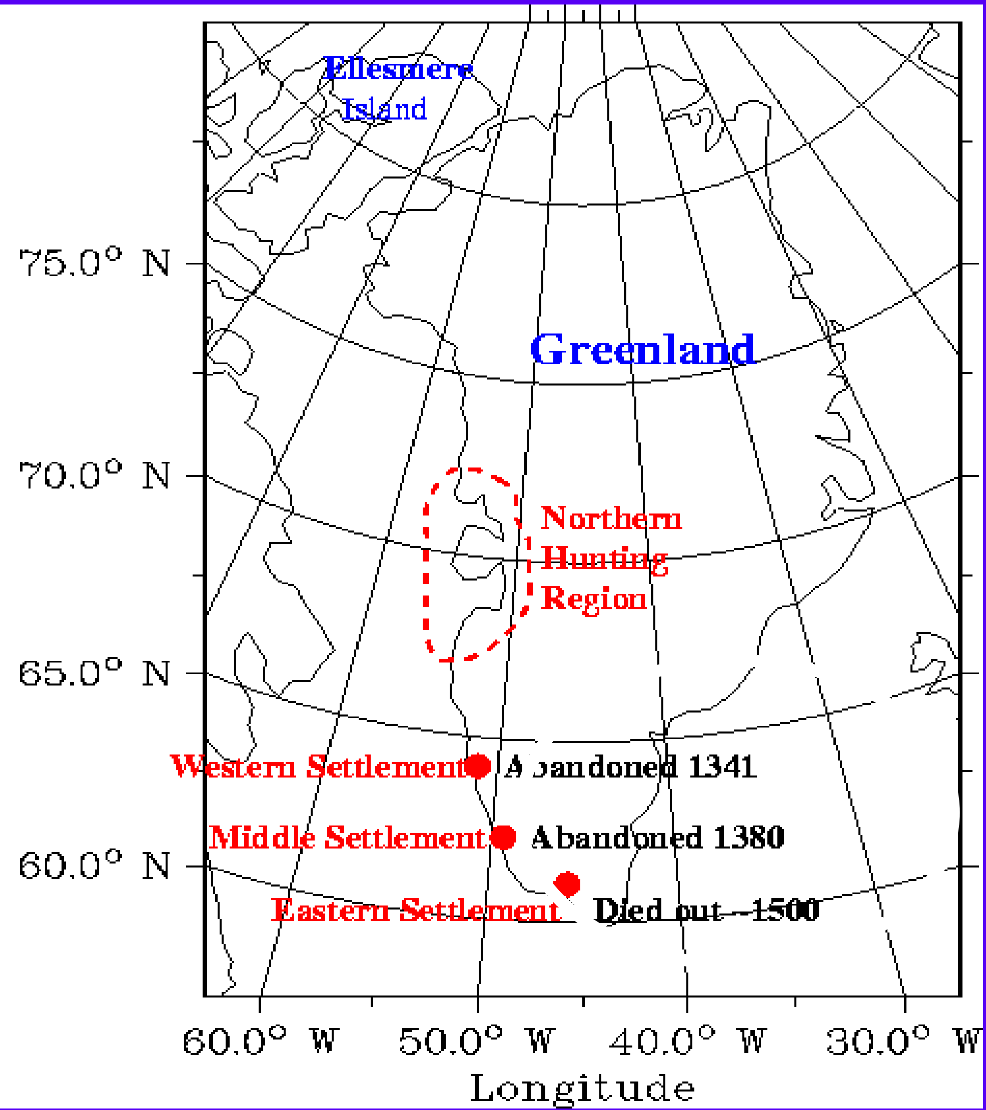
Victims of climate change

Example (2)

Causes of the Little Ice Age: XIII-XIX siècles

- Especially strong: AD 1640-1715
- Volcanic eruptions e.g. Mindanao (Philippines) in 1641
- Lower solar activity (less sun spots) – Maunder minimum
- Change in ocean currents and El Niño

The end of the Norse Settlements in Greenland



- After about 1300, the climate began to deteriorate.
- Stock rearing became unreliable, crops failed and the settlements were cut off from the outside world by sea ice for several years at a time.
- Unlike the Inuits, the Norse settlers were unable to adapt to living off the sea (where fish were still plentiful).
- The last recorded contact was in 1410

Example 2: Norse's cultural response to Inuit

by McGovern

- The Norse clung to European way of life

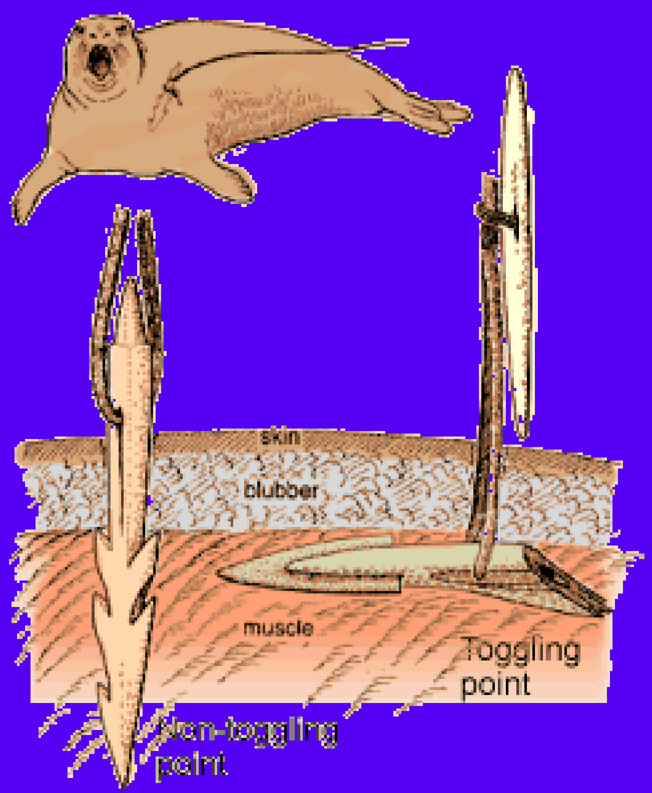
- Norse refused to learn from the Inuits
  - Toggle harpoons to hunt thru ice
  - Skin clothing
  - Skin boats

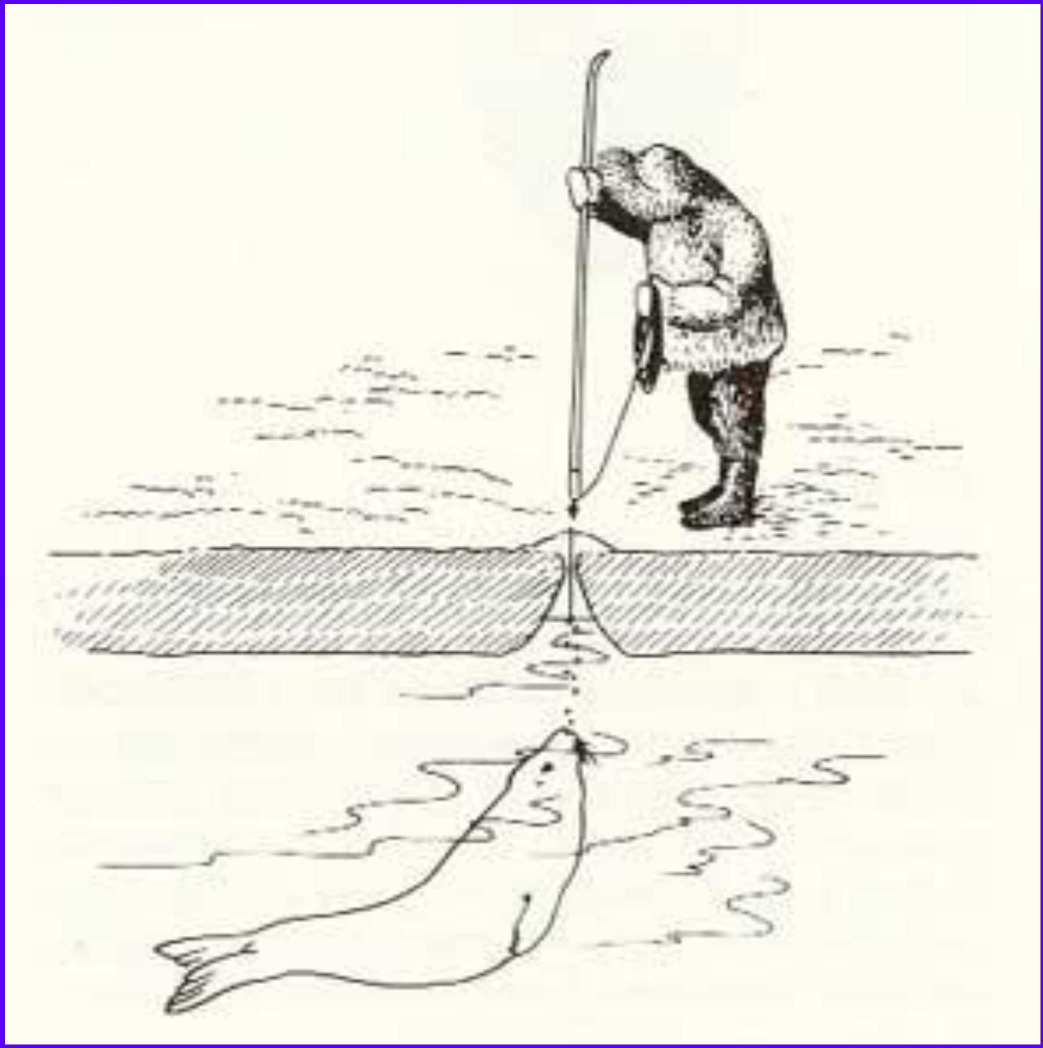
- Ethnic purity at expense of survival

www.nhne.com/newsbriefs/nhnenb66.html

Fishing tools: toggle harpoon

twists into the animal under the skin





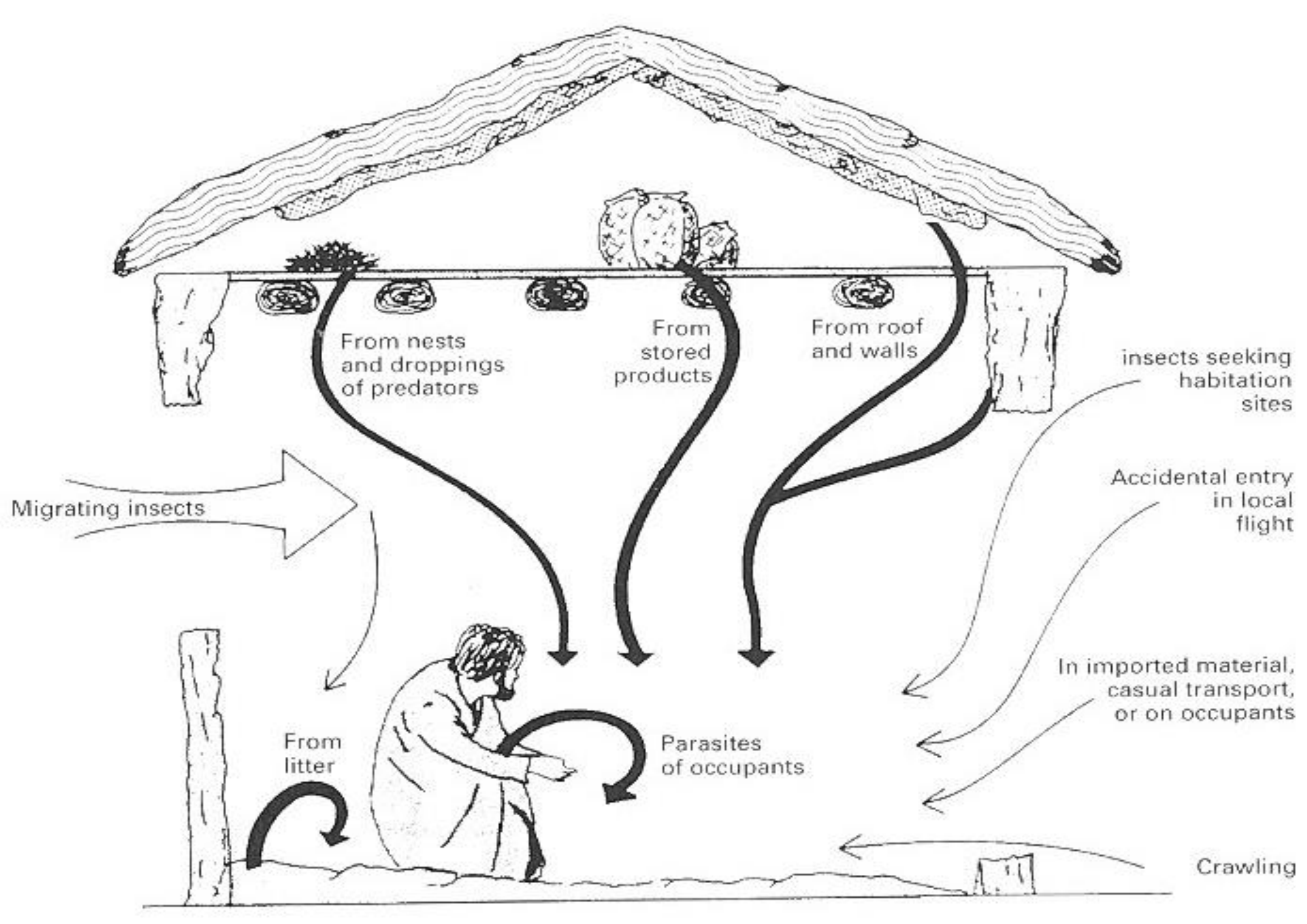
Gårdet under Sandet (GUS)

by P. Buckland and E. Panagiotakopulu

- The frozen ground of the Western Settlement provides ideal conditions for the preservation of insect fossils in the sediments which compose the remains of the Norse farms as well as parts of their surrounding landscape

- Samples
  - from the farm midden
  - from house floors
  - from organic lenses within sand deposits adjacent to sites

Sources of insect remains in human dwellings



Lowe and Walker, 1989
fig. 4.23

Some insects results

The fossil record shows that, for both Norse and Inuit, louse infestation was a fact of life throughout their existence. Fleas and louse **ever** present.

Modern human flea

Human flea

Human louse

The fly fauna of floor (Diptera) shows a succession:

1. thermophilous fauna (fire in the hearth)
2. cold fauna (no more wood)
3. outdoor sp (roof collapse)

Buckland et al., 1996

Example 3

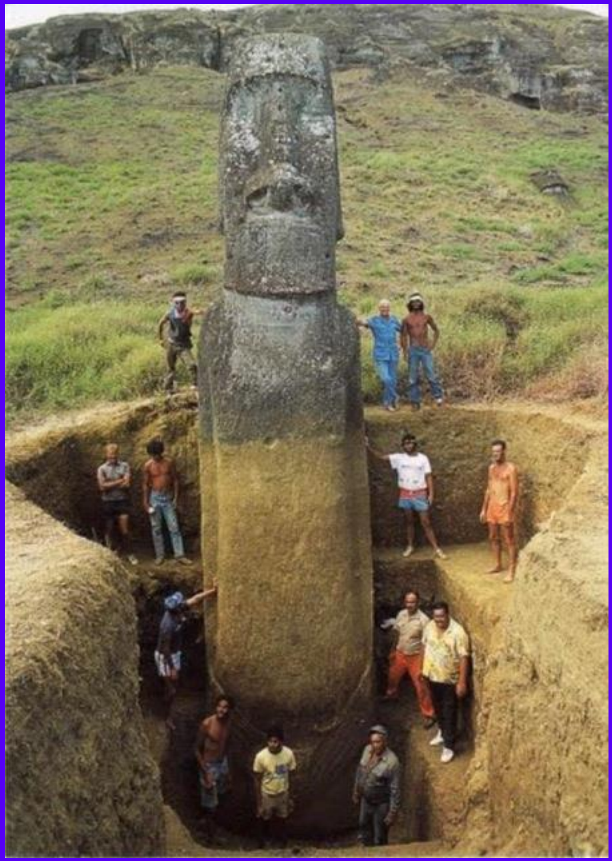
- Easter Island, c. AD 1600
  - 2: destruction of their own environment, culture

- **Location Description**
  - It is considered the most isolated inhabited island on the planet, located approximately 3700 km northwest of Santiago, Chile.
  - The nearest inhabited island (Pitcairn) is almost > 2000 km to the west.

- Its isolation makes it the clearest example of a society that destroyed itself by overexploiting its own resources

Example (3)

Ecological collapse caused by a primitive people



- A simple society.
- The island was only recently colonised by humans, c. 1250 AD (revised date).
- It was densely forested.

Example 3: Causes of collapse

- Deforestation
  - Loss of topsoil
  - Food shortage
- Destruction of bird populations
- Cultural factors

  (erection of stone statues requiring wood)
- Rat
- New hypo: disease

View of Monuments of Easter I. 1775, by William Hodges (1744-1797) www.nmm.ac.uk/upload/img/BHC1795.jpg

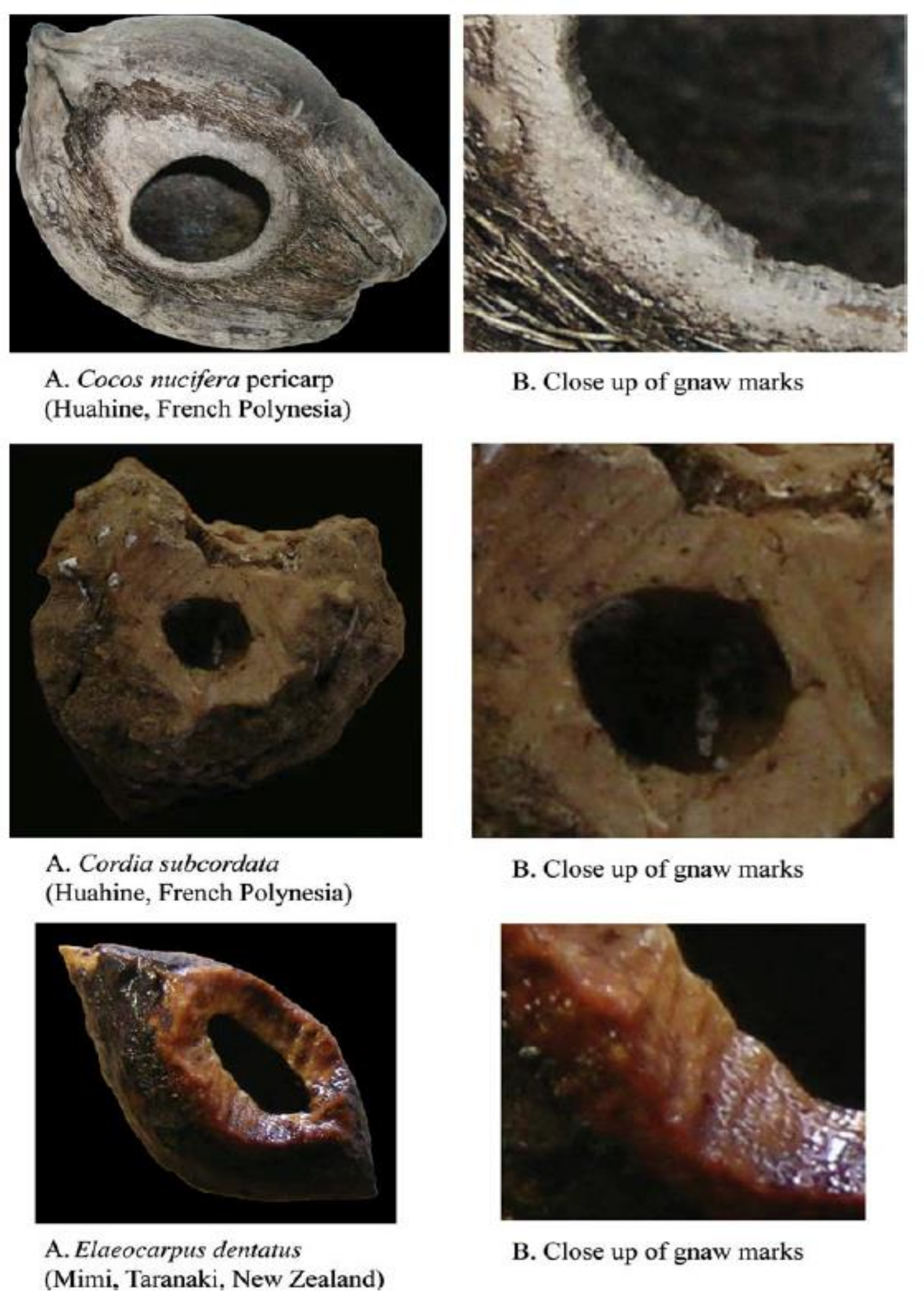
Rattus exulans from Anakena beach dune

Fig. 3. Archaeological sample of *Rattus exulans* femur.

- MtDNA shows origin in eastern Polynesia

- Genetic analysis suggests a single introduction event
- Isolation after initial colonisation

Barnes et al., 2006 JAS



Prebble and Wilmshurst 2009

Polynesian rat
Rattus exulans

Tests made in New Zealand:

By use of exclosures and measuring post-eradication responses, Pacific rats have been shown to **suppress:**

- coastal and lowland plants,
- flightless orthopterans,
- beetles, tuatara, geckos,
- shoreline skinks and some forest birds.

Towns et al. 2006

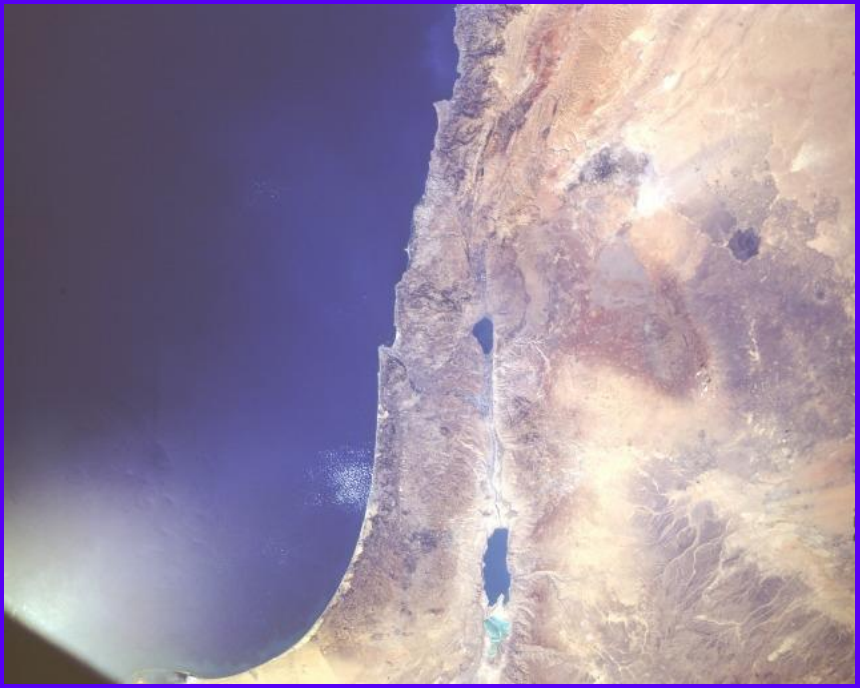
Example 4: Levant in AD400-600
a period of changes

Factors:

- Aridification of climate
- Earthquake cluster
- Invasions of the Roman Empire by ‘Barbars’
- Change from agriculture to nomadic pastoralism
- Rapid spread of Islam

Dead Sea
2 cases:

- AD 400/600 pervasive shift (deep sea core)
- Specific earthquakes (Ze’elim outcrop)



DS core lithology

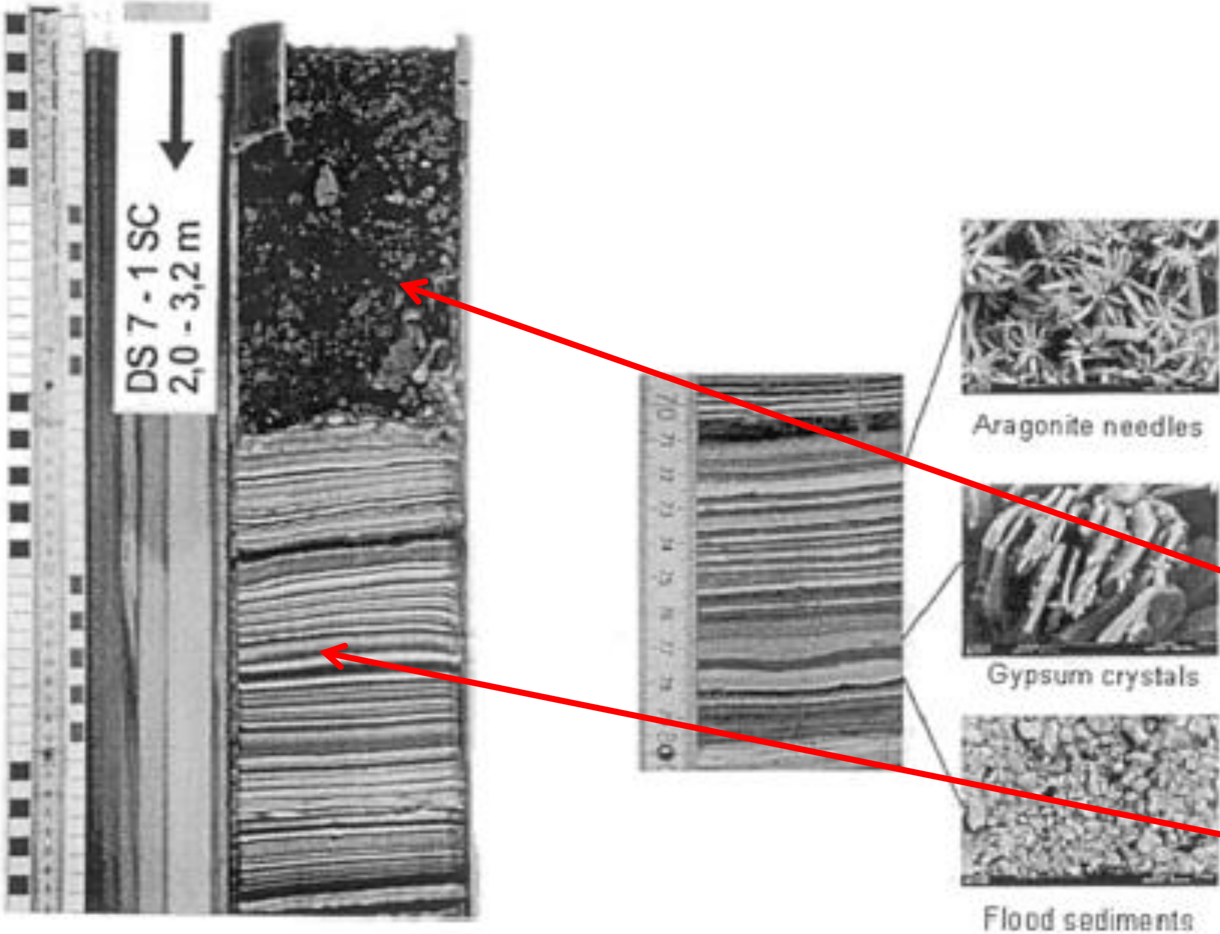


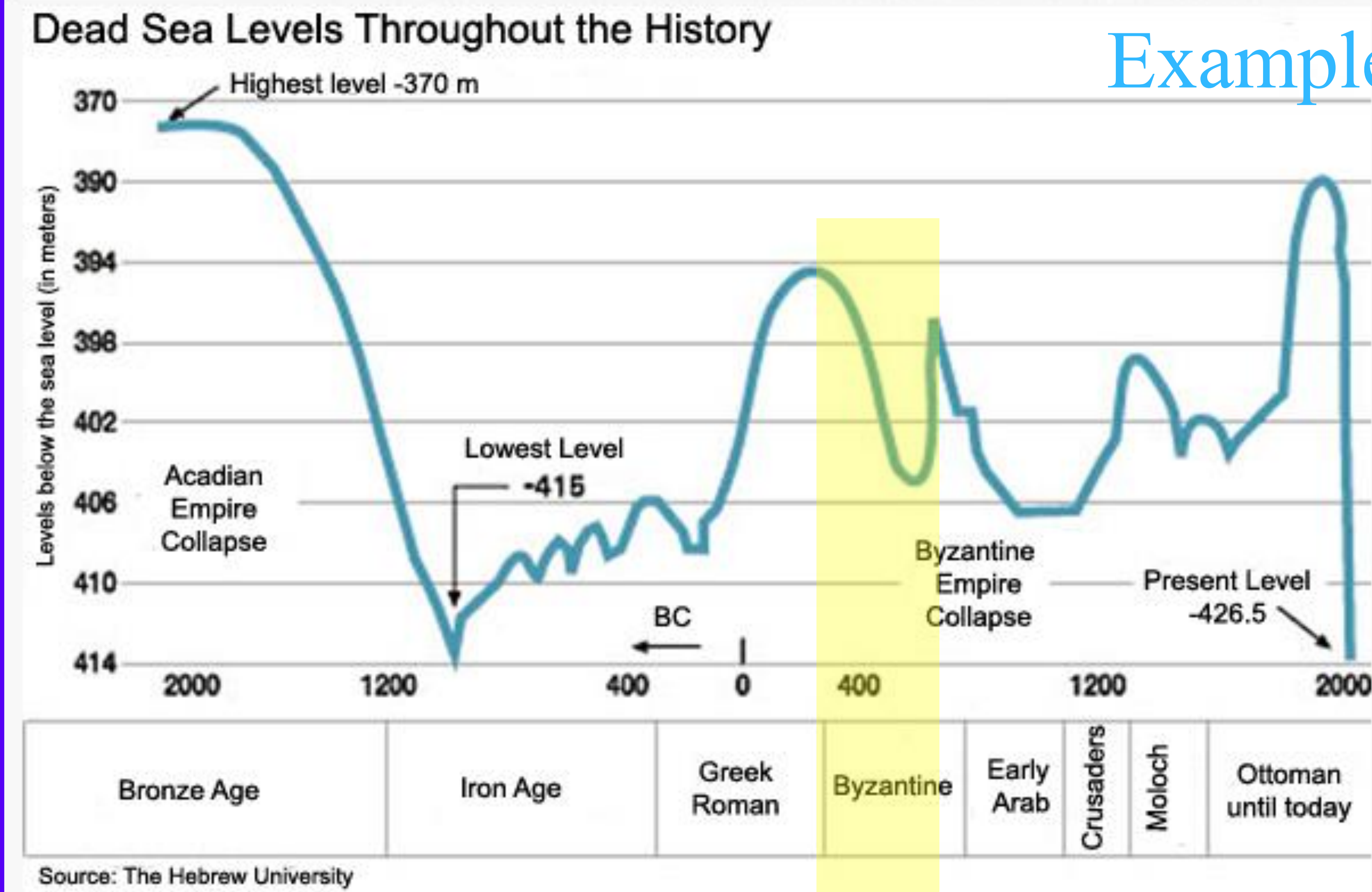
Figure 4. Left: Part of a core taken from the floor of the Dead Sea at a depth of 250 m near Ein Geddi. The bottom part is made up of layers of marl composed of annual sediment deposits of evaporitic minerals, calcite, aragonite and gypsum during summer periods, and clay and flood sediments during winter. The upper section shows a sequence of salt deposited during a time of low water levels (lower than 400 m below mean sea level) and indicates a dry period. The transition between marl and salt took place about 1500 years ago. Right: An electron microscopic section of the same core showing the composition of the layers.[19]

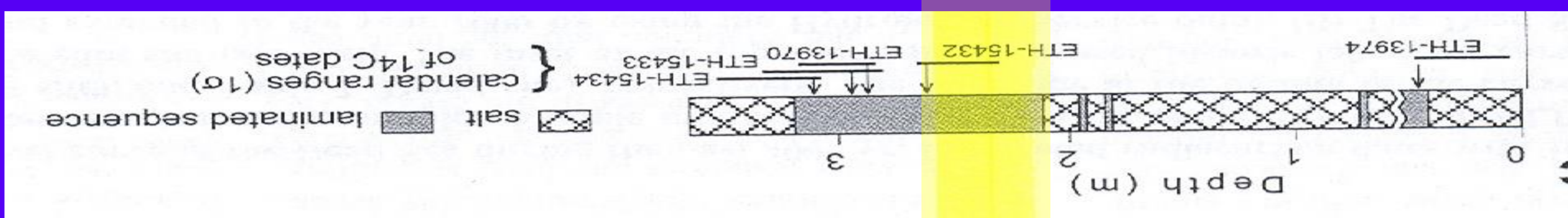
Halite: no inflow of freshwater

Laminites: Jordan river and precipitation

Heim et al., 1997

Example (4)



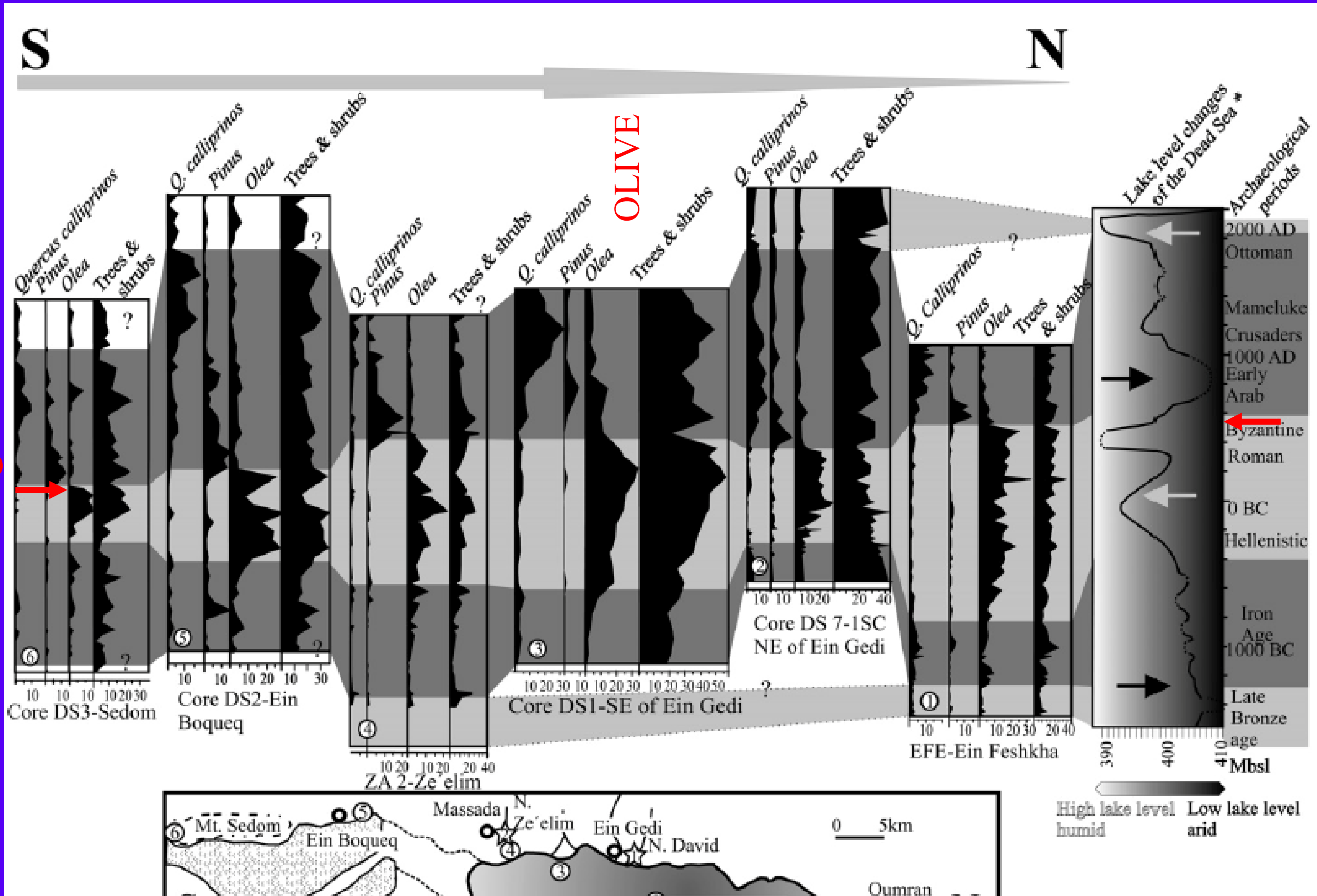


Bookman et al., 2004 fig. 8
Heim et al., 1997

Climate=> agriculture collapse

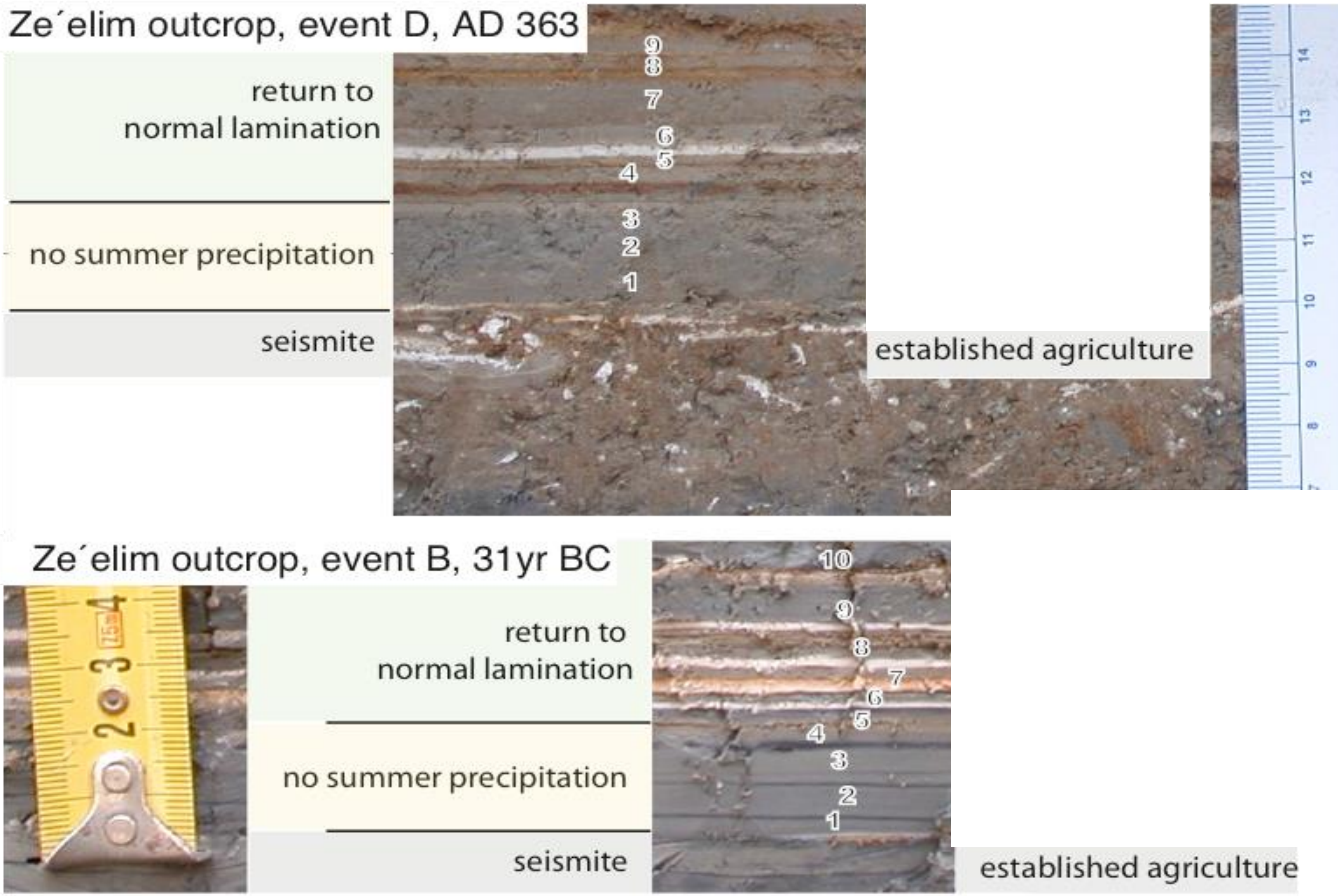
Example (4)

c. 1500 ago



Neumann et al. 2010

Brief impact of earthquakes

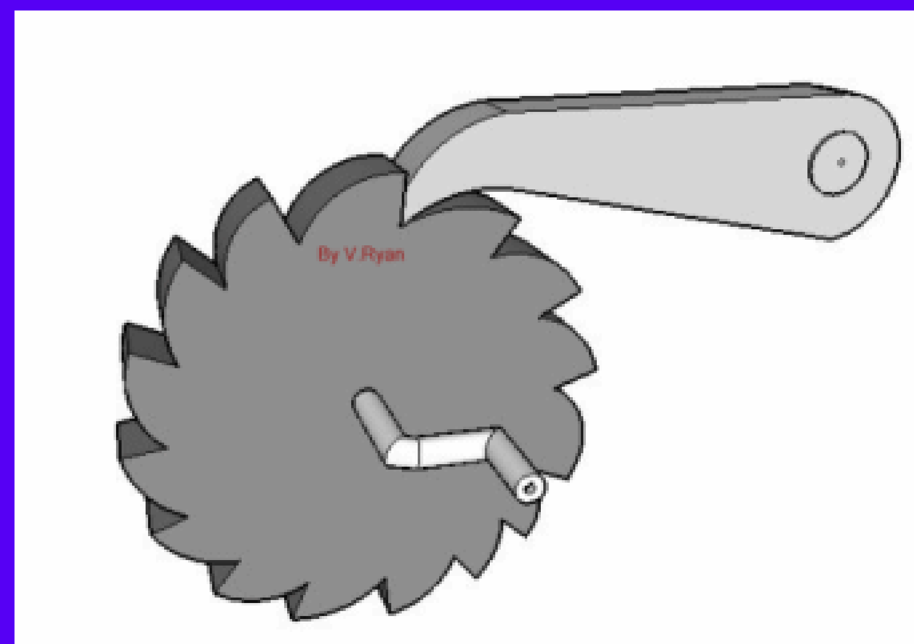


Leroy et al., subm to JOPL

Causes

- First climatic change
- Then other disasters accumulating
- Eg earthquakes
- Social changes

- => the ratchet effect



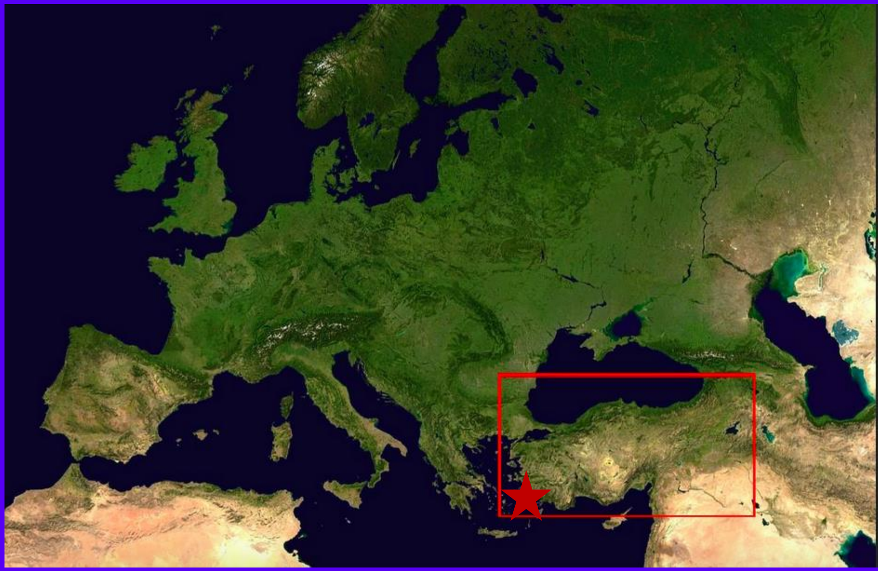
The ratchet effect

- Two or more disasters may occur in quick succession (before total societal recovery) or even at the same time.
- Following an accumulation of disasters, it becomes more difficult or impossible to return to previous conditions: this is known as the ratchet effect (Ford et al. 2006).
- Each time there is a new disaster the capacity for the society to recover decreases and it may reach a point when there is a societal collapse.

Part 2: Human response

- Wrath of god >< scientific observation
- **Milesian school, Anatolia, 6th century BC**
  - The Milesians presented a view of nature in terms of methodologically observable entities, and as such was one of the first truly scientific philosophies.

- Natural phenomena are not anymore explained solely by the will of gods
- The Milesians created philosophical and scientific rationality



The four factors of failure (J. Diamond)

A group of people may make the wrong decisions

1. Failure to **anticipate** the problem before the problem actually arrives
2. Failure to **perceive** a problem when it actually arrives
3. Failure to **try** to solve it
4. Failure to **succeed** to solve it

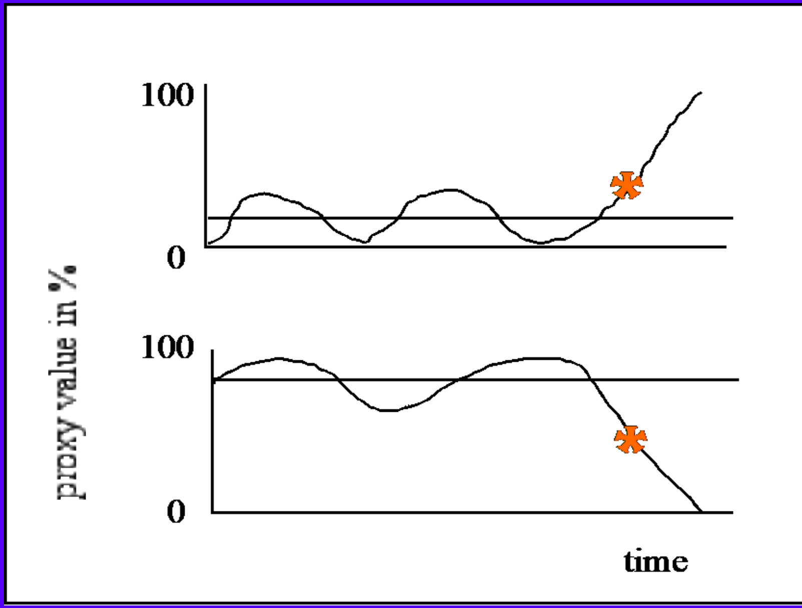
1 Failure to anticipate the problem

- **Lack of prior experience**: The Greenland Norse could hardly anticipate that increasing sea ice would impede ship traffic to Europe

- **Previous experience that has been forgotten**: Earlier droughts had occurred long before the birth of any Anasazis affected by the big drought of 12th c. AD

2 Failure to perceive a problem

- Literally imperceptible
- Distant managers
- Concealed slow trend
- Landscape amnesia



3a Failure to try to solve it

- Rational behaviour: correct reasoning, even though it may be morally reprehensible

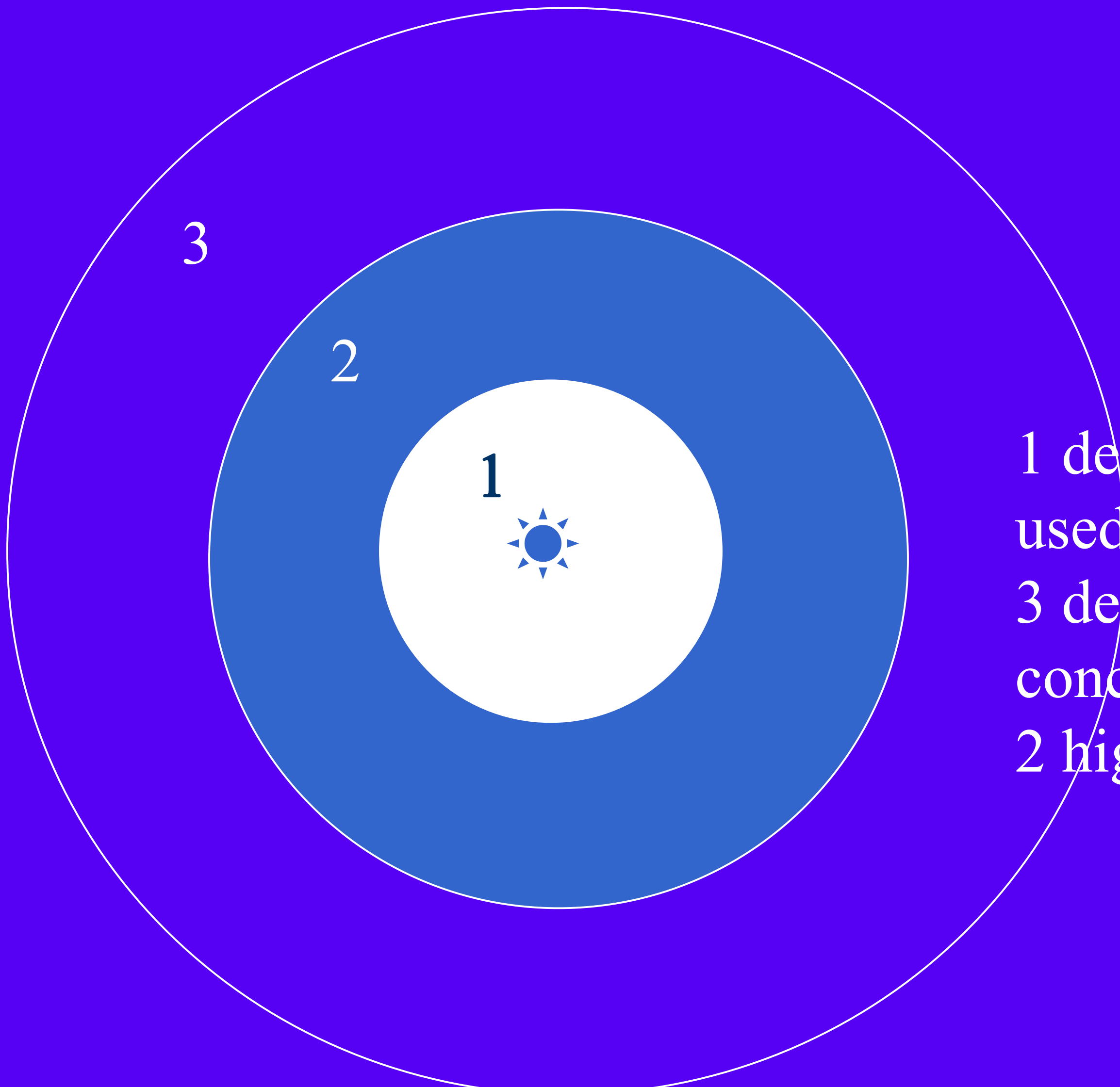
Eg: decision-making elite in power clash with the interests of the rest of the society

3b Failure to try to solve it

Irrational behaviour:

- Disliking those who first perceive a problem
  - wrong political party
- Dismissing a warning because there has been previous false alarms
  - evacuation because of volcanic eruption
- Overwhelming by imminent disaster and paying attention only to the problems on the verge of explosion
  - "the 90-day focus" of Washington DC administration
- Psychological denial
  - People downstream of a dam

The doughnut effect
eg downstream of a dam



1 denial because job opportunity and used to it

3 denial because too far away and not concerned by it

2 highly aware, concerned, active

Istanbul: rational or irrational?

- Istanbul: 15 M inhabitants, still expanding and too often without the respect of anti-seismic building regulation

- New earthquake predicted within 20 yr

- Landslides are common occurrences where new habitation complexes are been built

Succession of 12 historical earthquakes, the last one near Istanbul

Zip-like propagation

https://climateandgeohazards.wordpress.com/tag/north-anatolian-fault/

4 Failure to succeed to solve it

- Greenland's cold climate

Norse ruins at the head of Kangikitsoq

Disasters as a source of innovation and trigger for social development

£ Adaptation is costly and time consuming.

♫ Unexpected: Rapid environmental changes did not always lead to collapse of ancient civilisations.

§ It may be argued that this led to the **rise of some civilizations**, as it provides a clean slate to start with.

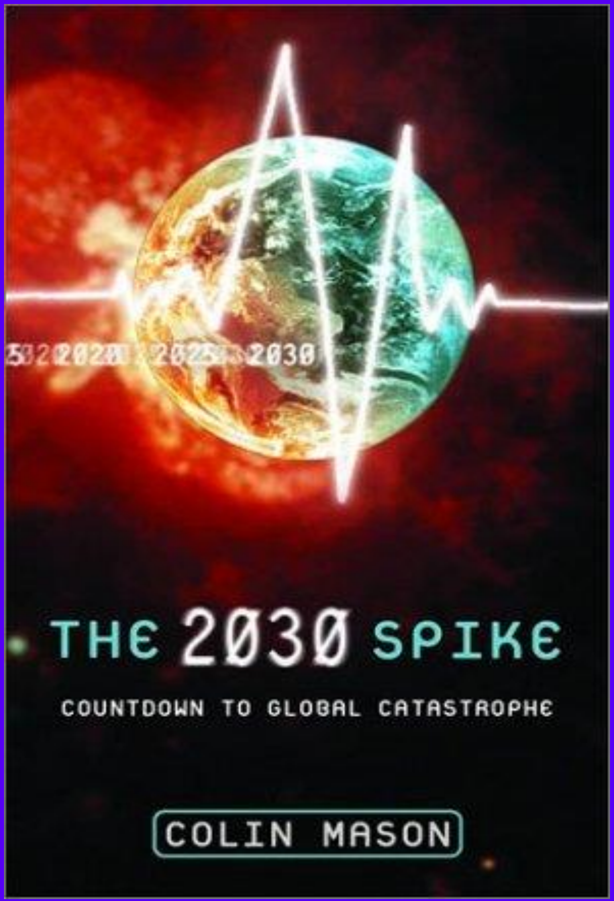
For example: the drying of the Sahara led to the emergence of the Egyptian dynastic civilisation, and others that encouraged the development of urban centres.

It has been proposed that the earliest complex, highly organised, state-level societies emerged at a time of increasing aridity throughout the global monsoon belt.

Brooks 2006

Part 3 Relevance & future

Prediction & mitigation



Catastrophism vs the science of catastrophes

No lesson learned?

After the disaster of the Indian Ocean in 2004 rebuilding villages and replanting fields **too often exactly where they were!**

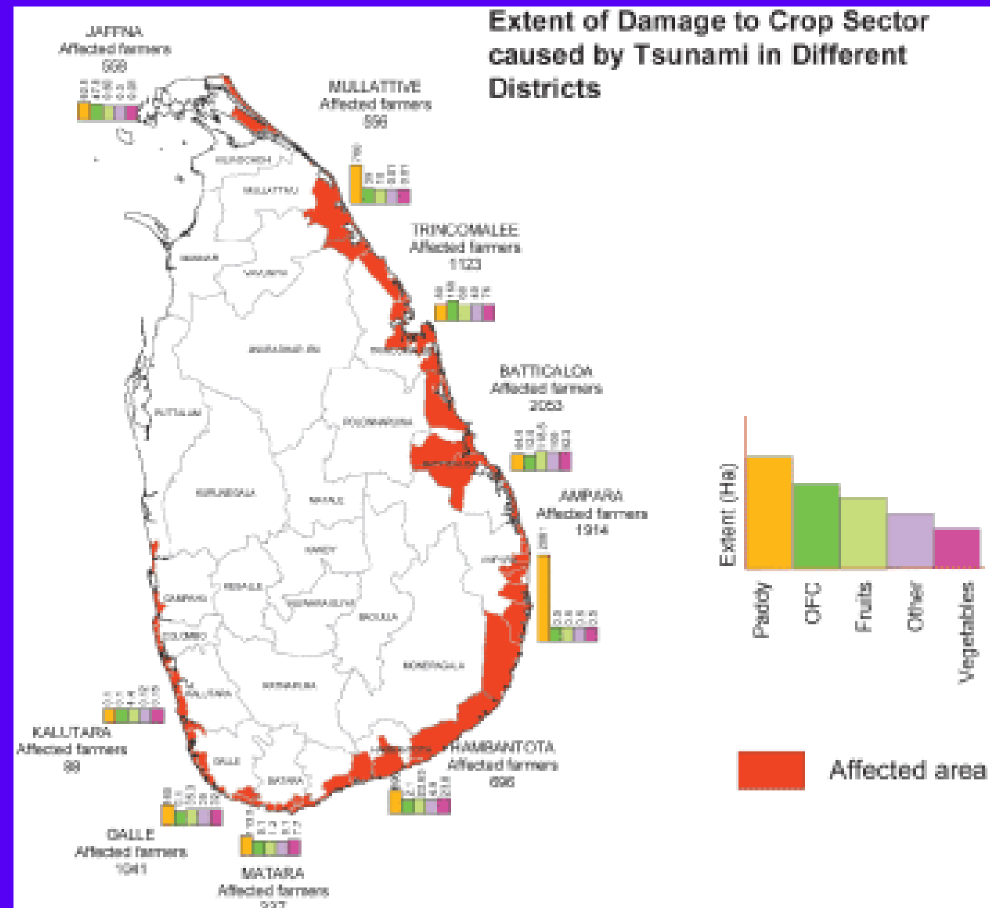
Tsunami 2004, Sri Lanka, from http://www.tsunami.org

The case of Sri Lanka

- No building along the coast on a strip 100 to 300 m wide = Project proposed by the party at government now

- Opposed by opposition political party that is in favour of better quality infrastructure

- => public consultation to determine some zones for no reconstruction in high priority



Solutions?

- Ancient societies could declare a land impure and create a **myth** that would keep people away and teach them to respect nature

- Some cultures may adapt to a risk incorporating a strategy to avoid risks in their cultural organisation

Responses: origin of the word taboo

The new Zealand Maori populations are exposed to a frequent volcanic activity in the North Island.

Their culture can adapt to risk by establishing a tapu (taboo) over areas which were clearly at risk.

Maori legend tells of catastrophes which befell those who broke these tapu

These areas only appear to have been entered when the perceived benefit was particularly high, or the threat from competing clans was severe,

necessitating the need to balance one risk against another.

Grattan 2006

Responses of inhabitants to Pinatubo in 1991

In the Philippines:

Recurrent dangerous lahars and cyclones

Response by the Bacalors was novel and entirely unanticipated.

A large proportion of the population of this town preferred to stay and adapt to the threat rather than relocate to other areas.

In some cases the response to the threat was an architectural one: houses were raised on concrete stilts, perhaps several times

Houses were extracted from the mud by cricks

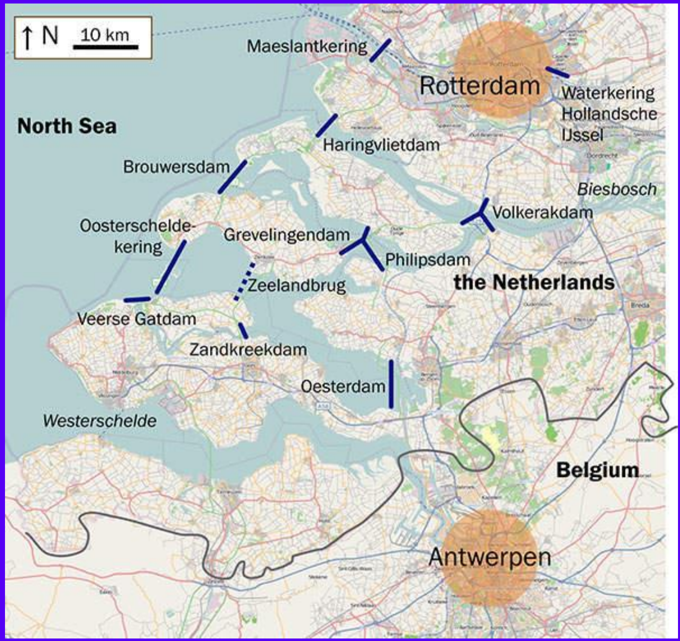
Book by Grattan and Torrence

Grattan 2006
Gaillard 2008

Physical, geological solutions

In the XXIst century, we must try to find modern solutions with **politicians/end-users closely working with scientists**

- Technology
  - the Dutch dams against flooding



- Monitoring of the environment
- Understanding of mechanisms and long-term prediction

=>Eg: Creation of nature parks with limited habitations

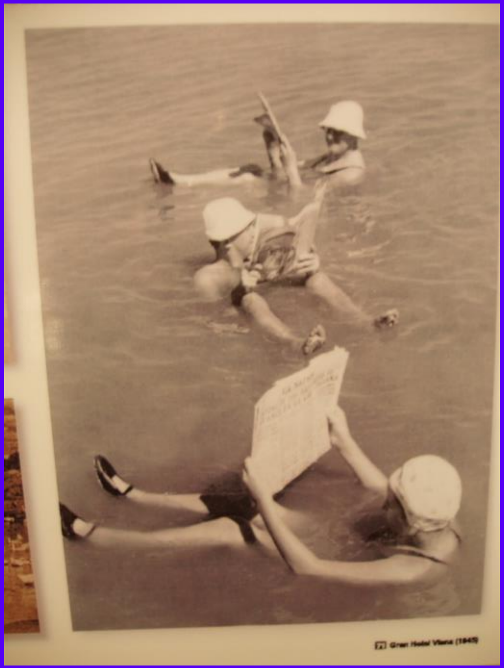
=>Eg: Realistic preparedness plans

Education

- Bridges between disciplines
  - Attend same meetings
- Bridges between scientists and wide public
  - A new quality bridge for info transfer
- Education of people
  - Starts early at school

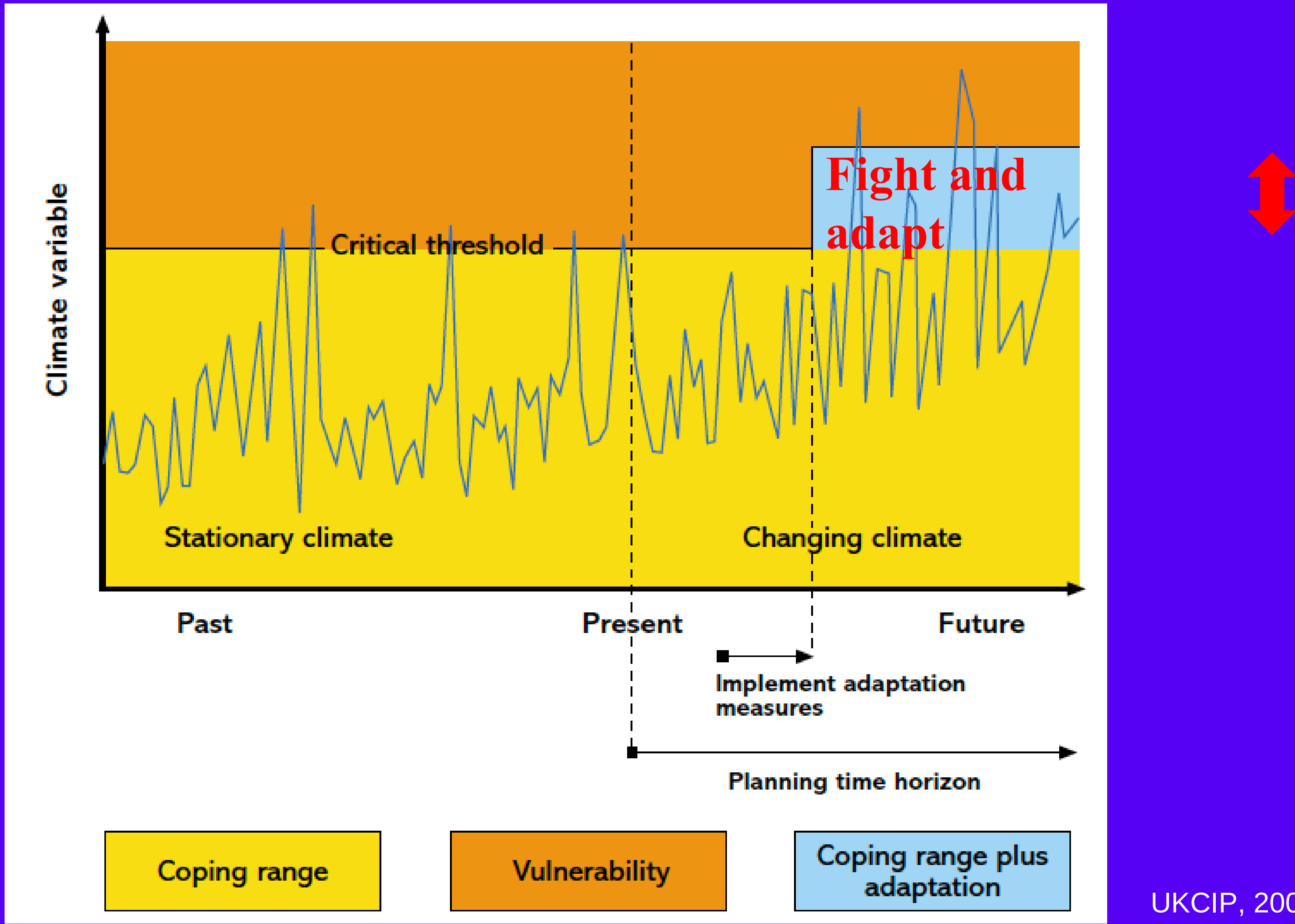
Science communication

- Example: a success story in information transf
- when the geologists came from the village wh disaster is taking place. People are listening to integrate geoscientific data in the building plan
- => **participatory approach** Leroy et al., 2010



Dr Eduardo Piovano

Adaptation



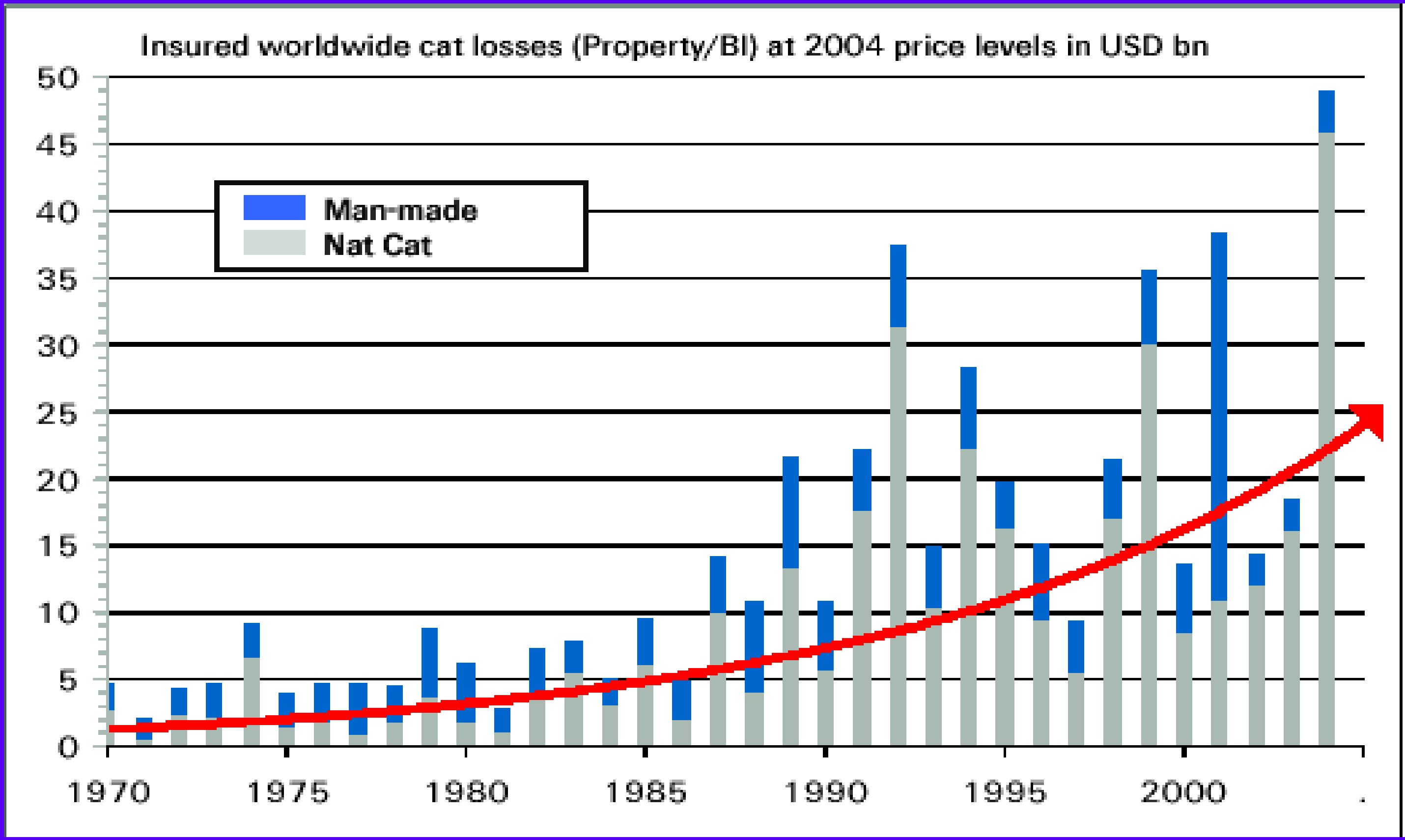
UKCIP, 2003

Social and political

- **Ready to drop core values**:
  - religion
  - source of income/energy
  - ideal location
  - hierarchy
  - nationalism/racism
    - Eg: the Norse despising the Inuits
  - population movement
    - Eg: rebuild New Orleans elsewhere

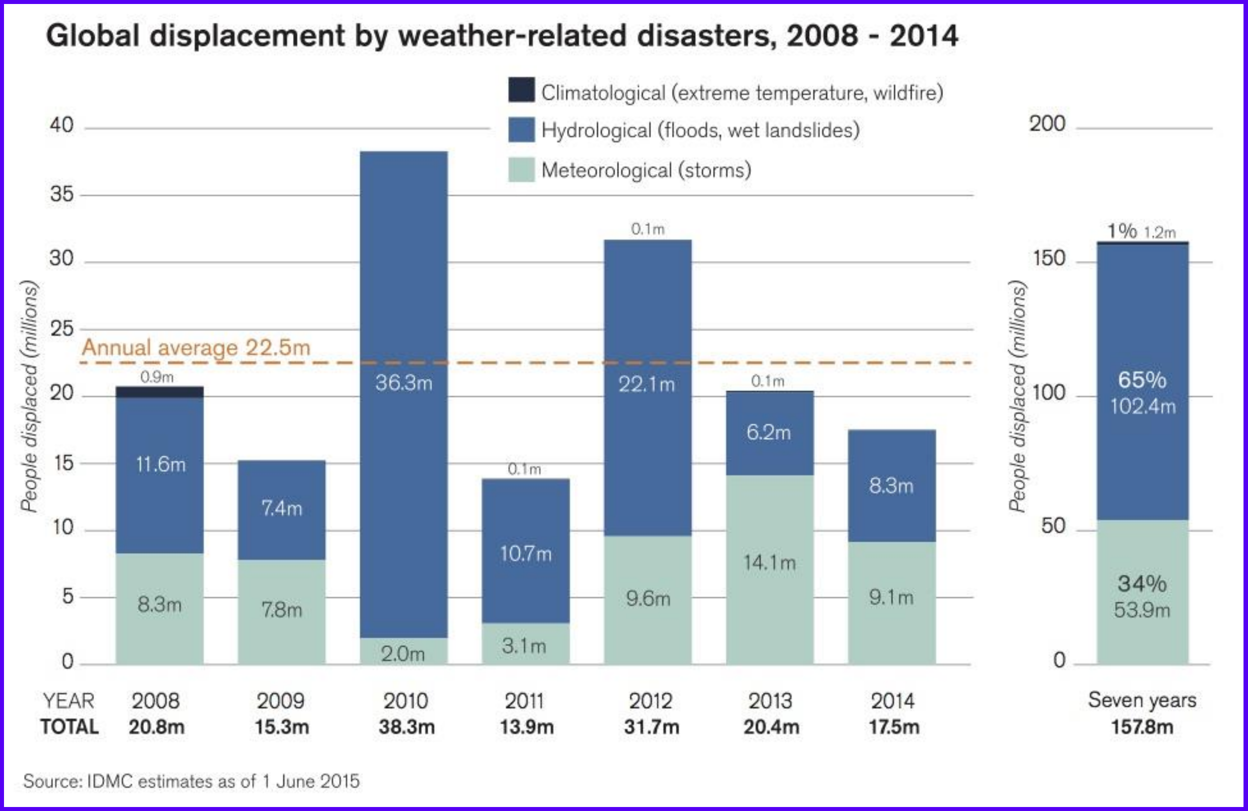
New forces

- People go where jobs are
- Insurance companies = messenger of impacts thru terms and price



www.itc.nl/unu/dgim/unedra/refresher/_docs/ guest_lectures/20_09_2005_Swiss_Re_hazard_modelling.pdf -

Population displacement

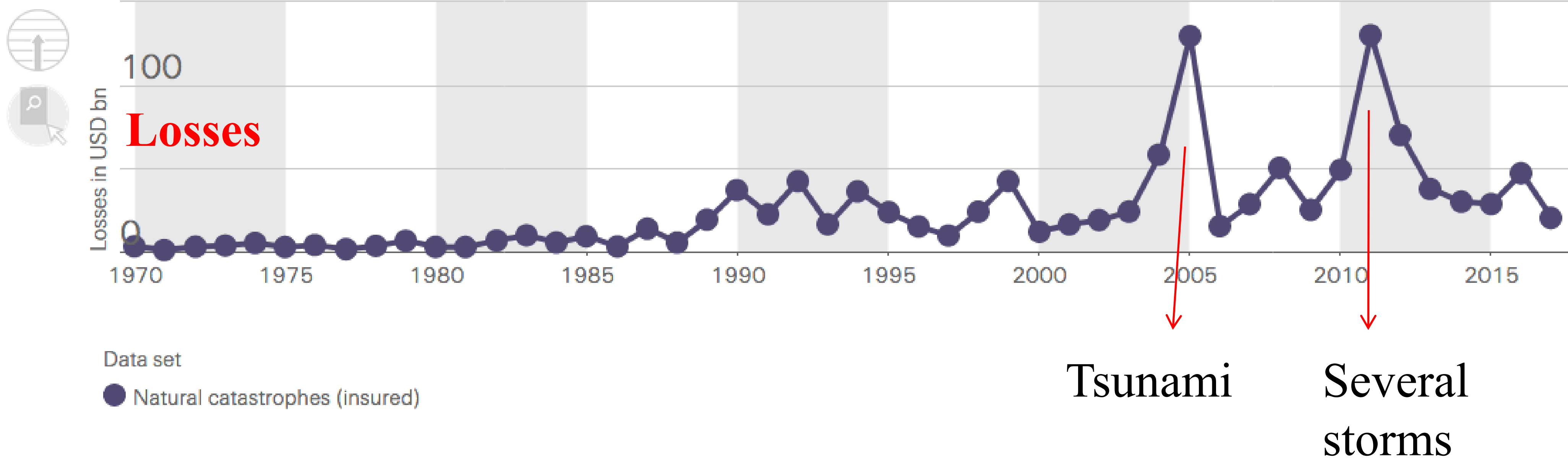


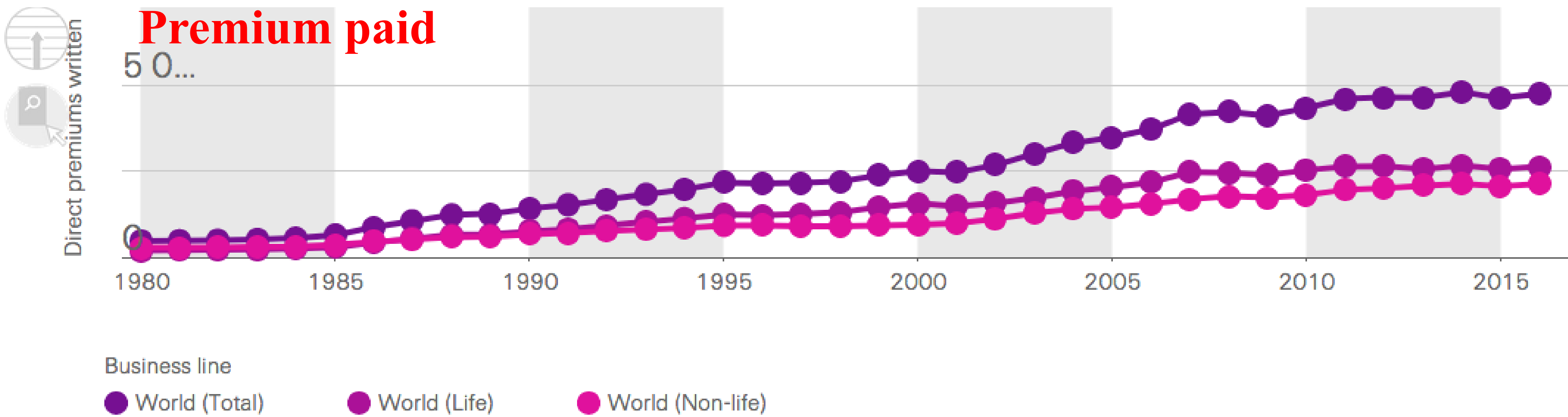
- 90% in developing countries
- Mostly in East Asia and the Pacific

https://public.wmo.int/en/resources/bulletin/disaster-related-displacement-changing-climate

New forces => economical

- Nowadays, governments cannot any more force people to move. Thus only voluntary displacements :
  - Displaced people go where where are jobs
  - The insurance compagnies = messenger of the impacts via conditions and costs





http://www.sigma-explorer.com/

Is our society more or less resilient?

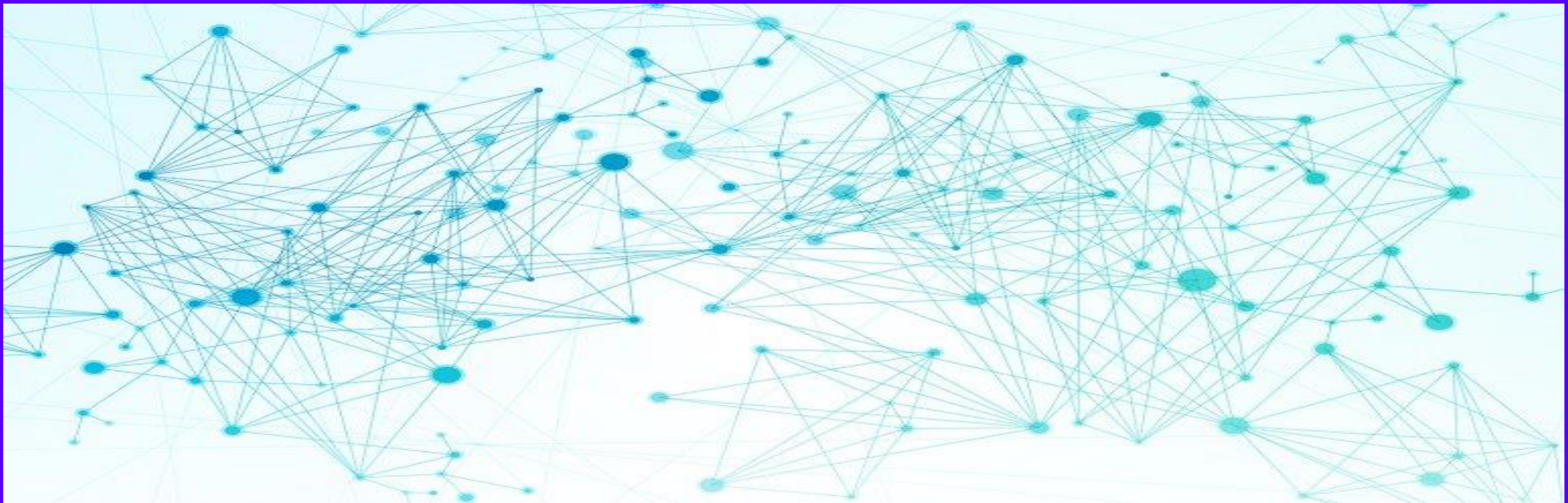
- Resilience = the capacity to recover quickly from difficulties
- We rely more on technique: However we do not know how to catch a rabbit, skin it and cook it on a wood fire
- Are we more fragile?
  - Eg volcanic eruption and disruption to air traffic
  - Eg frost and electric lines broken

Leroy 2013

Resilience? We are interconnected.
Is it always for the best?

- Of the 5 largest power failures in the world in terms of number of people affected,
- 4 have resulted from the cascading effects of localized outages due to poor weather in a rather small area
- eg Southern Brazil in 1999 (75 million people affected) due to a lightning strike

Leroy 2013



Population growth and marginal areas

Because of population growth, increasingly marginal or hazardous environments become inhabited

- the flanks of volcanoes
- landslide-prone areas (e.g. in the Caucasus)
- floodplains (e.g. the Ganges-Brahmaputra Delta),
- low-lying or even subsiding coasts (New Orleans and parts of The Netherlands)
- areas of uncertain rainfall

(Sahel)

Conclusions

- 3 factors contribute to the amplitude of a disaster + Ratchet effect
- 5 causes of collapse
- Why a society chooses to fail? 4 factors
- Forces to move population
- Are we really so resilient?

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