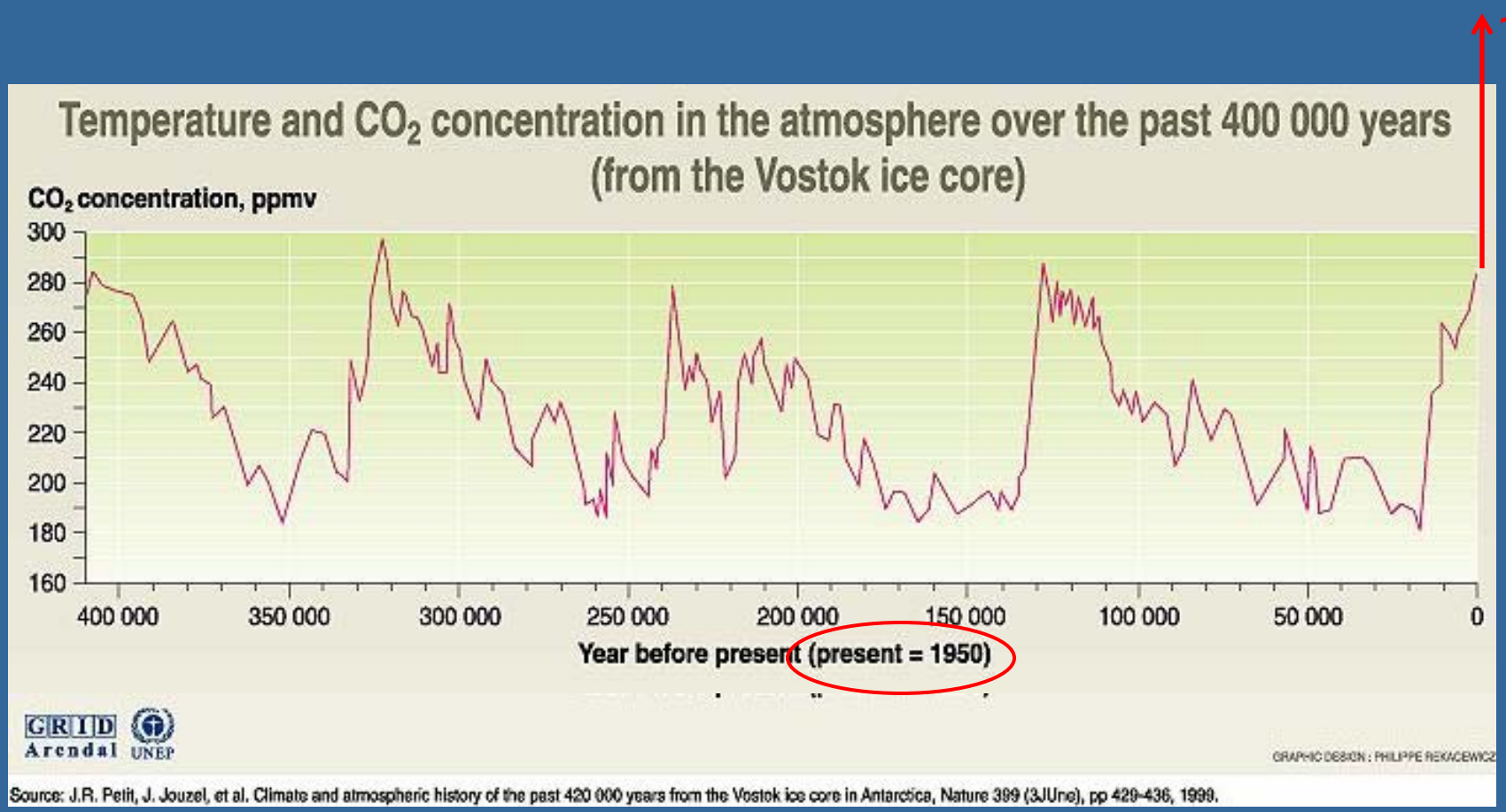
Adapting Management to Climate Change

Dr. Lara Hansen, Chief Scientist, WWF Climate Change Programme


~385
Temperature and CO_2 concentration in the atmosphere over the past 400 000 years
(from the Vostok ice core)
CO_2 concentration, ppmv
300
280
260
240
220
200
180
160
400 000
350 000
300 000
250 000
200 000
150 000
100 000
50 000
0
Year before present (present = 1950)
GRID Arendal
UNEP
GRAPHIC DESIGN : PHILIPPE REKACEWICZ
Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

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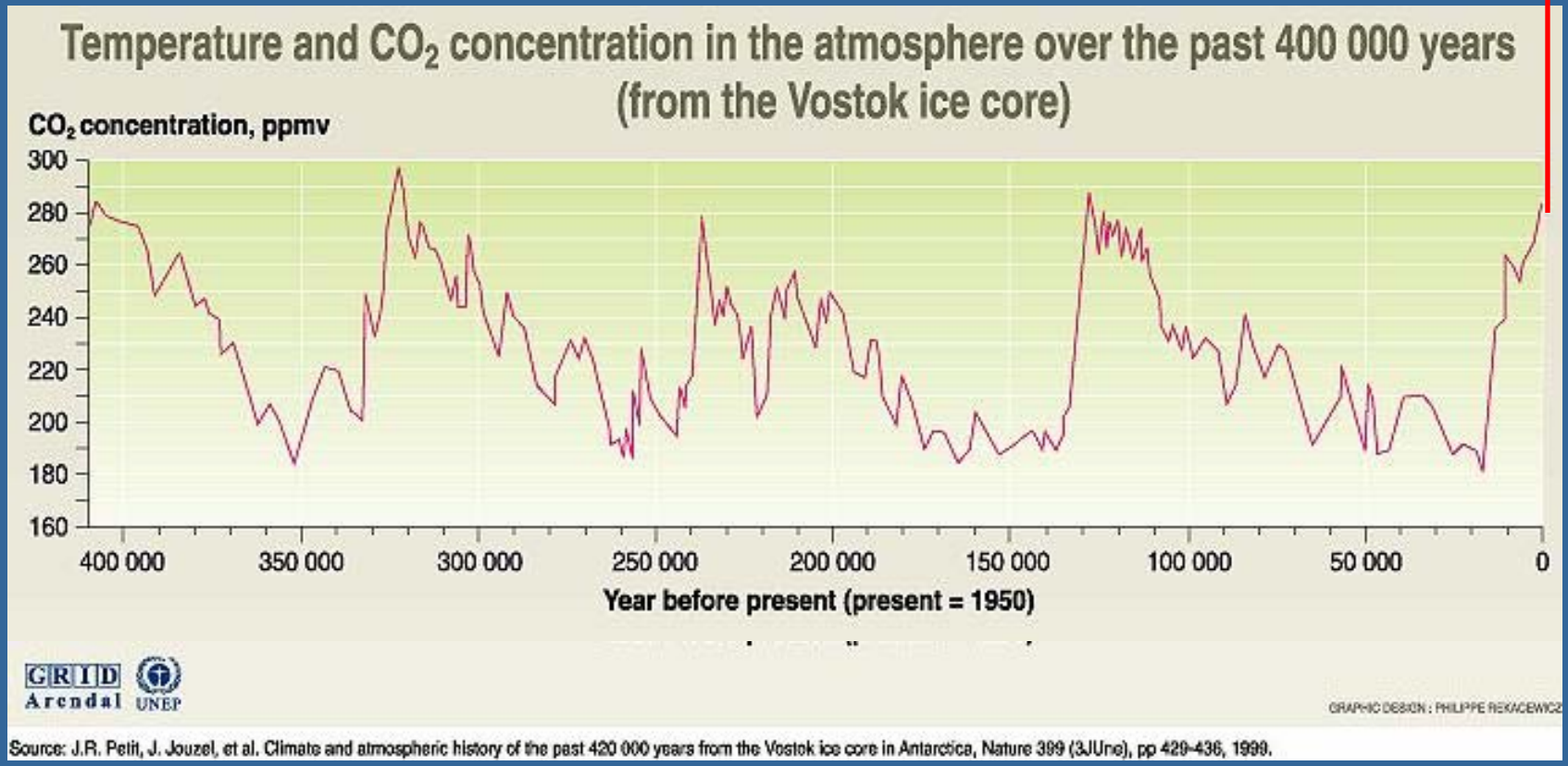

Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

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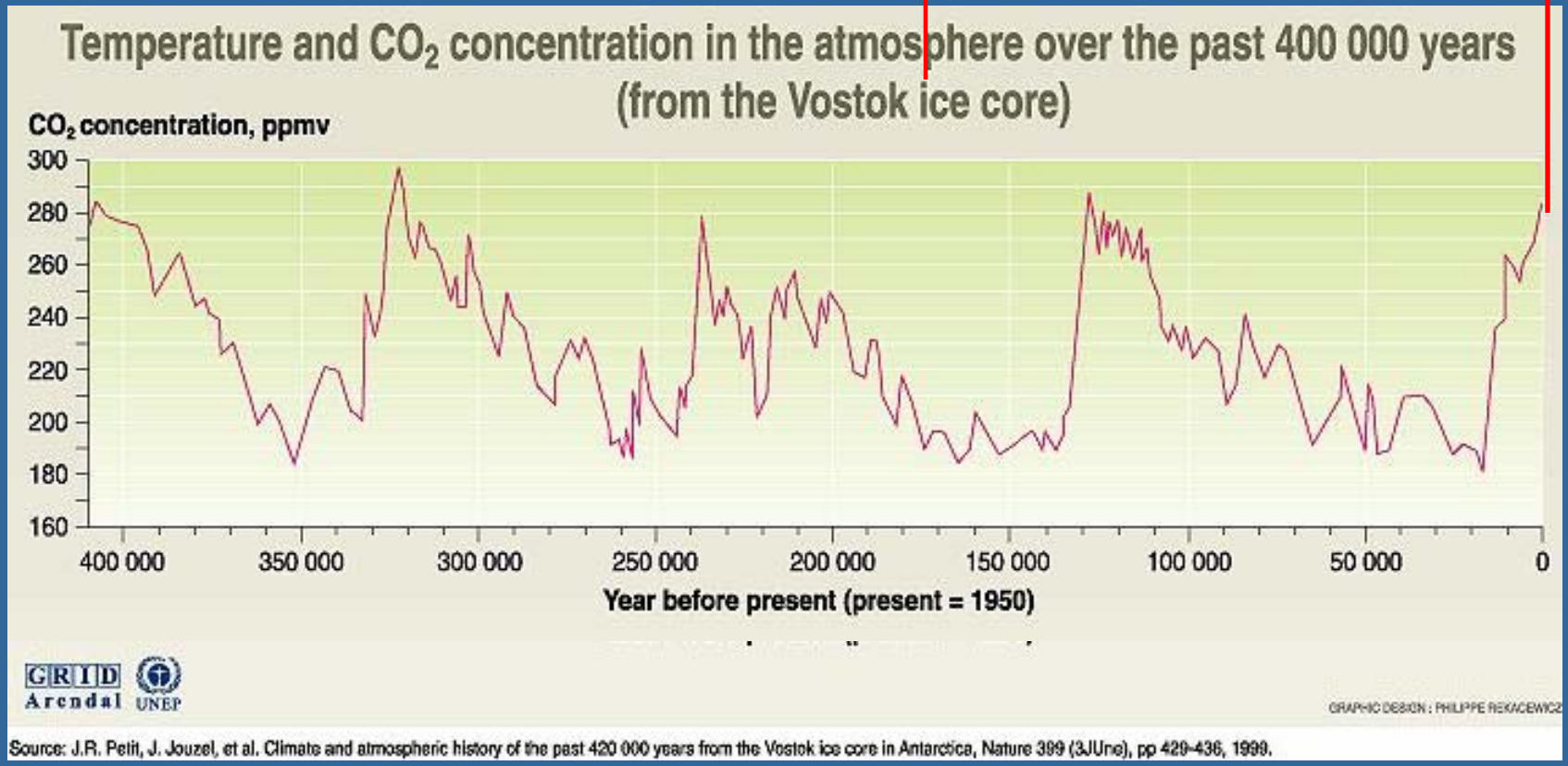
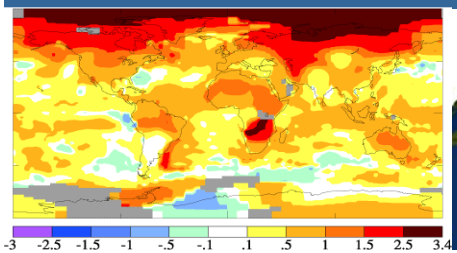


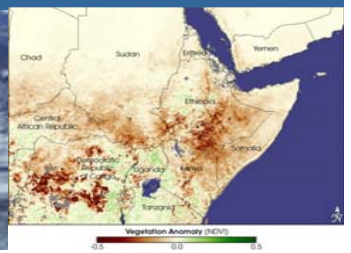
Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

2005: A Year of Records

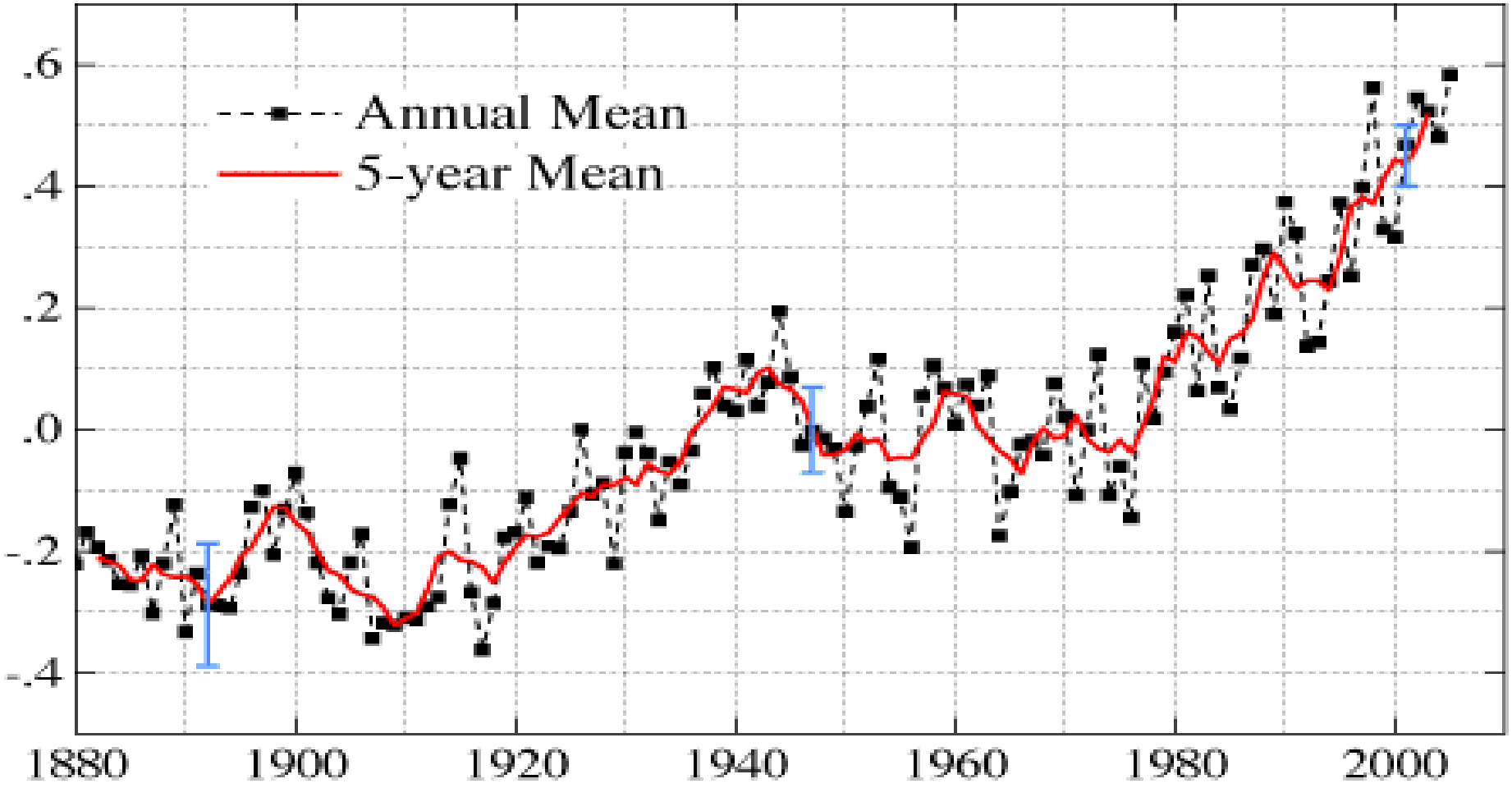
- **Hottest Year Ever**
- **Least Icy Arctic Ever**
- **Hottest Water Ever in the Caribbean**
- **5 Records Broken by Atlantic Hurricane Season**
  - **most named storms (26)**
  - **most hurricanes (14 storms w/winds exceeding 74 mph)**
  - **most category five storms (5 storms over 155 mph)**
  - **most storms hitting the US (4 make landfall)**
  - **most expensive (well over $100 billion)**
- **Record Droughts around the planet**





2005 Surface Temperature Anomoly Global Average



0.72ºC above historical average

Source: NASA

Ocean Acidification

- 0.1 unit reduction in the pH of surface sea water over past 200 years
- (=30% $[H^+]$ increase)
- 0.5 unit reduction predicted by 2100
- (=300% $[H^+]$ increase)
- Change and rate of change greater than seen in “hundreds of millennia”

Royal Society 2005

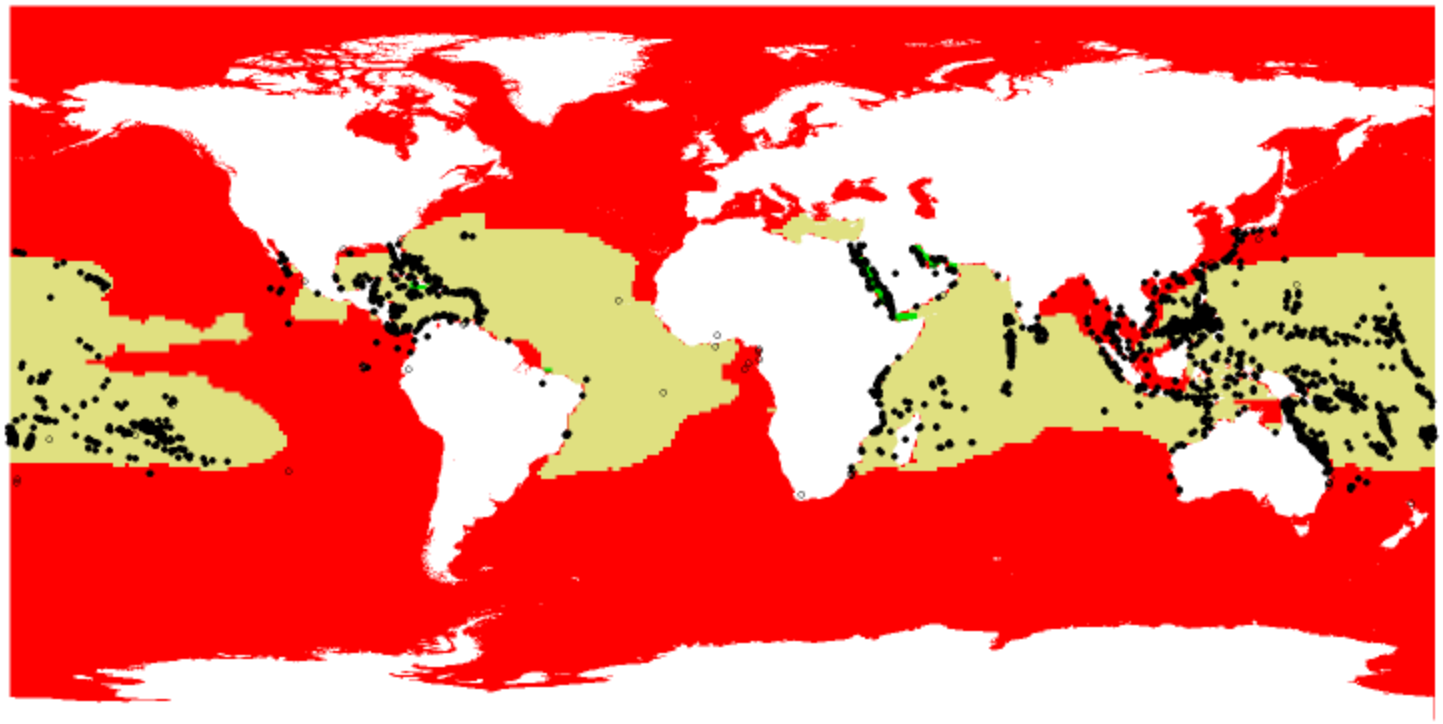
Predicted Future (~2065) Surface Ocean Aragonite Saturation State

ReefBbase.shp
- Coral Reef
- Reef Community

Country.shp

Saturation State Future
- > 4.0 Optimal
- 3.5 - 4 Adequate
- 3 - 3.5 Marginal
- < 3.0 Extremely Low
- No Data

References: 5, 7



INTERACTIVE EFFECTS

Interactive Effects

- Stressors can interact to make the intensity of their effect different than one would expect.

- Antagonistic $1 + 1 < 2$
- Additive $1 + 1 = 2$ (anticipated response)
- Synergistic $1 + 1 = 3$
- Potentiated $1 + 1 = 200$

Climate & Contaminant Interactions

Climate Change :

↑ Temperature & ↓ PH

Frequently:

↑Temperature → ↑ Toxicity

↓ PH → ↑ Toxicity

Climate & Contaminant Interactions

Implications:

- Energetic Taxation (particularly in polar regions)
- Altered Hydrology- TMDLs, permits
- Increased use of chemical in response to climate change
- Temperature/precipitation-altered transport distance and destination

Interactions ~ Temp/Contaminants

Rainbow Trout

2 x2 experiment (Ammonia and +2ºC temperature)

Ammonia alone = little impact on gill protein synthesis, protein or muscle degradation, although some liver protein degradation

+ 2ºC = slight increase in liver and gill protein turnover

Ammonia + 2ºC = inhibited protein dynamics in gill and liver (Reid *et al.* 1998)

Similar effects have been found with metals, pesticides,

Interactions ~ pH/Contaminants

Hg toxicity ↑ with ↓ pH in penaeid prawns	penaeid prawns	**Das and Sahu. 2005. Chemosphere 58(9):1241-8**
Zn toxicity can ↑ at both ends of the pH spectrum	brown trout	**Everall, Macfarlane and Sedgwick. 1989. Journal of Fish Biology 35(1):27–36**
↓pH increases [ ] of Al, Mn, Zn; Hg, Pb and Cd bioaccumulation ↑ with ↓ pH	Across aquatic systems	**National Academy of Sciences. 1985. Acid Deposition: Effects on Geochemical Cycling and Biological Availability of Trace Elements**

Another Global Change:

UV Interactions

- PAHs
- Pesticides
- Metals

- Global Climate Change

Interactions ~ UV/Acidity/Climate Change

Experimental Lake Area (ELA), Ontario Canada

UV attenuation in water largely due to [DOC]

Climate warming and acidification both ↓ DOC,

thereby ↑ UV-B (more so than ozone depletion)

Stratospheric ozone thinning = 10% UVB increase at ELA

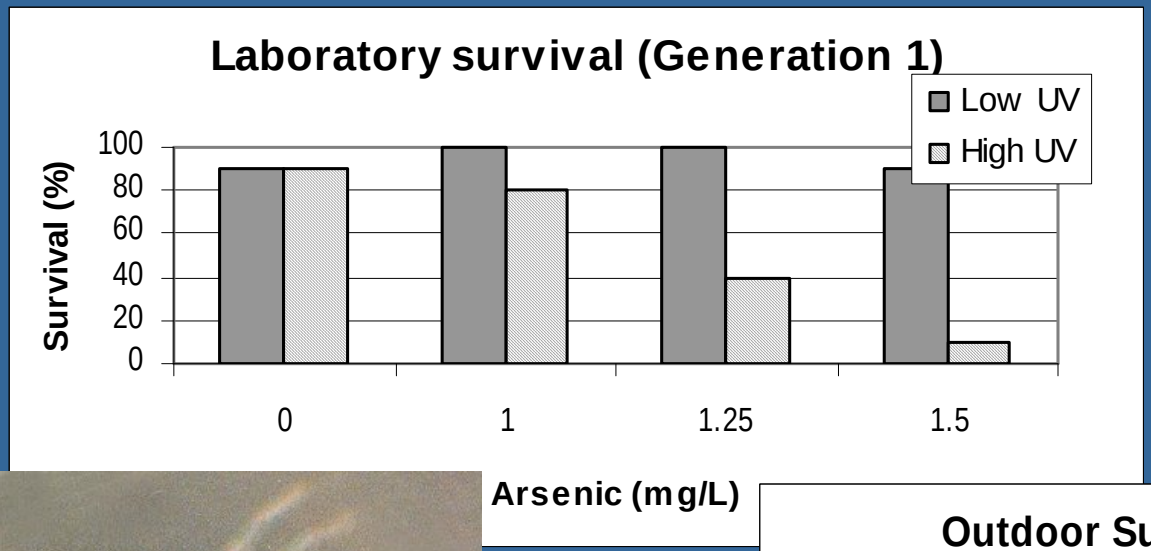
10% Decrease in DOC = 11% UVB increase at ELA

80% Decrease in DOC = 400% UVB increase at ELA

(Schindler *et al.* 1996)

Interactions ~ UV/Metals

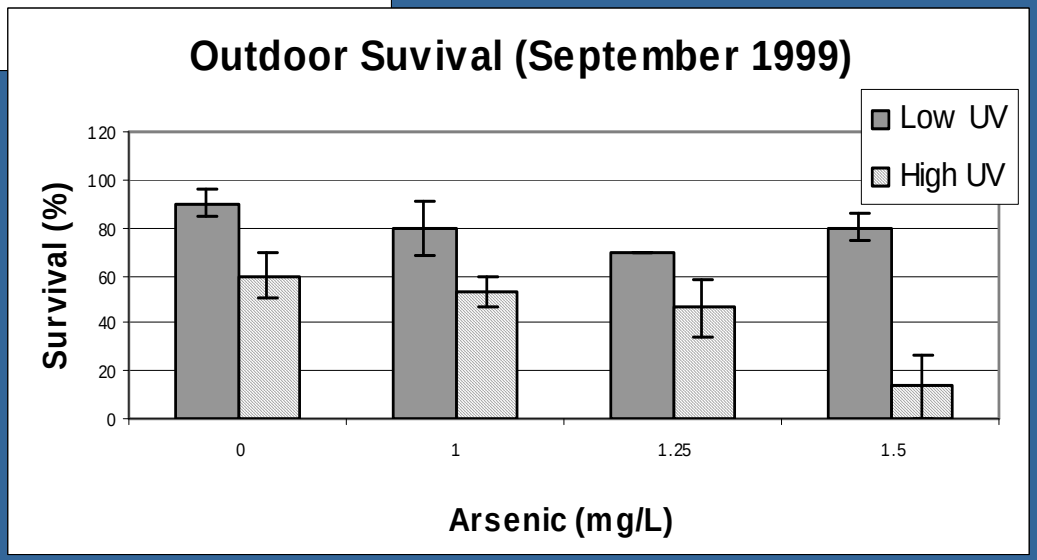
UV and Arsenic



Potentiation

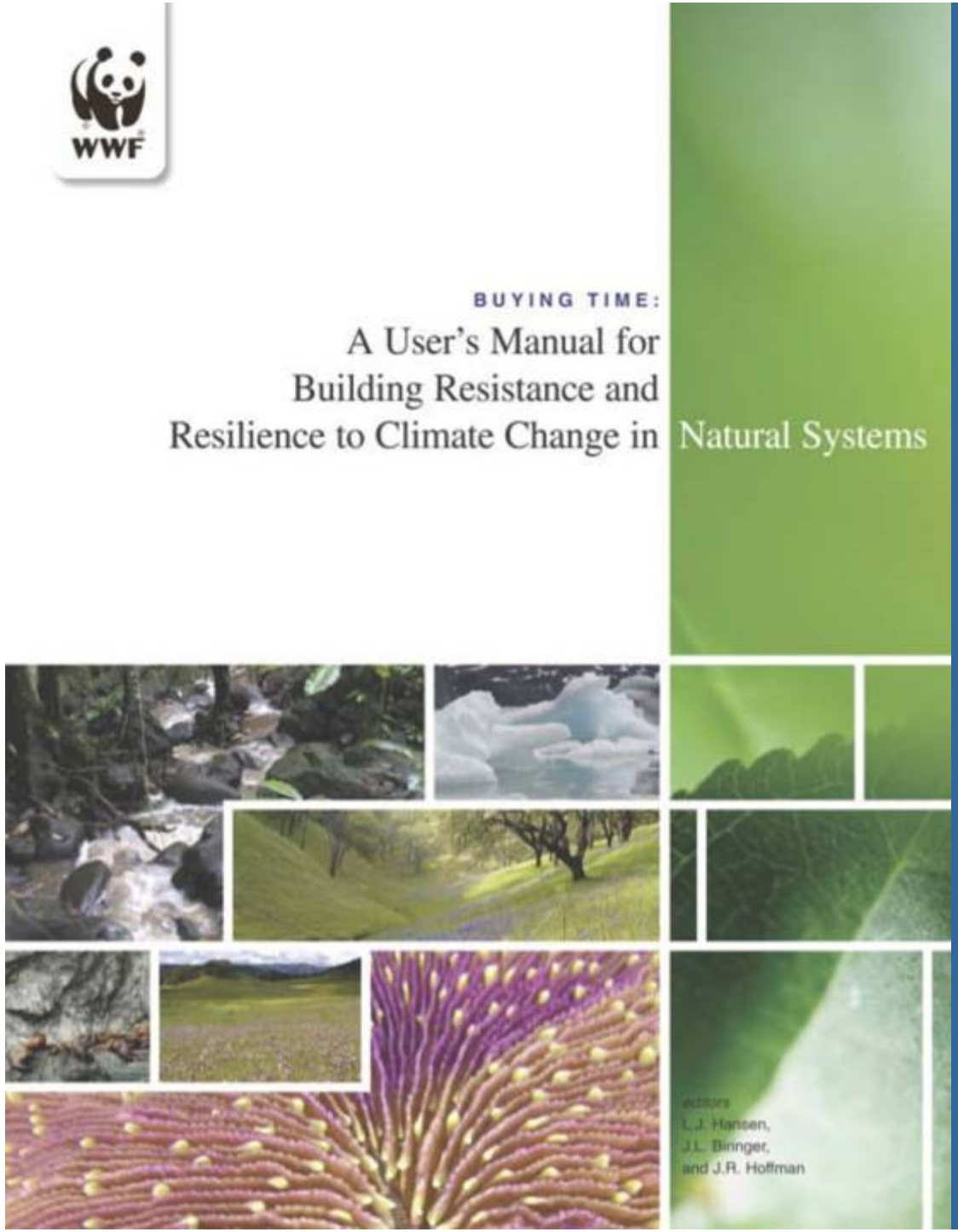
or

Synergism



Hansen *et al*. 2002

What do we do about it?



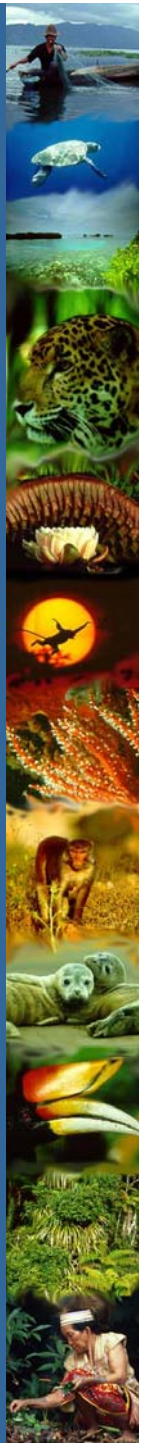
WWF Approach to Climate Adaptation

1) Protect **Adequate and Appropriate Space**

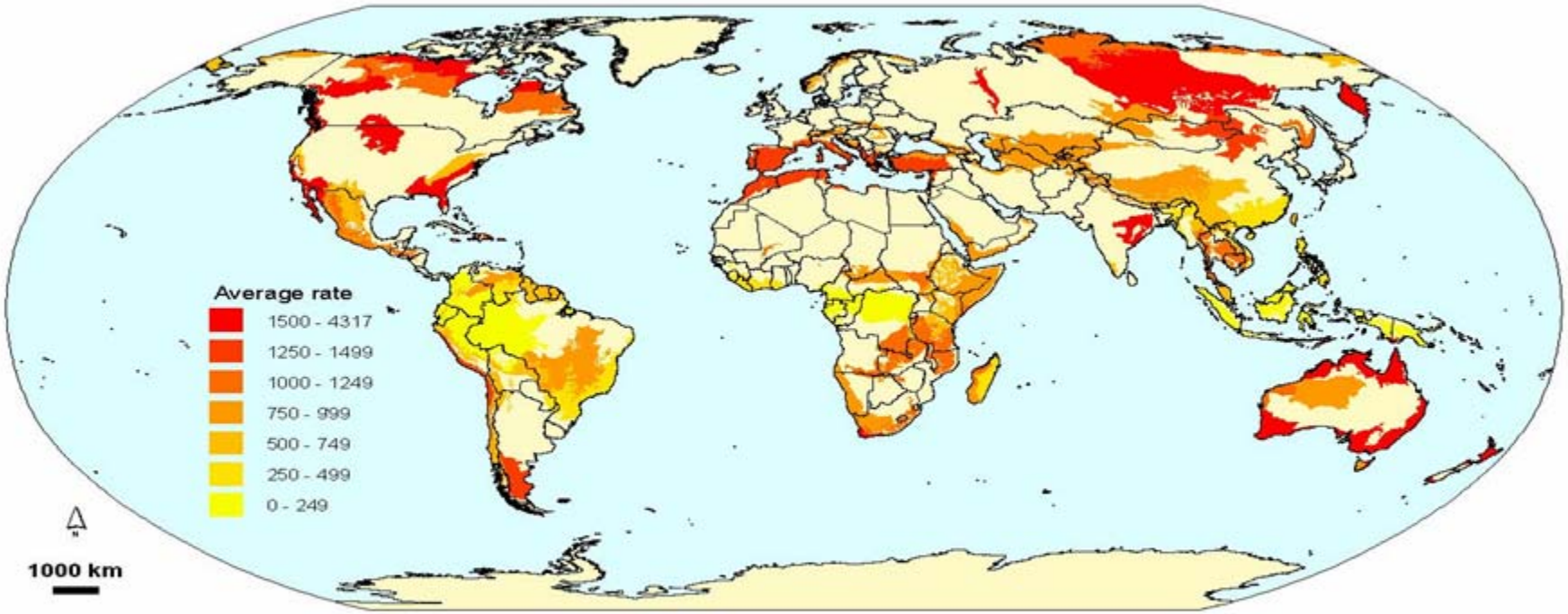
2) Limit all **non-climate stresses**

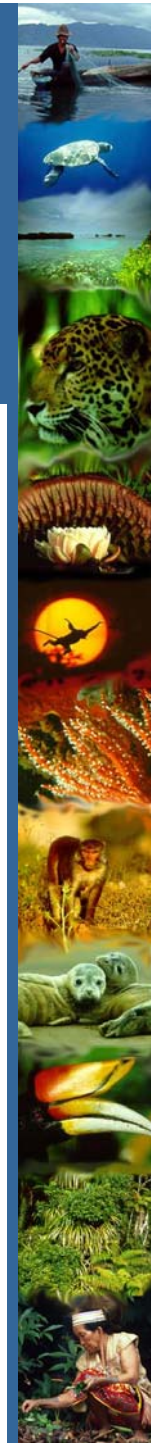
3) Use **active adaptive management** approaches and start **testing** strategies

4) **Reduce** Greenhouse Gas Emissions



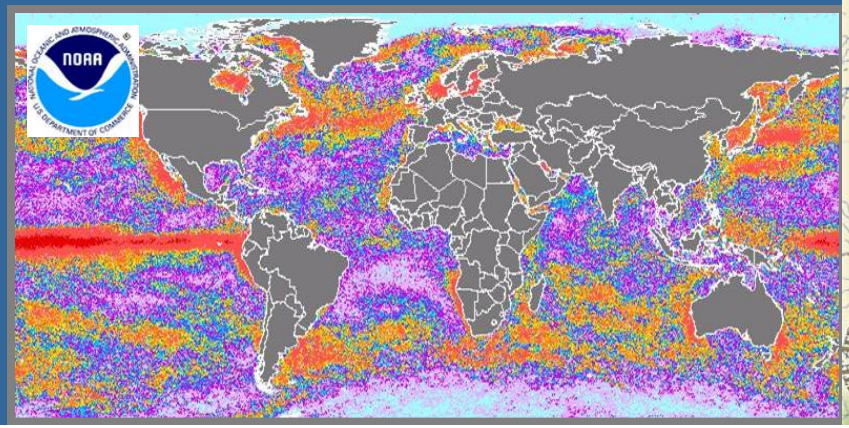
1) Protect adequate and appropriate space for a changing world





Spatial Considerations Require Temporal/Climate Aware Thinking

- Refugia
- Gradients (Latitudinal/Elevational)
- Heterogeneity
- Gene flow/Connectivity
- Inclusion of other changes in the watershed/landscape/seascape



2) Reduce non-climate stresses on natural systems

Unsustainable Harvest

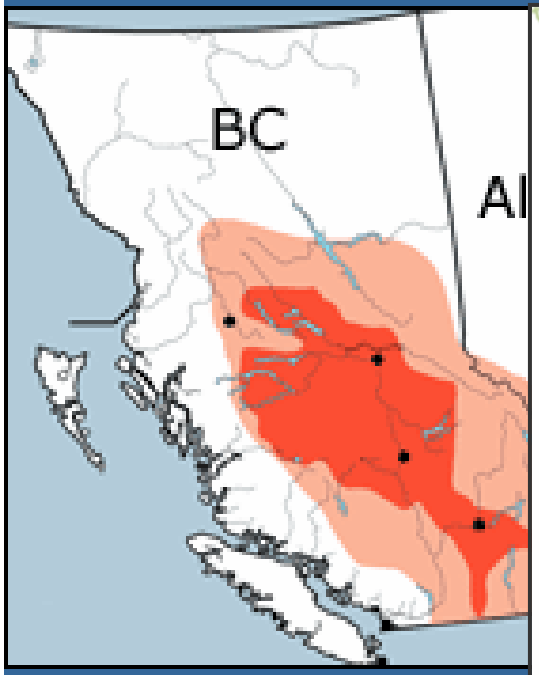
Invasive Species & Pests

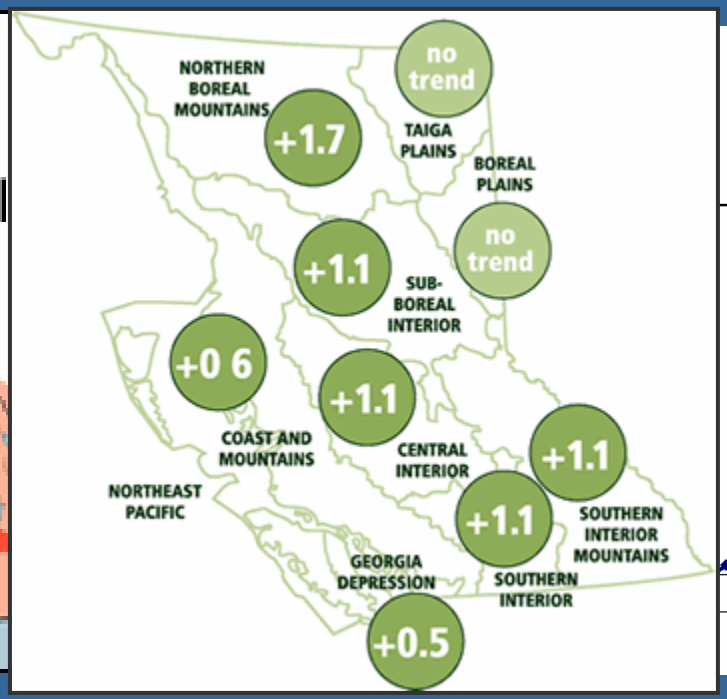
Pollution & Habitat Degradation

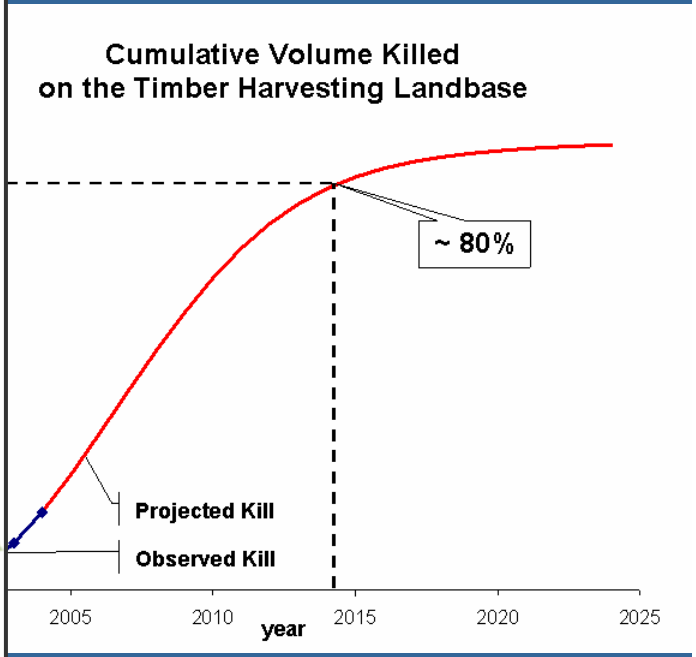
Agriculture & Habitat Fragmentation

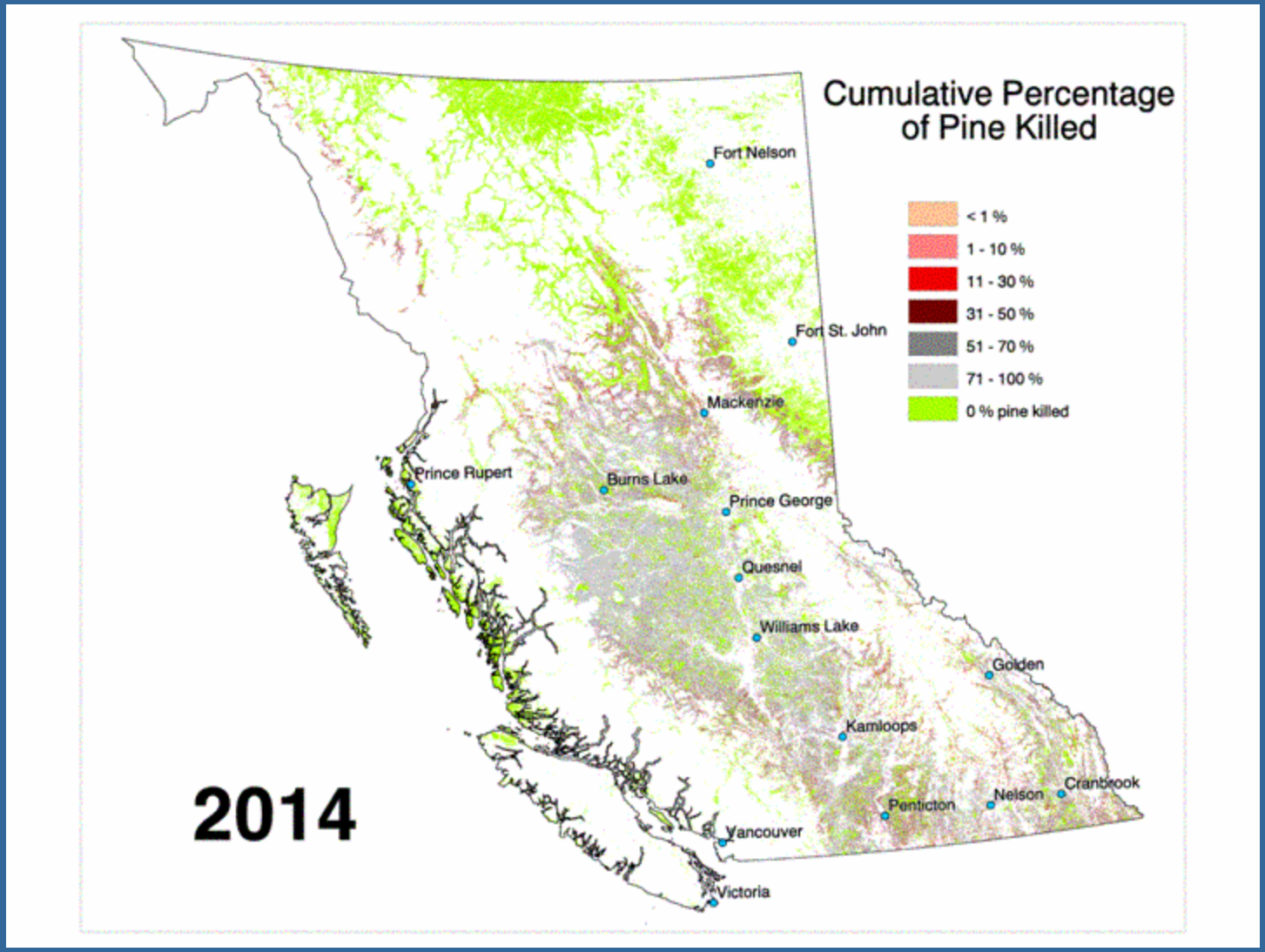
Non-climate stresses

- Mountain pine beetles
  - 10 years
  - Winter low of -40°C or sudden cold snap in early fall or late spring of -25°C would end the outbreak.







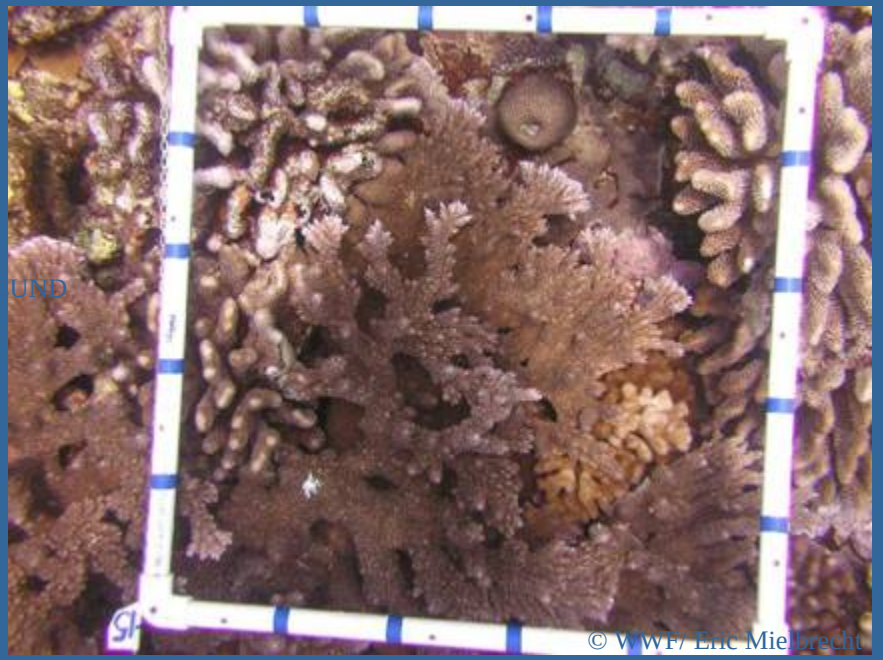


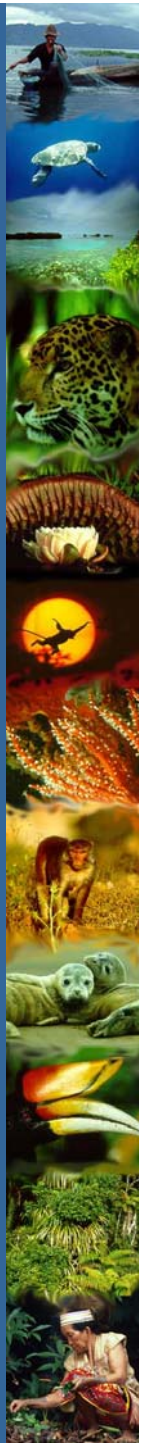
Source: Ministry of Forestry and Range

Managing with Change in Mind

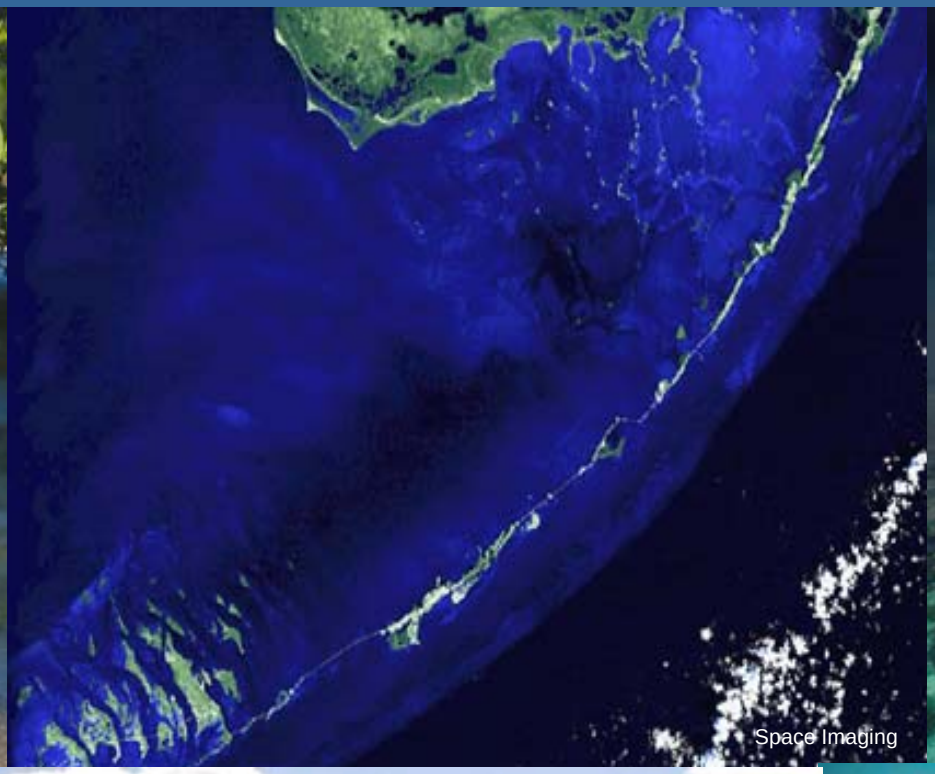
- Reconsider regulatory limits
  - Physical and chemical changes may interact
- Reconsider monitoring approaches
  - Do sites and sampling times account for regional change and variability?
  - Are there parameters that you should be adding?
- Prepare for possible changes before they come
  - There are thresholds- Mountain Pine Beetle

3) Employ active adaptive management approaches and start testing strategies

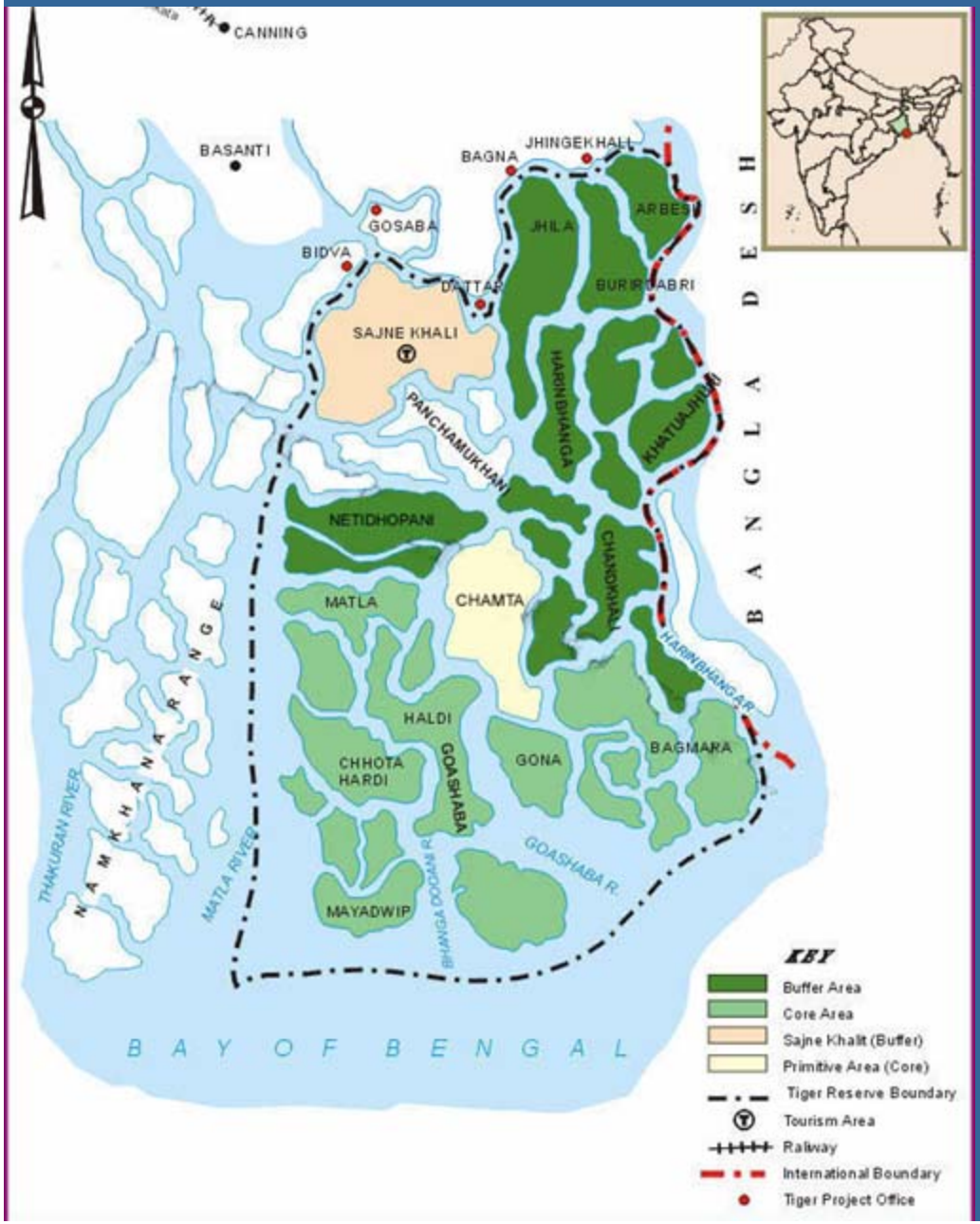


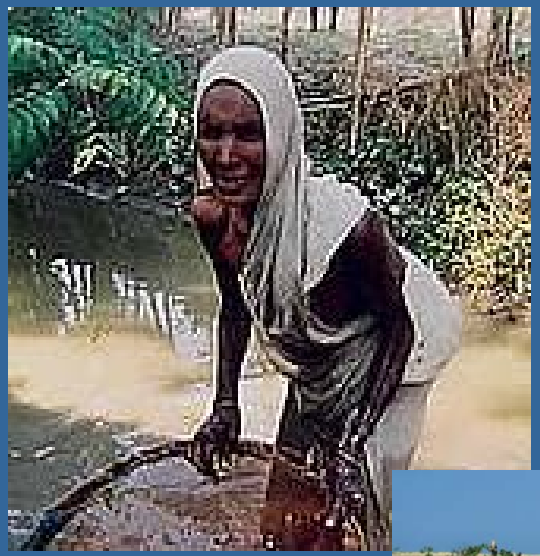


Coral Reef Resilience



Losing India to Rising Seas





Conservation in the face of sea level rise in the Sundarbans

3.14mm/year sea level rise

12 islands lost by 2020

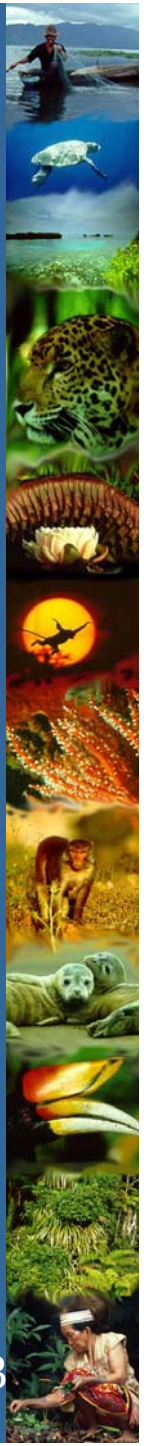
4) Reduce Greenhouse Gas Emissions

For some systems resilience building options are scarce and mitigation is needed

Limitations to Resilience Building

Temp. Change	Effects on Biodiversity
2 °C	Some species lost Possible management options exist
4 °C	Many species lost Some management options may exist (EXTREMELY EXPENSIVE, Low Likelihood of Success)
6 °C	Dire

From Parmesan, 2003



Take Home Messages

- Contaminant and Climate Impacts are important to conservation efforts
- Impacts seen all over the world (even in seeming pristine areas)
- Impacts are often sublethal, resulting in longer response times
- Variability and Scale must be considered
- Current and future regulatory efforts must catch-up with on-going anthropogenic change

Non-climate stresses

- Mountain pine beetles