Climate change and biodiversity on the edge of the tropics

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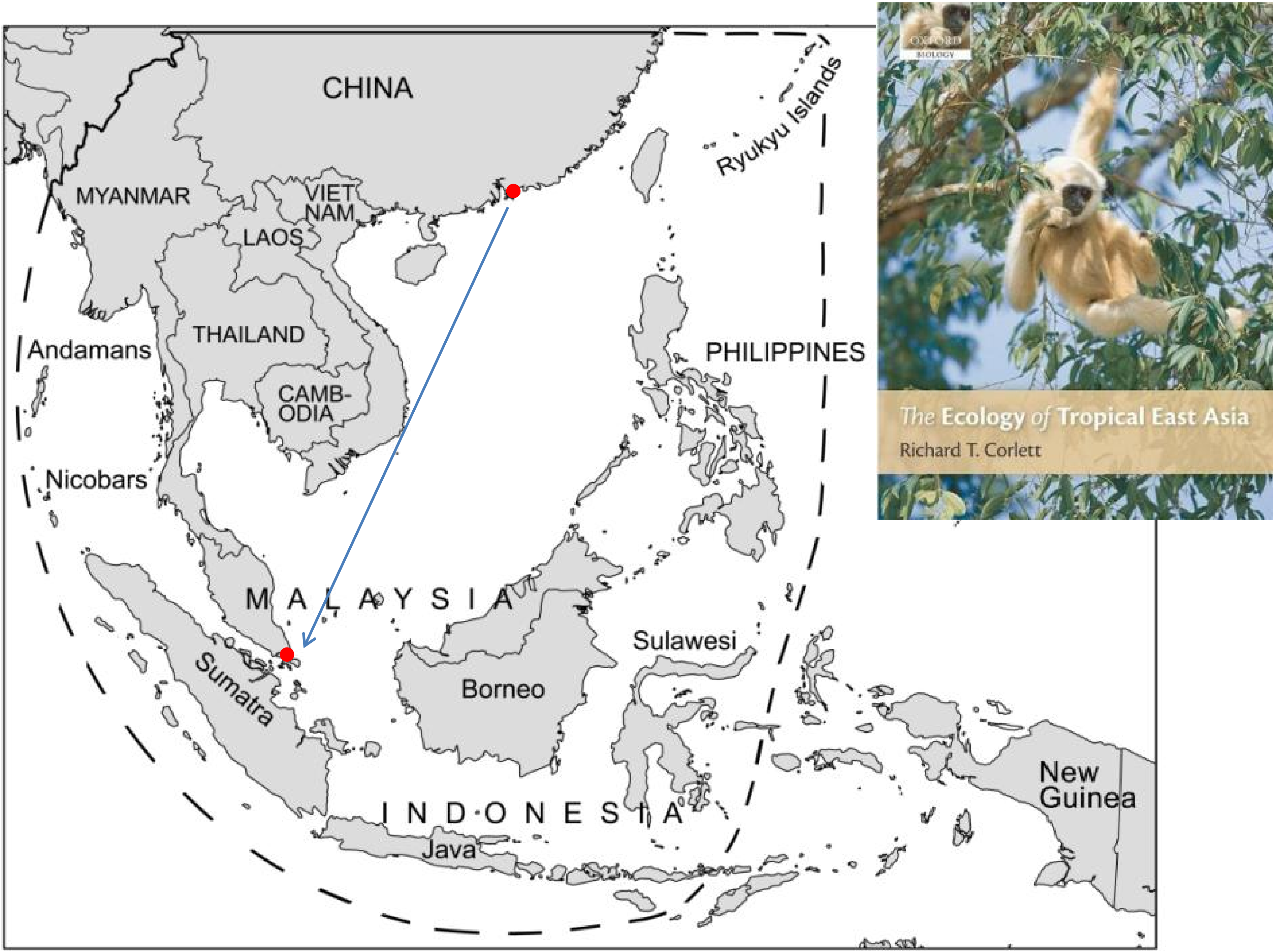
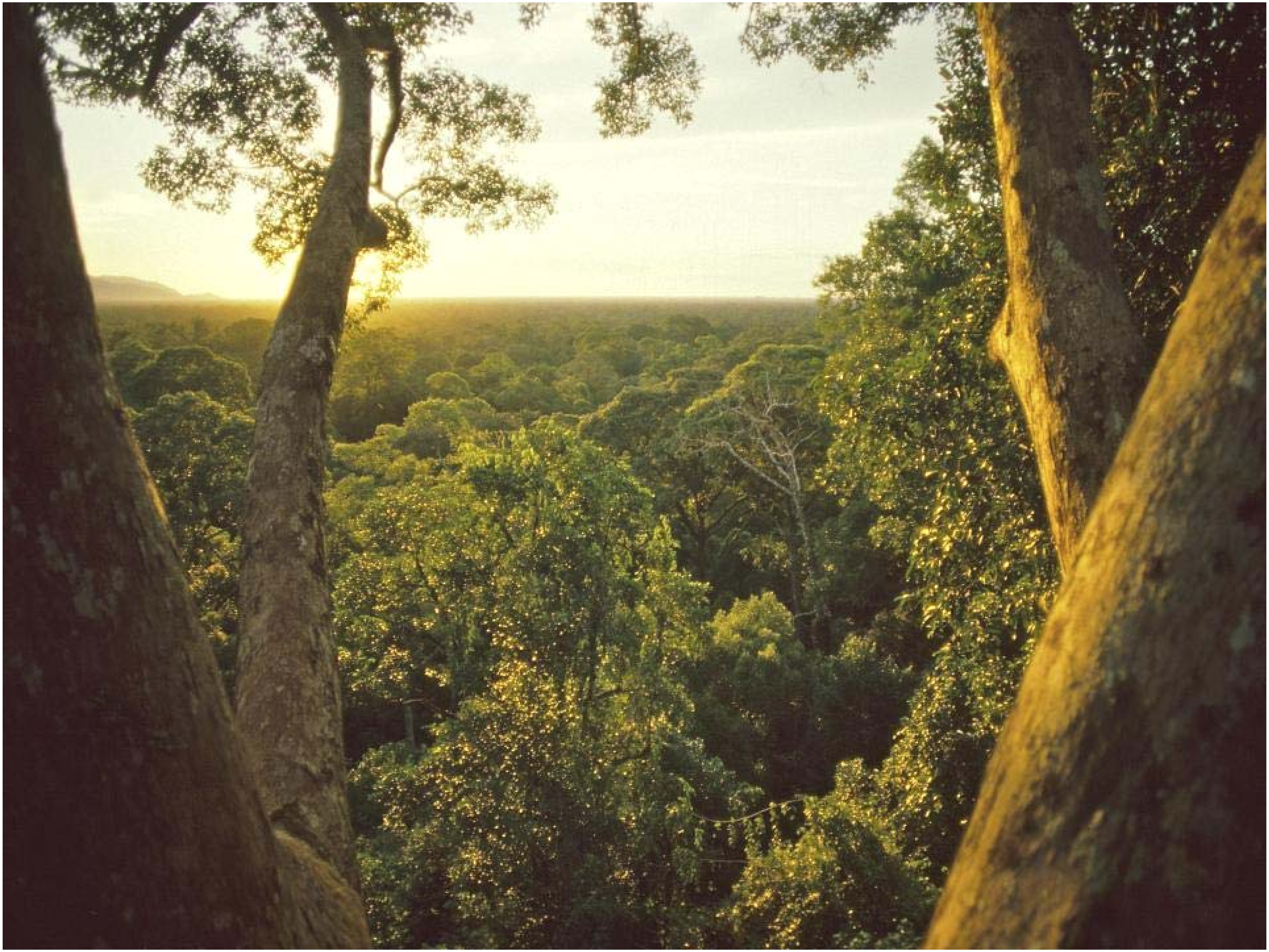
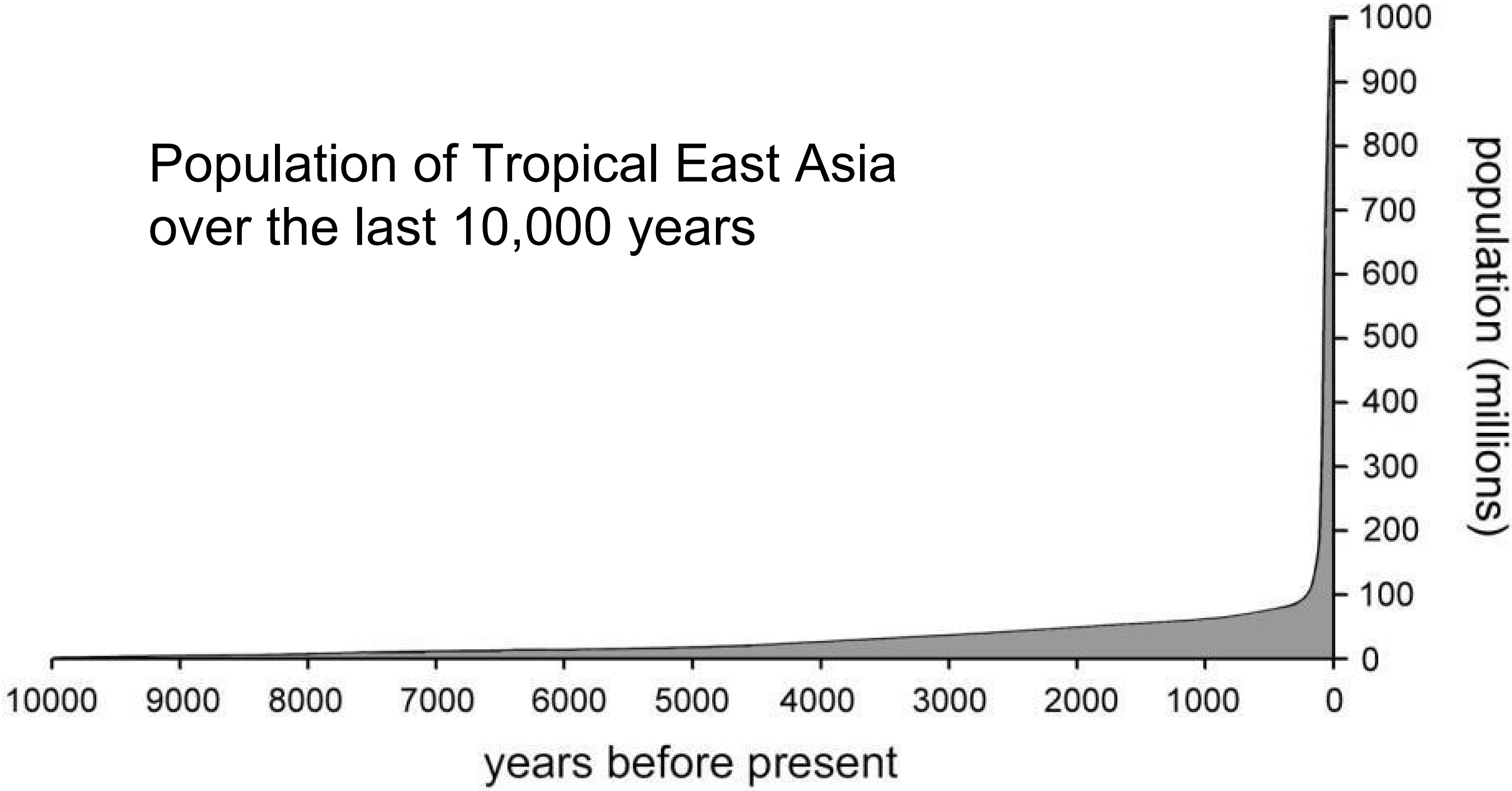
Greetings from clean & green Singapore!

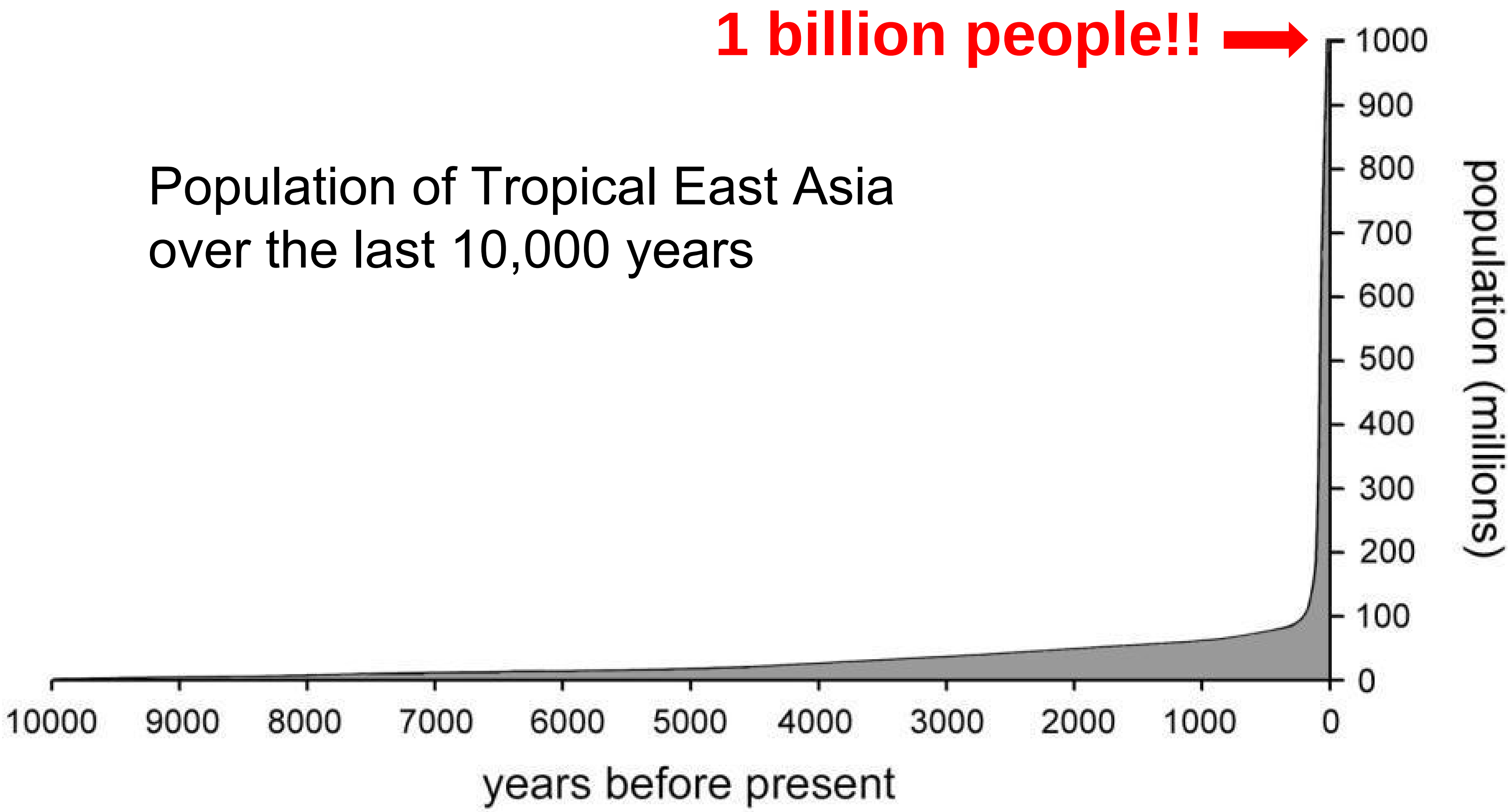

CHINA
Ryukyu Islands
MYANMAR
VIET NAM
LAOS
THAILAND
PHILIPPINES
Andamans
CAMB-ODIA
Nicobars
M A L A Y S I A
Sulawesi
Sumatra
Borneo
New Guinea
I N D O N E S I A
Java
OXFORD BIOLOGY
The Ecology of Tropical East Asia
Richard T. Corlett



Population of Tropical East Asia over the last 10,000 years

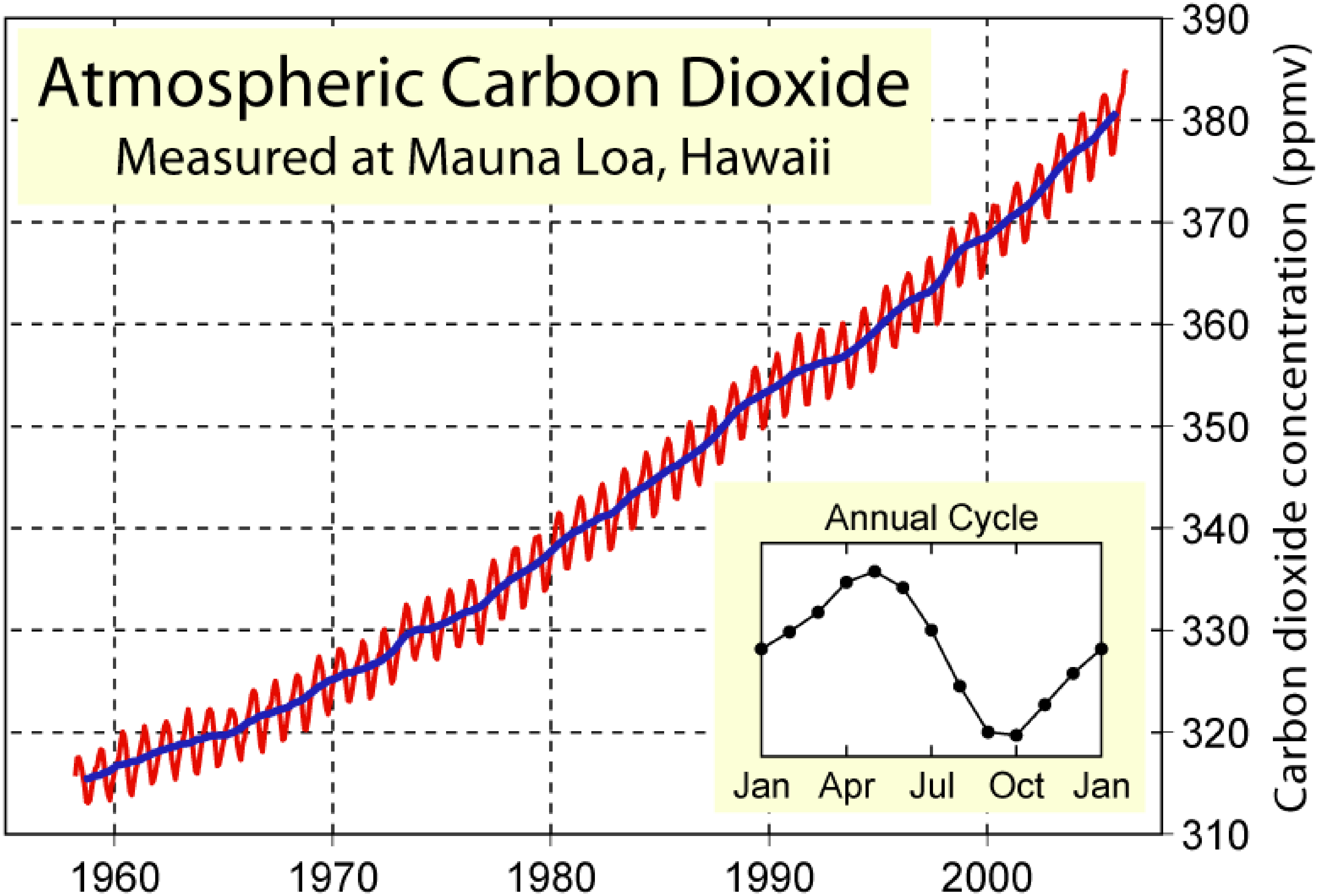


From: Corlett, 2009

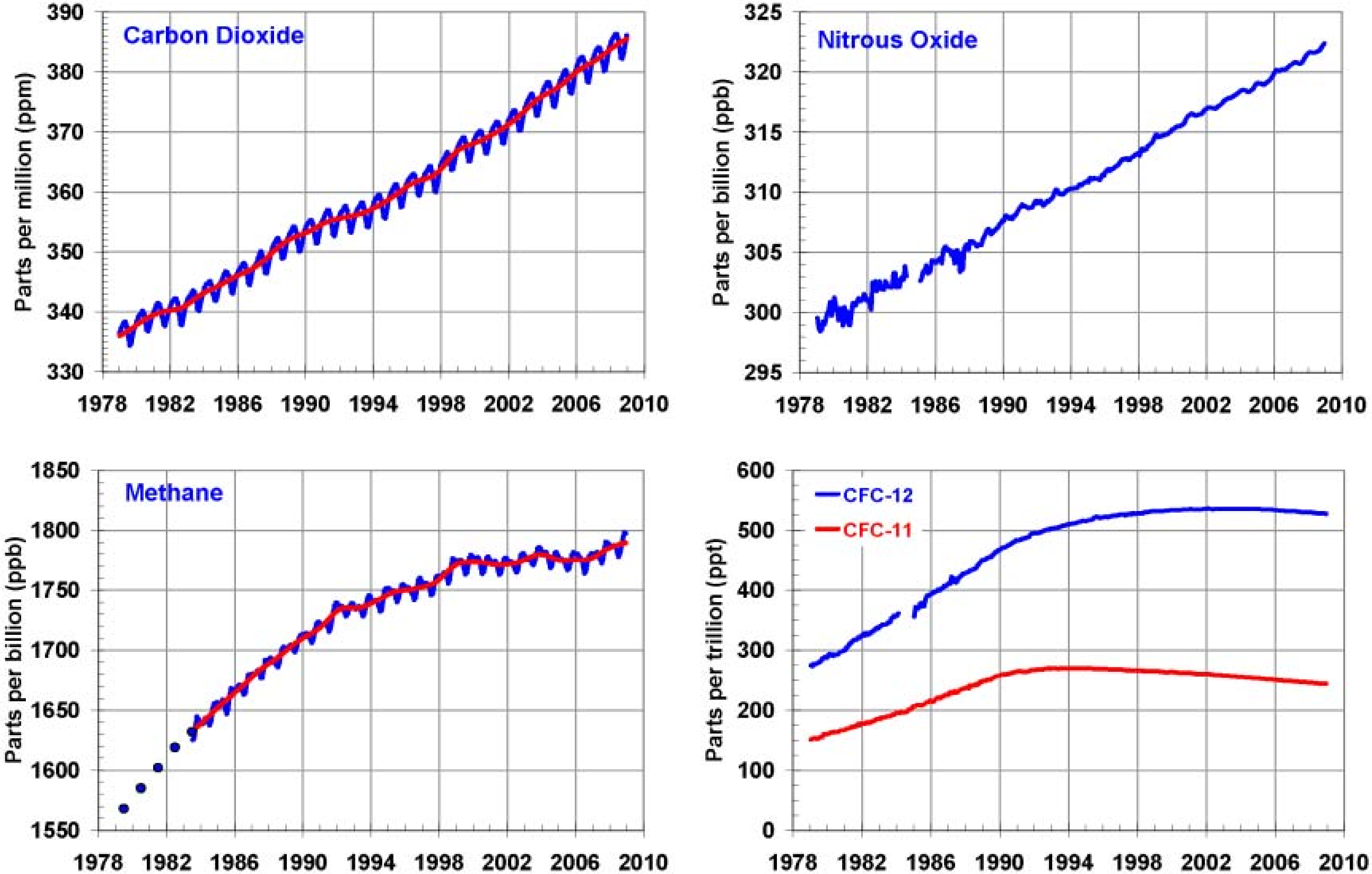


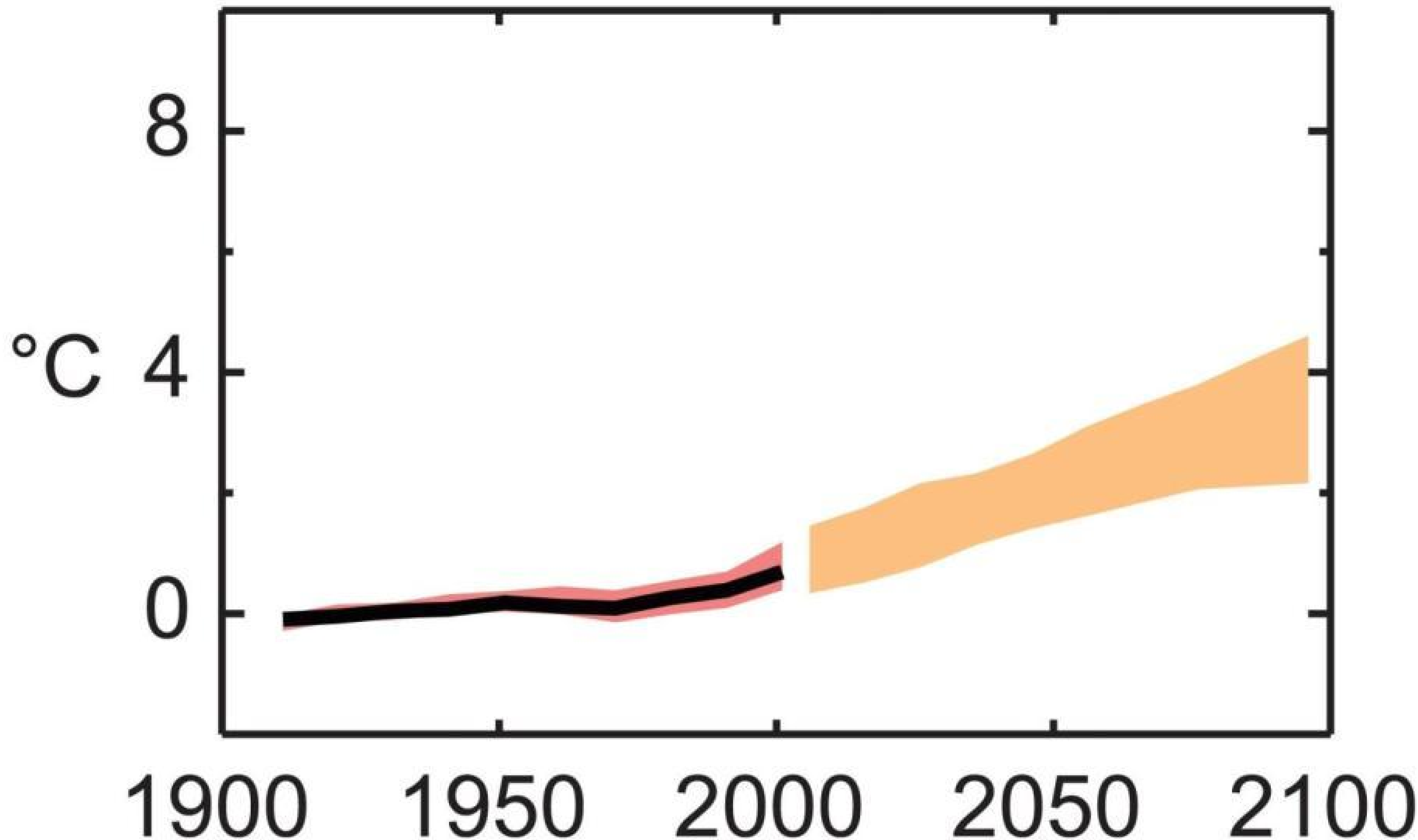
From: Corlett, 2009


deforestation
logging
hunting
pollution

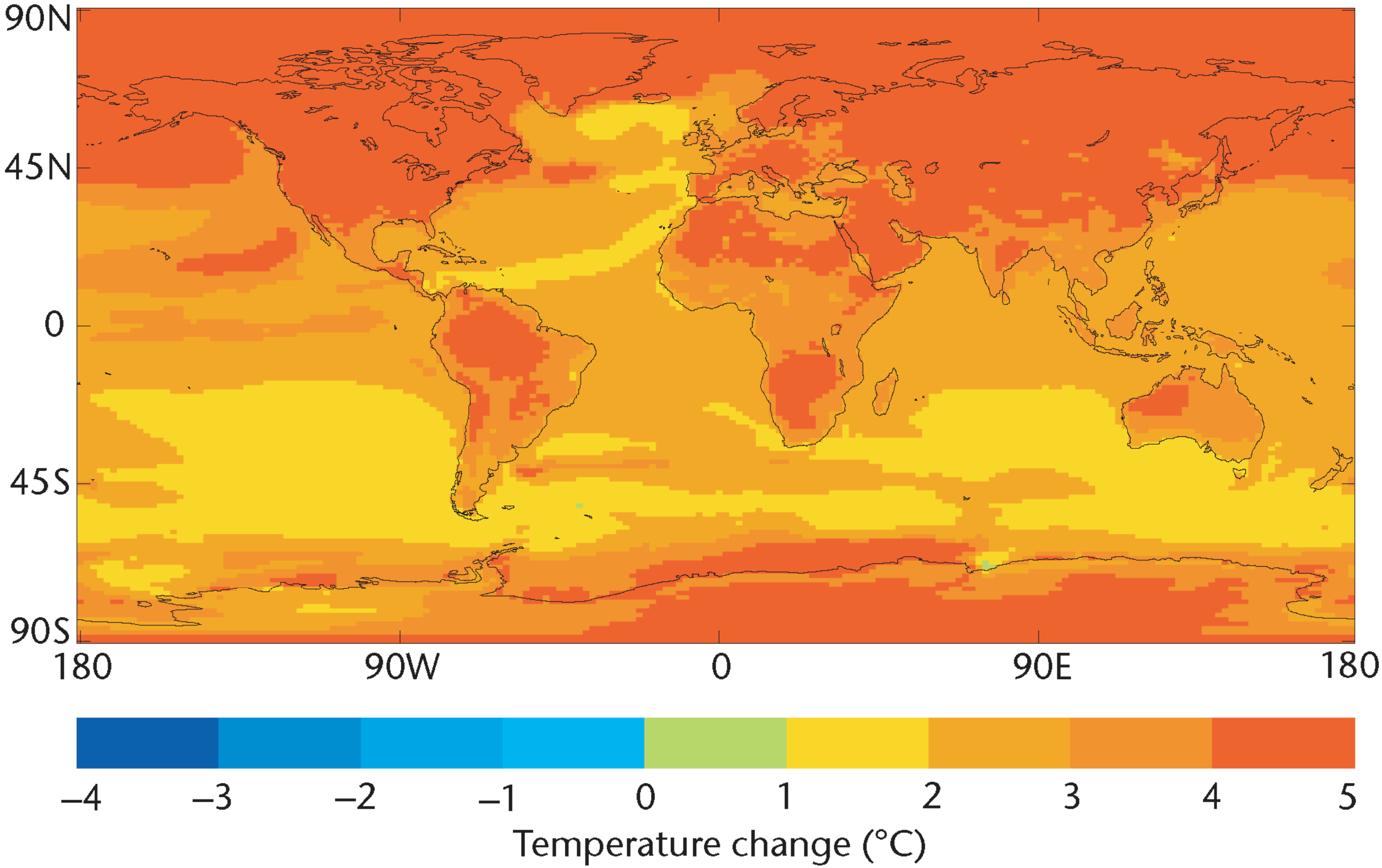


Global Warming Art

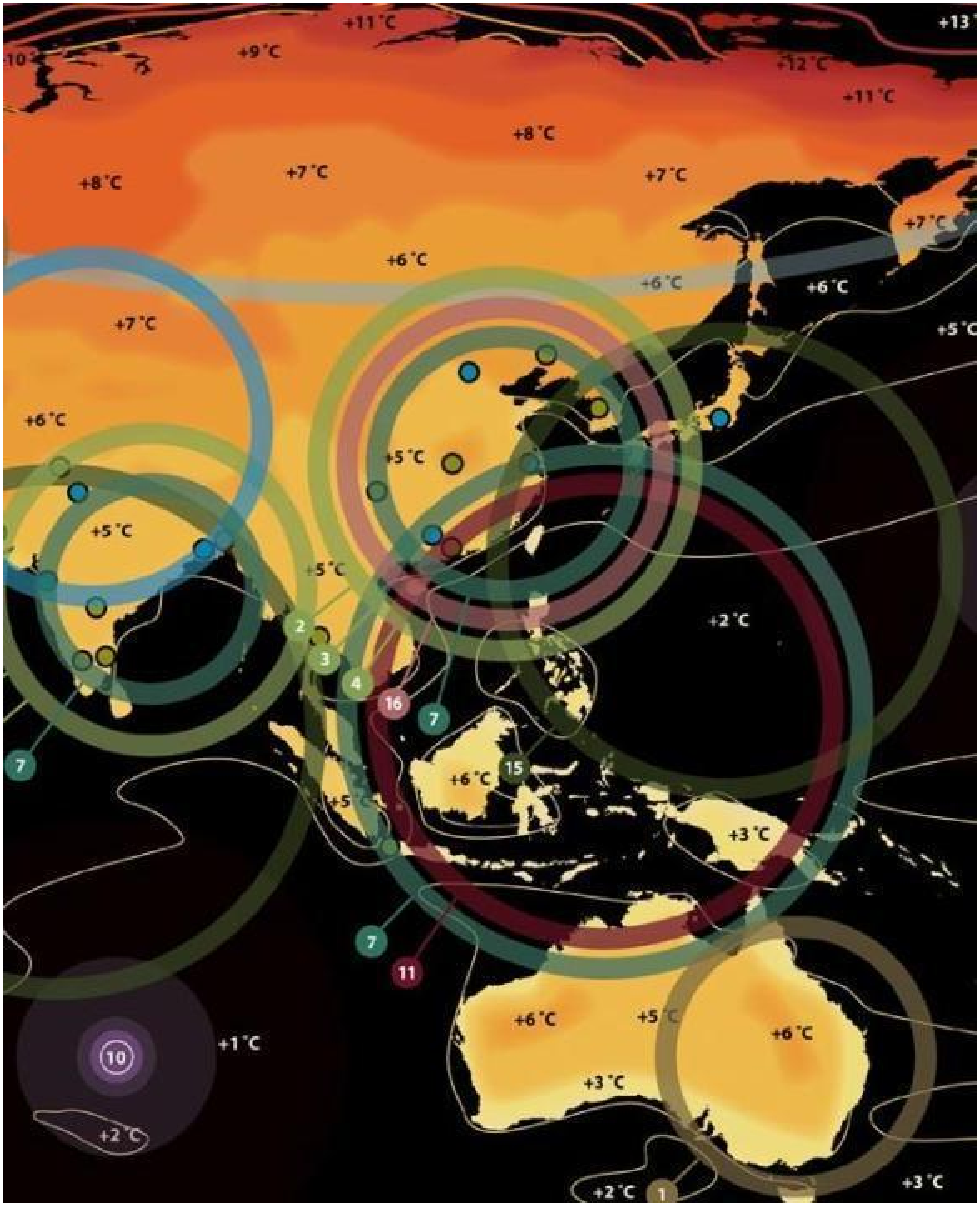

Carbon Dioxide
Parts per million (ppm)
390
380
370
360
350
340
330
1978
1982
1986
1990
1994
1998
2002
2006
2010
Nitrous Oxide
Parts per billion (ppb)
325
320
315
310
305
300
295
Methane
Parts per billion (ppb)
1850
1800
1750
1700
1650
1600
1550
CFC-12
CFC-11
Parts per trillion (ppt)
600
500
400
300
200
100
0



From: IPCC 2007



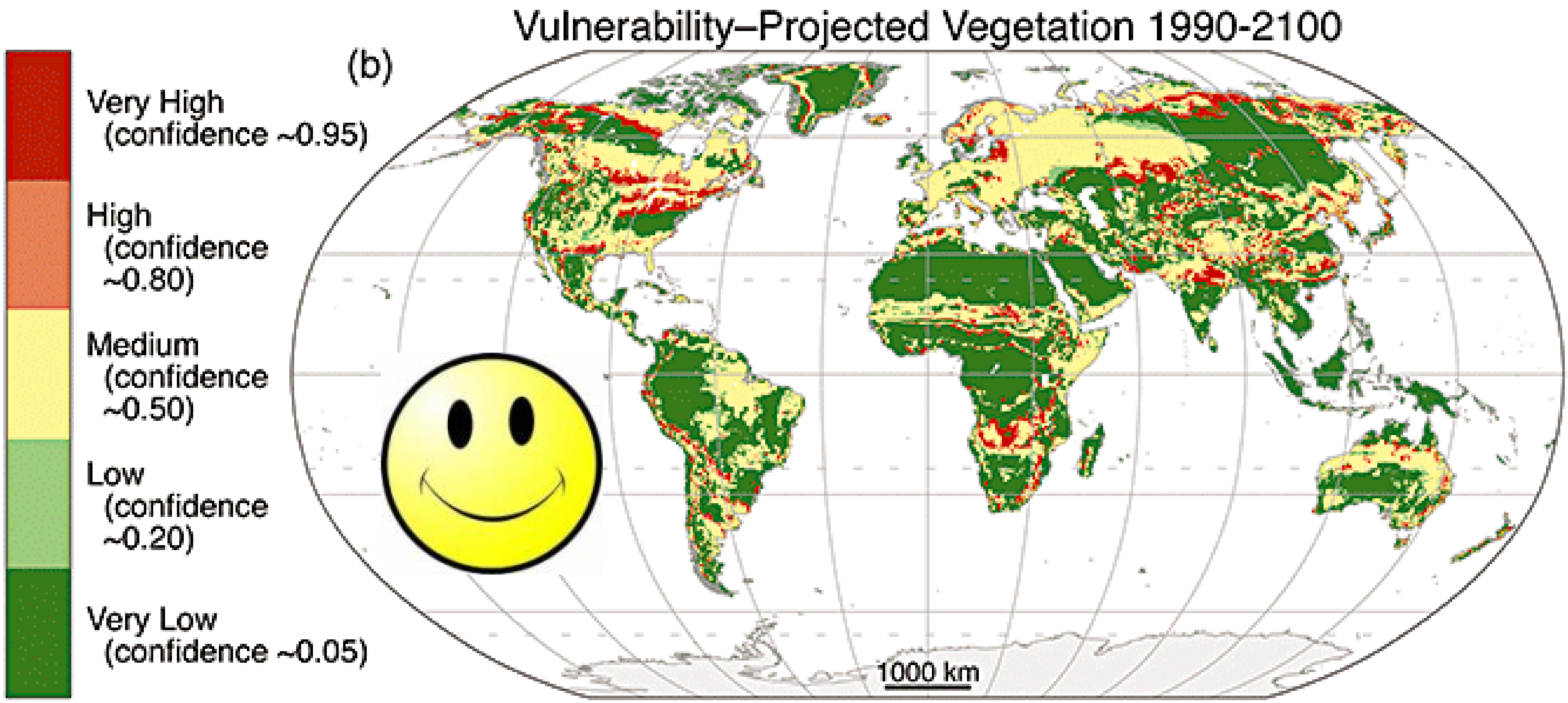
Predicted changes in annual mean temperature from 1960-1990 to 2070-2100 according to the Met Office Hadley Centre global environment model, HadGEM1.



“Business as usual” climate projection from the UK’s Met Office

+5^{o}C for HK!

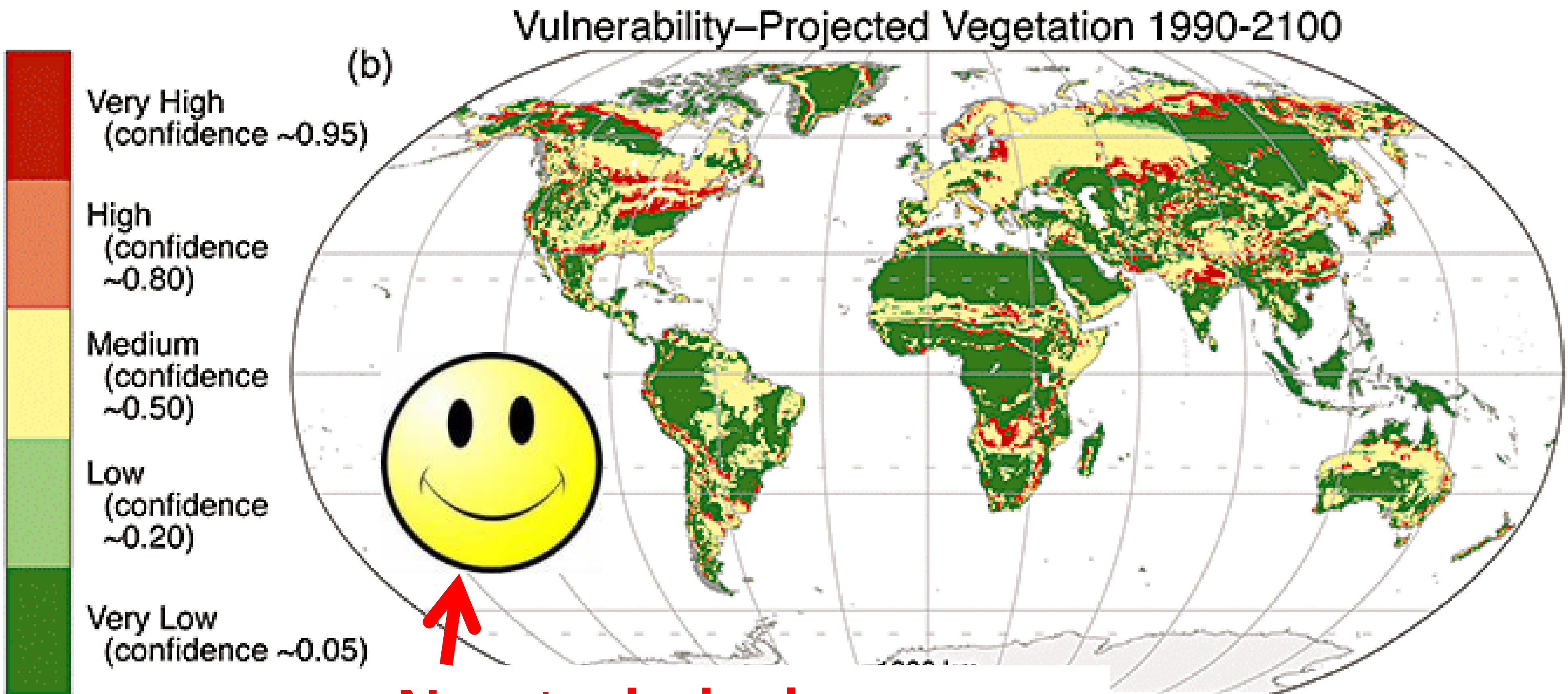

How vulnerable is
tropical biodiversity?



Vulnerability to biome change during the 21st century:

- **Low** for tropical forests, except the eastern Amazon

Gonzalez et al. 2010 *Global Ecol. Biogeogr.*

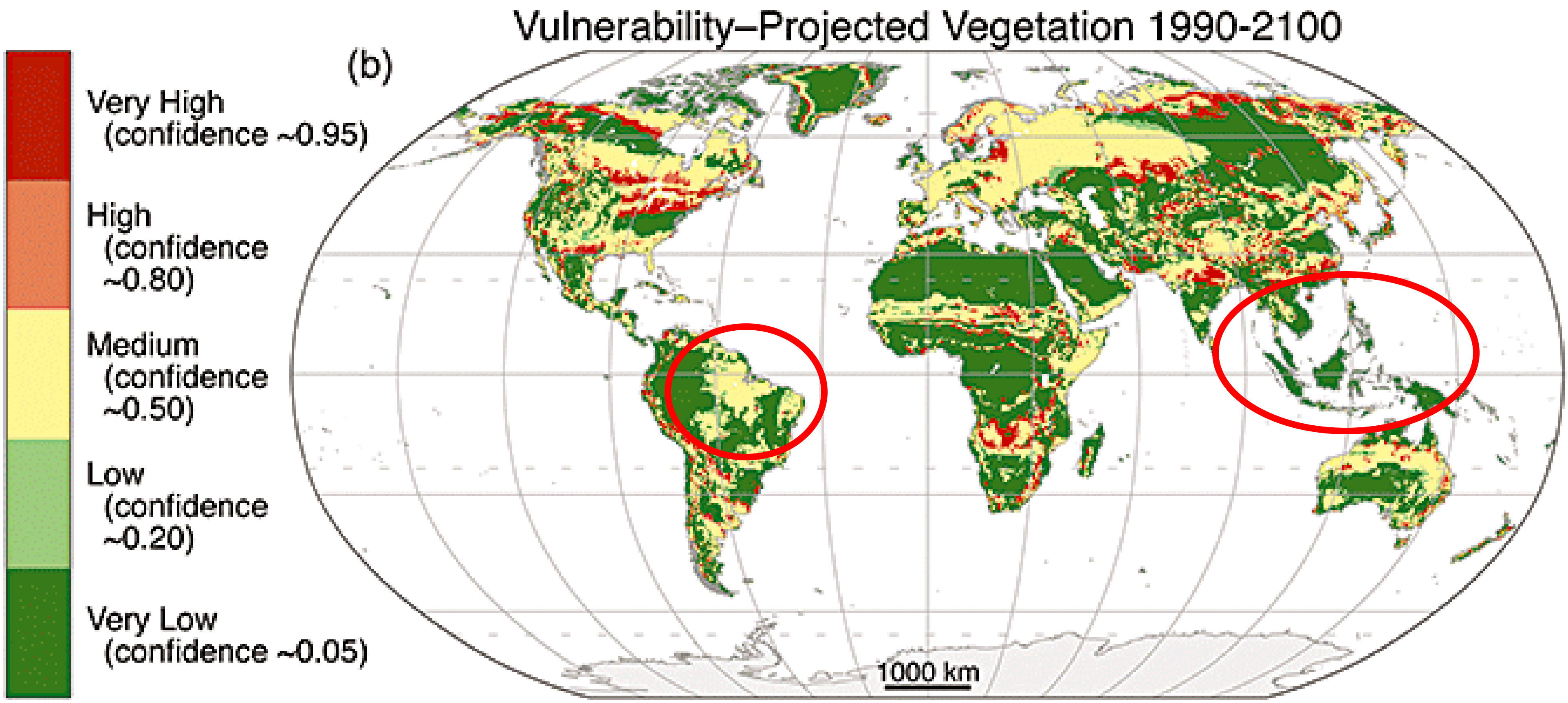


Non-technical summary

Vulnerability to biome change during the 21st century:

➢ **Low** for tropical forests, except the eastern Amazon

Gonzalez et al. 2010 *Global Ecol. Biogeogr.*

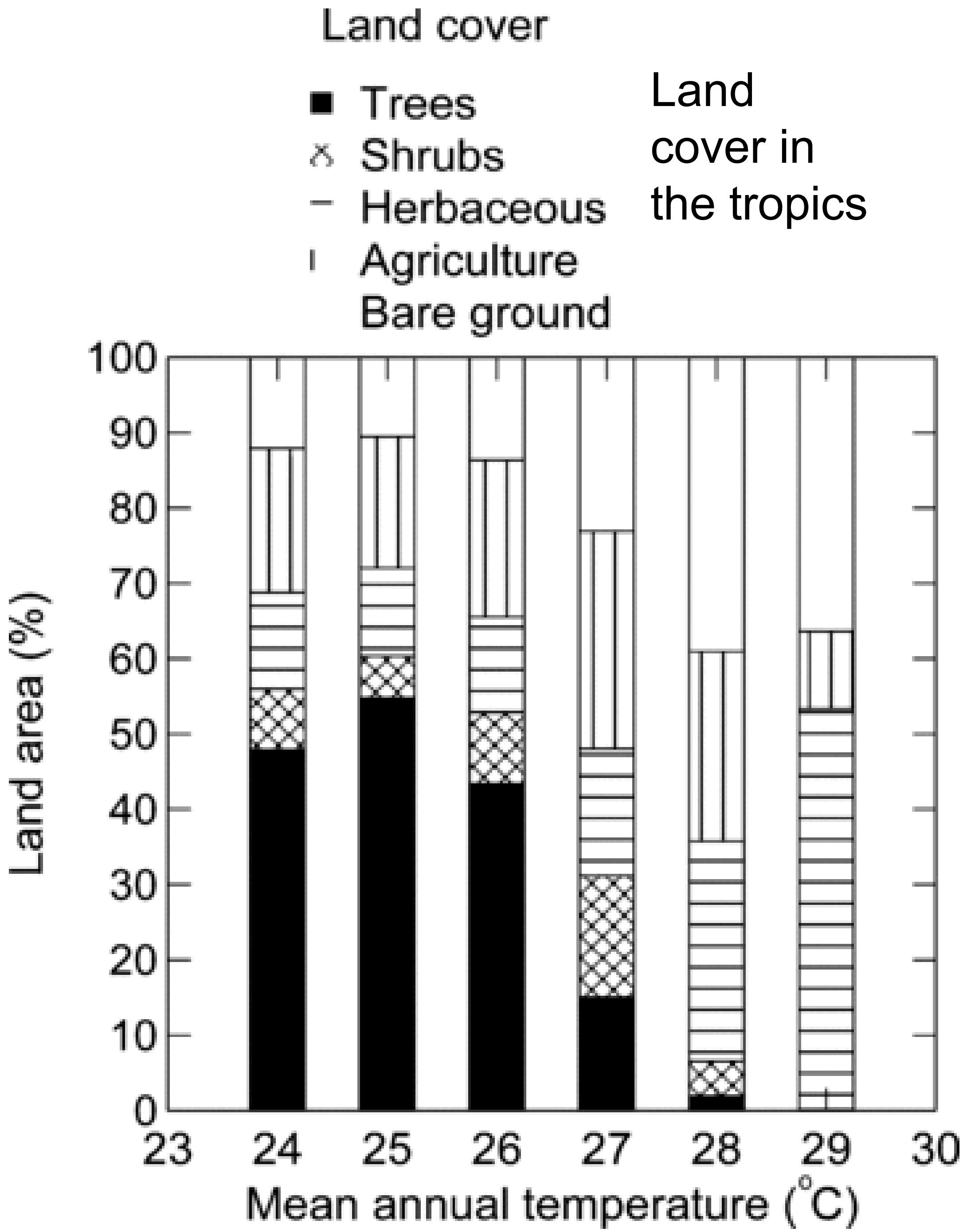


Vulnerability to <u>biome change</u> during the 21st century:

➢**<u>Low</u>** for tropical forests, except the eastern Amazon

Gonzalez et al. 2010 *Global Ecol. Biogeogr.*

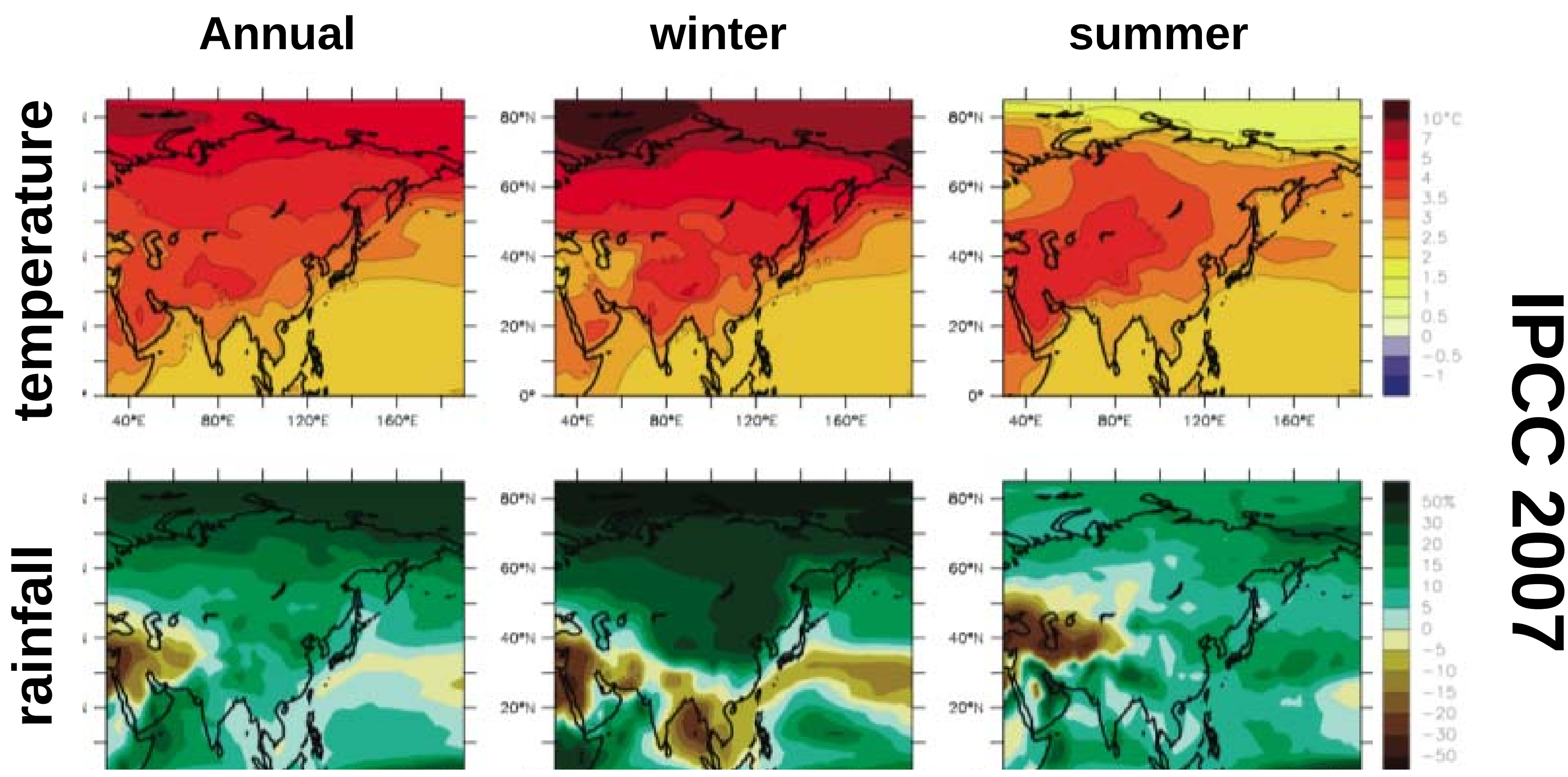
Land cover in the tropics



But:

There is _no_ tropical forest today at a mean annual temperature >28^{o}C

(Wright et al. 2009 *Biotropica)*



<u>Most</u> climate models suggest a 0-15% *increase* in annual **rainfall** over most of the region, but dry seasons will generally be *more severe.*

Problems with the current climate projections:

1. Temperature predictions are robust for a given GHG scenario, but all other predictions are +/- **model-dependent**, including **rainfall** in the tropics and subtropics.

2. The climate models perform *badly* with the **monsoons** and **ENSO** and don't work over **rugged topography**.

3. Reliable **sub-100 km** predictions are impossible.

4. The **GHG scenarios** currently used do not reflect reality.

Problems with the current climate projections:

5.On decadal timescales, there are *huge uncertainties* in **carbon cycle feedbacks**. Climate change will alter the balance between CO_2 *uptake* (via NPP) and *losses* (via decomposition and respiration), but we cannot even predict the *direction* of the impact, never mind its magnitude.

6.The impact of '**carbon fertilization**' from rising CO_2 is not understood.

7.The capacity of long-lived plants for **acclimation** to new climate conditions is unknown. Short-term experiments may be a *very poor* guide.

When the climate changes, wild species can either:

tolerate the changes (*physiological acclimation*)

adapt to them (*genetic changes*)

move

or **die**

When the climate changes, wild species can either:

tolerate the changes

adapt to them

move

or **die** → loss of biodiversity and carbon storage

When the climate changes, wild species can either:

tolerate the changes

adapt to them - genetic adaptation is too slow, even in short-lived species('adaptational lag')

move

or **die** → loss of biodiversity and carbon storage

When the climate changes, wild species can either:

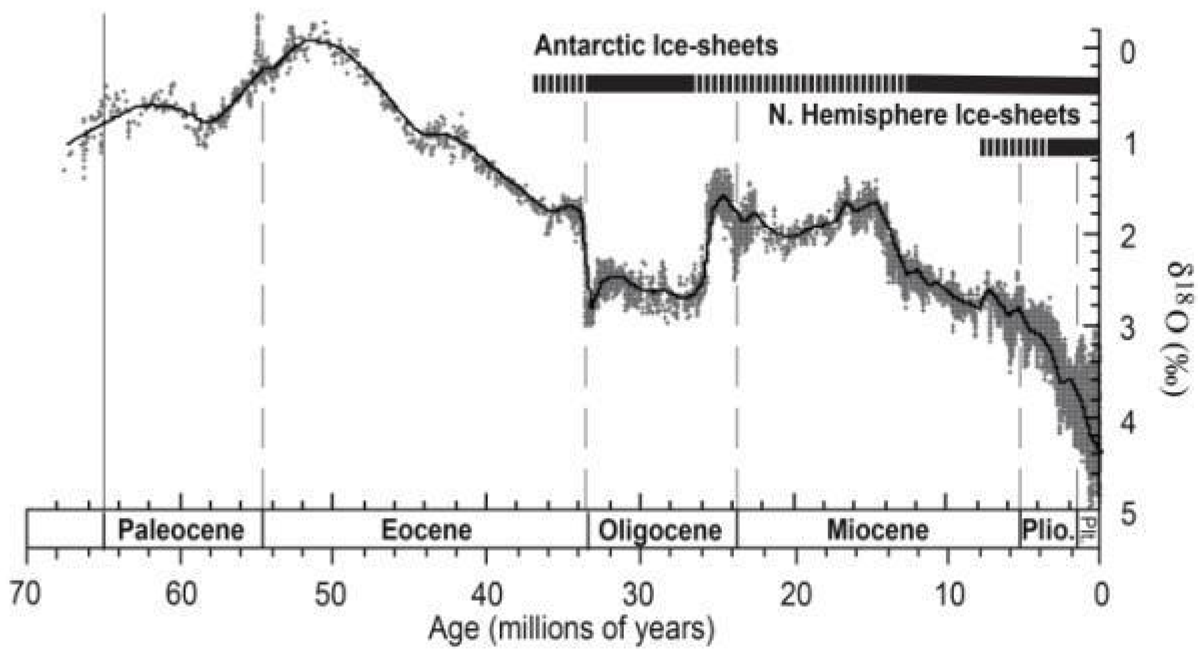
tolerate the changes – is this possible?

move - is this possible?

When the climate changes, wild species can either:

tolerate the changes – is this possible?

YES? – tropical biodiversity was greatest during the warmer parts of the Tertiary and many modern species originated by the early Pliocene, when temperatures were 3^{o}C or more warmer than today.



When the climate changes, wild species can either:

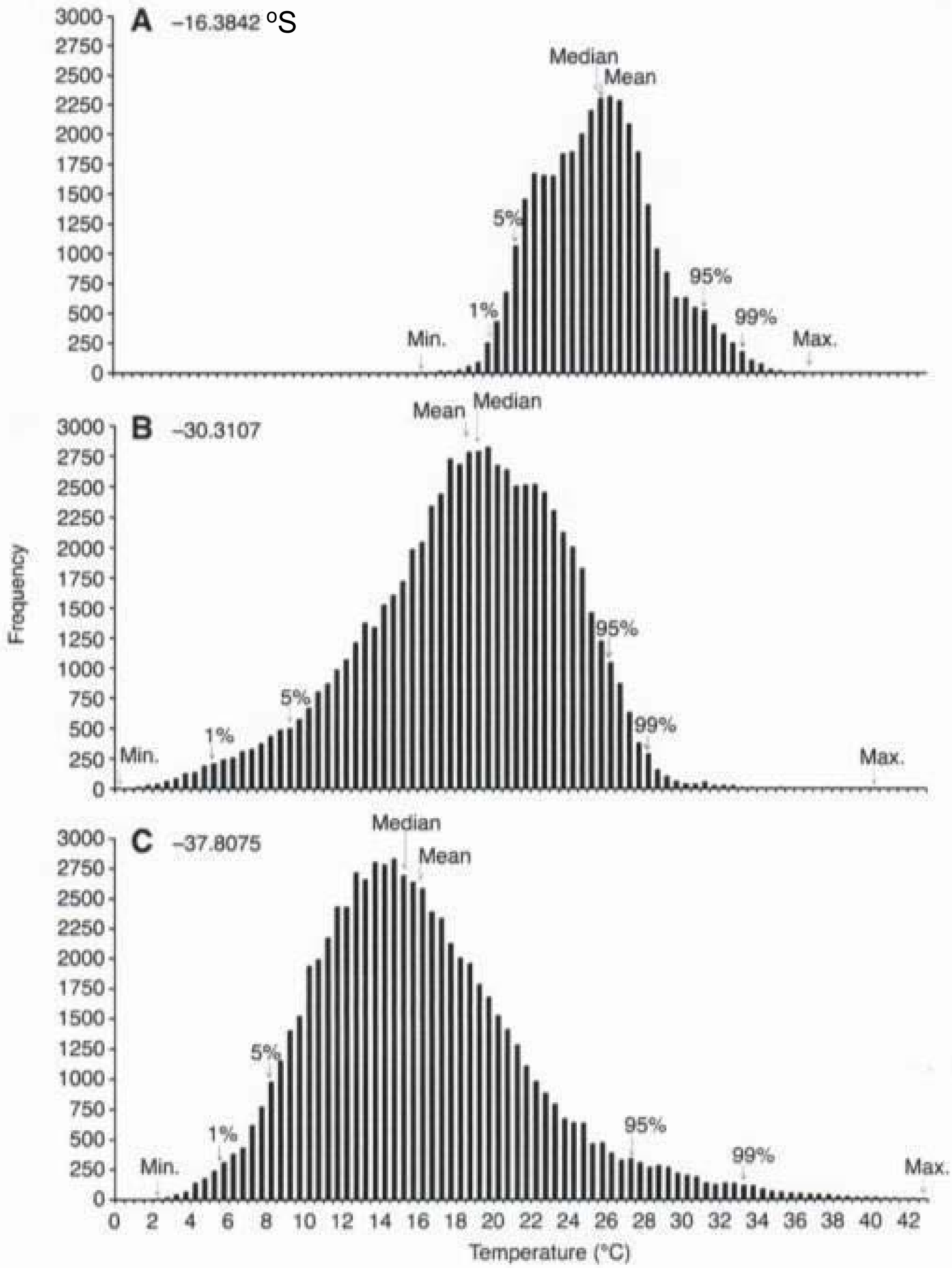
tolerate the changes – is this possible?

NO? – 3 million years of relatively cool climates have eliminated any adaptation to warmer conditions. Warming in the tropical lowlands will therefore lead to "**lowland biotic attrition**" (Colwell *et al*. 2008) as species die or move and are not replaced, since there is no source of species adapted to warmer conditions.

When the climate changes, wild species can either:

tolerate the changes – is this possible?

There is currently little evidence on the **temperature tolerances** of tropical lowland species, but most of this suggests that many species <u>are</u> near their upper limits of thermal tolerance.

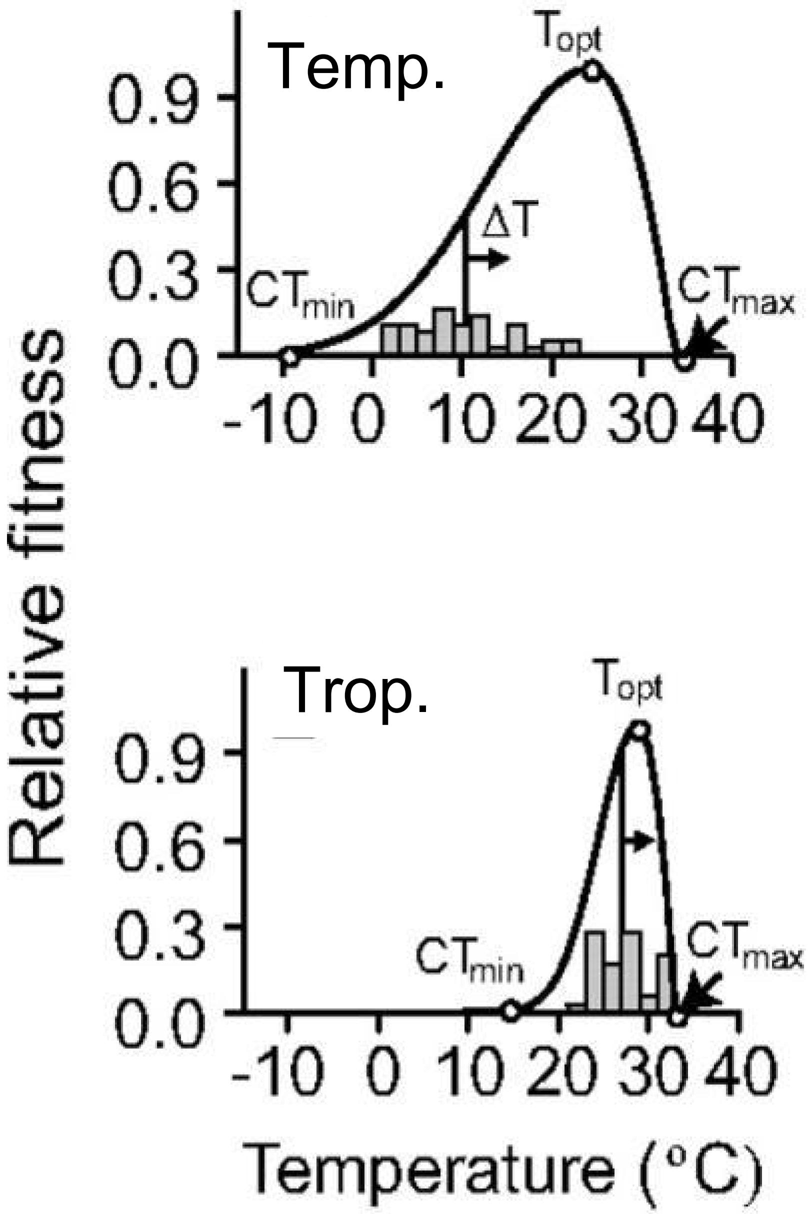


Temperatures in the tropics, subtropics and temperate zone in eastern Australia.

Note:

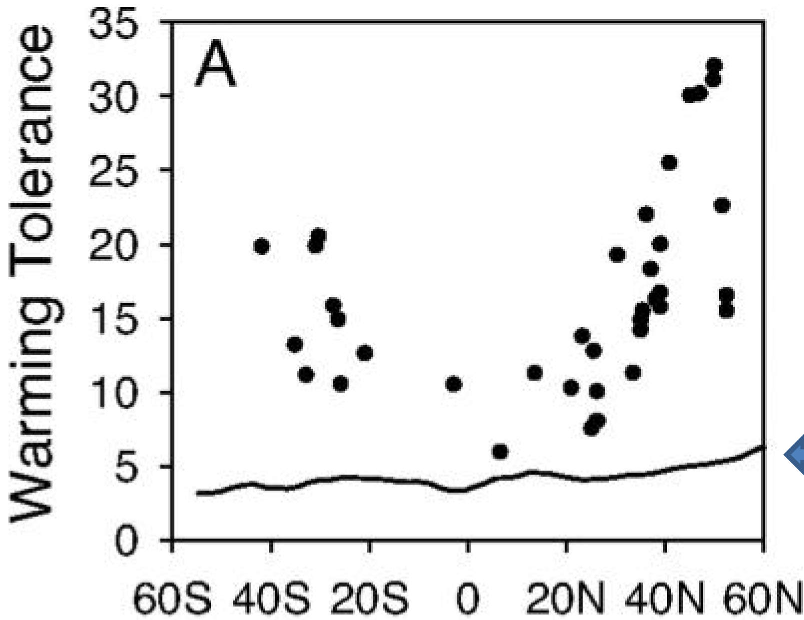
1. Mean *declines* as move away from the equator
2. But range and maximum *increases*.

(Singapore has an even narrower temperature range than the tropical site shown here.)



Fitness curves for temperate vs. tropical insects (mostly pests).

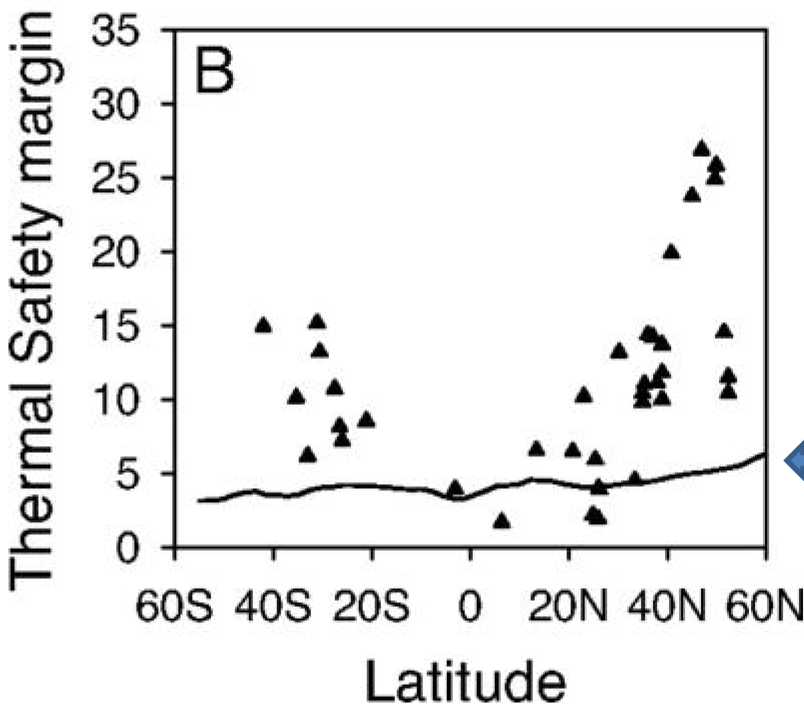
(Fig. 1 in Deutsch et al. 2008. PNAS)



2100

Latitudinal trends in the warming tolerance of insects:

A.lethal - actual temperature

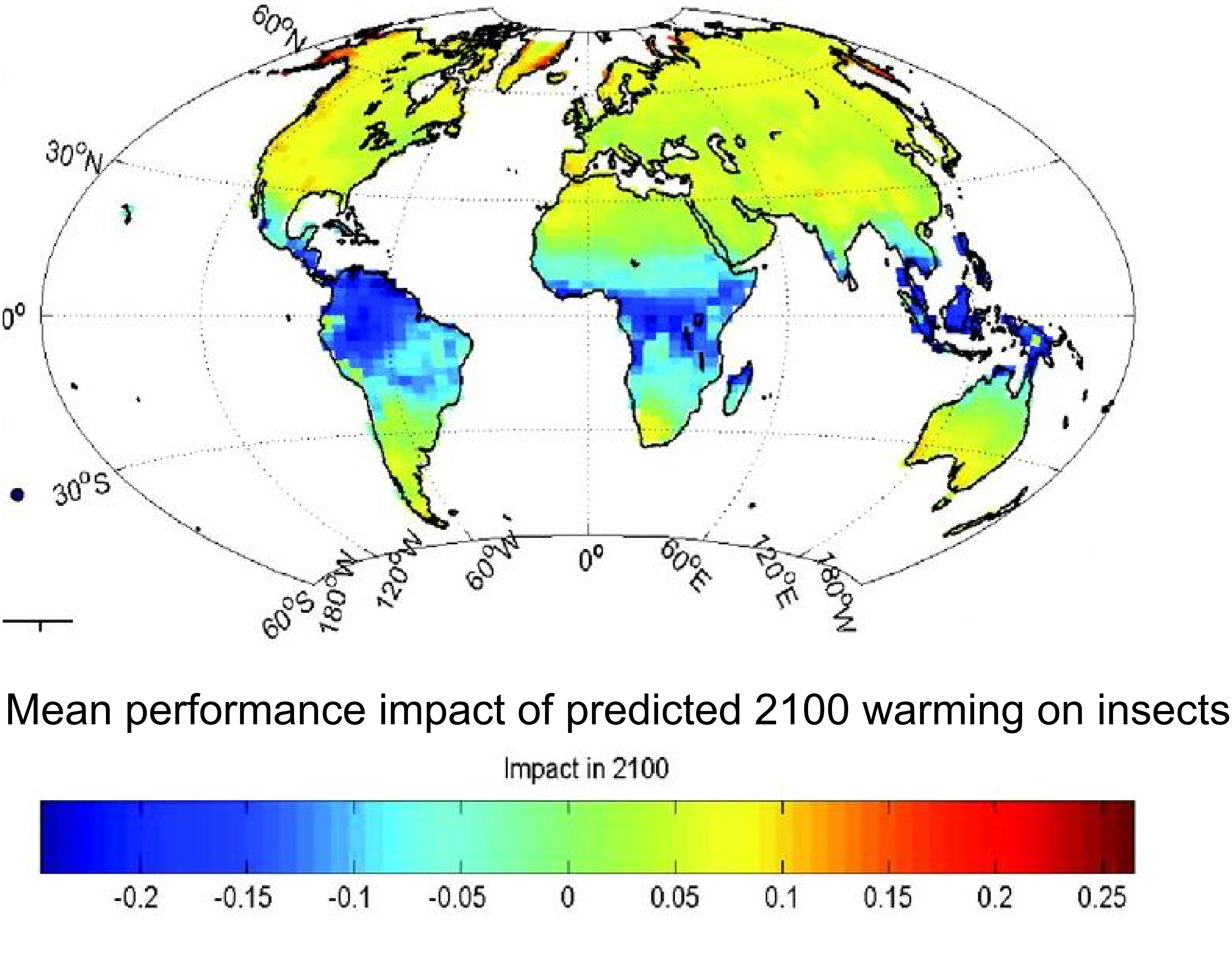


2100

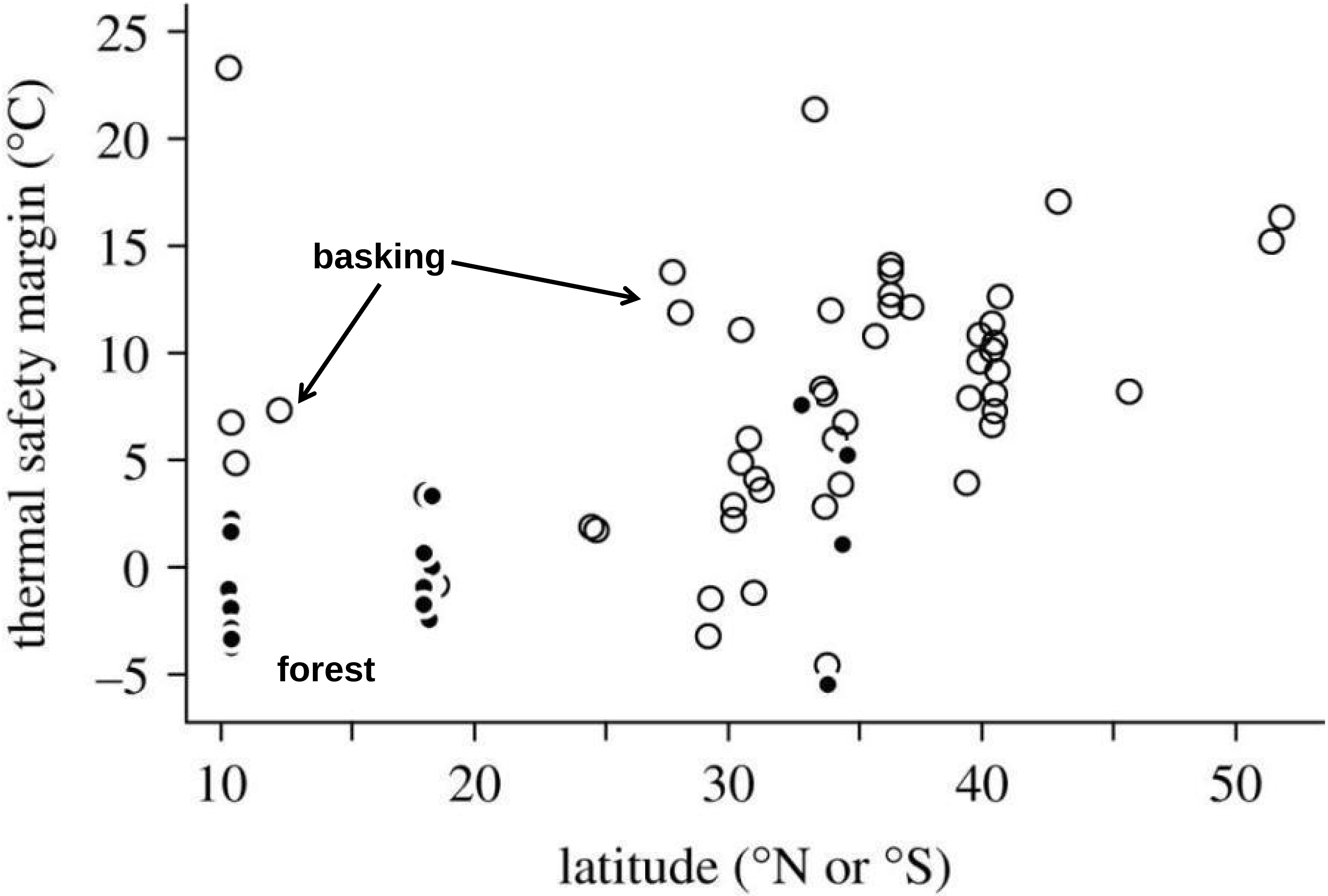
B.optimum - actual temperature

Deutsch et al. 2008.

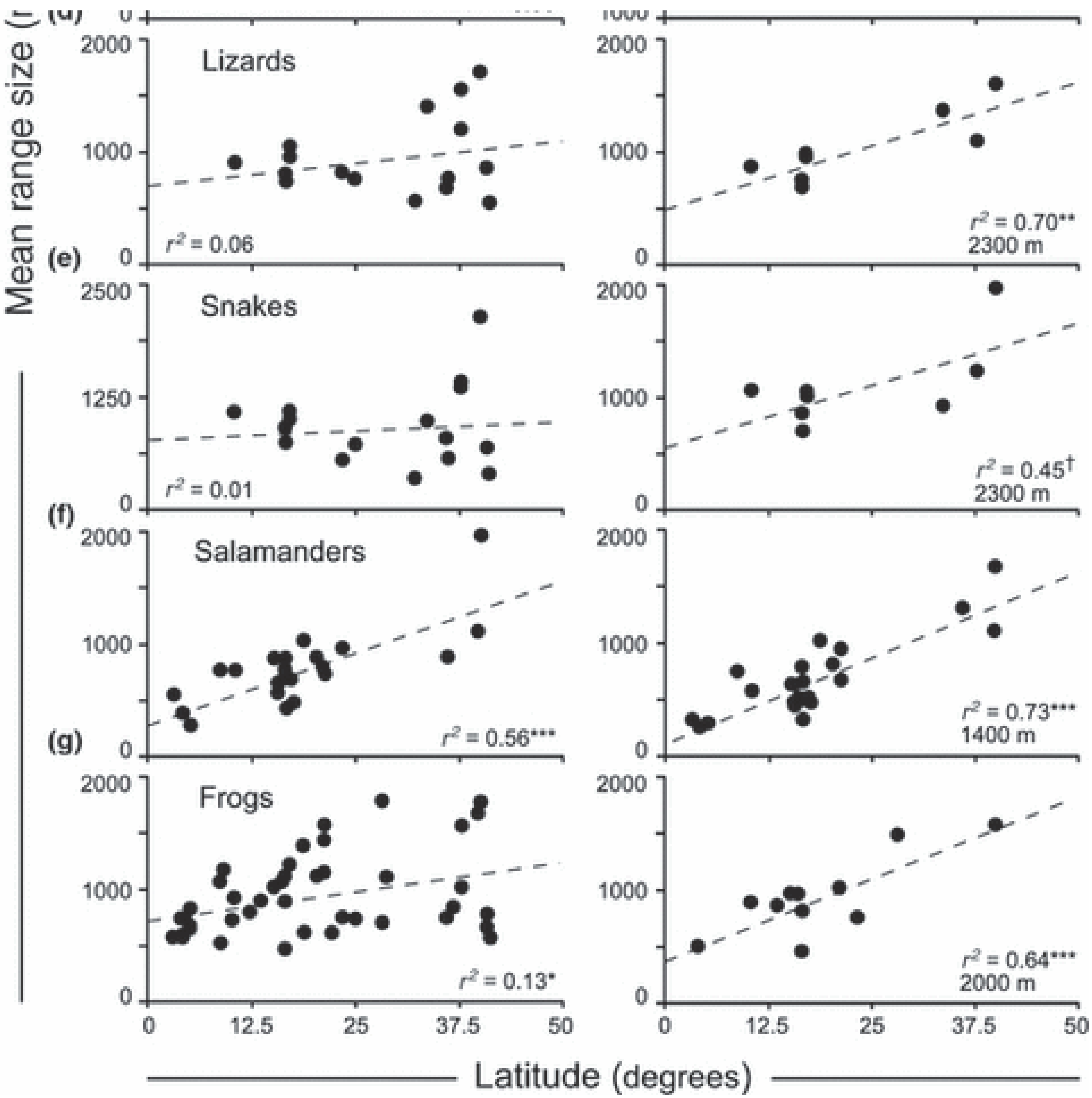
PNAS



Mean performance impact of predicted 2100 warming on insects

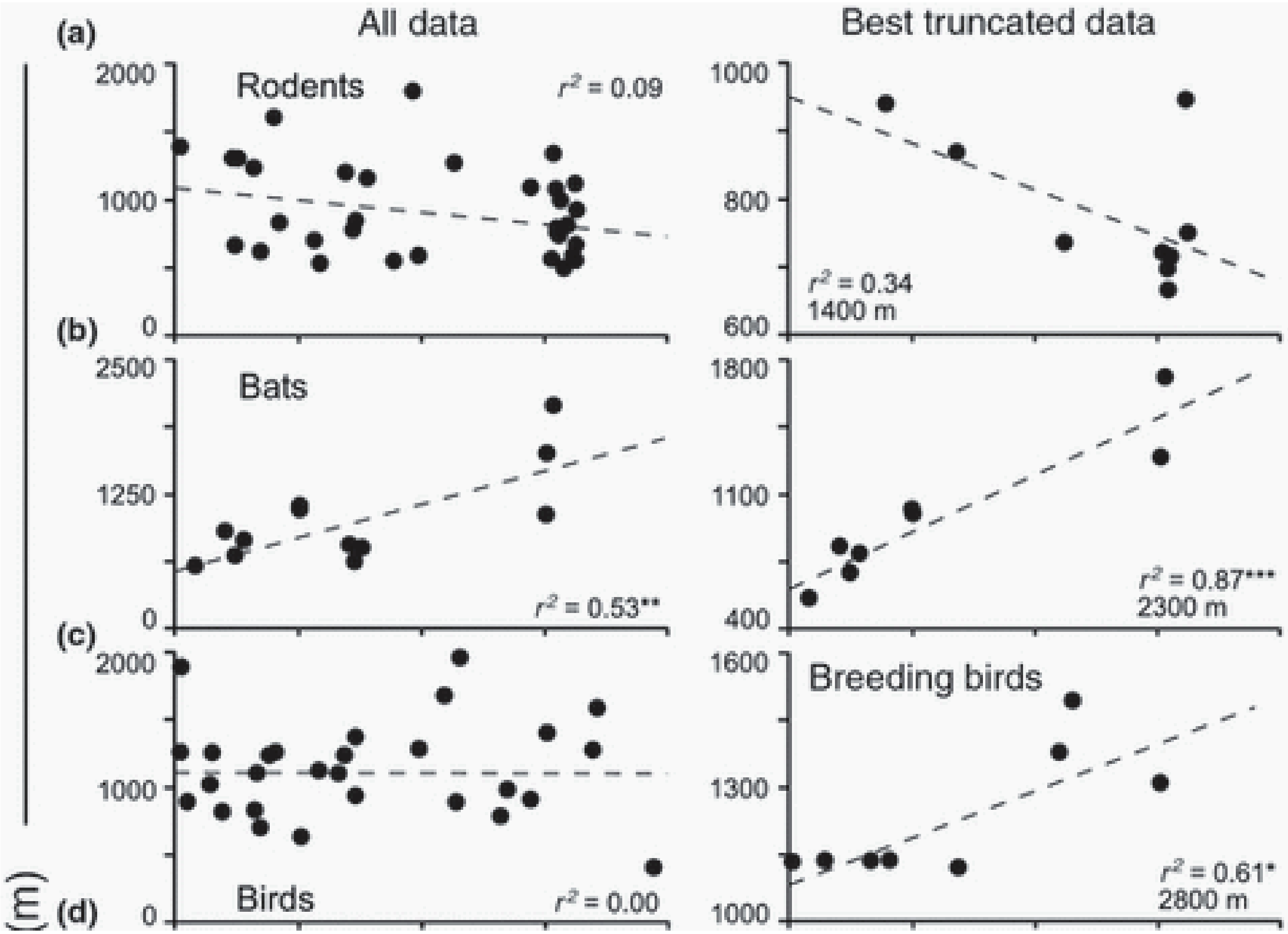


Thermal safety margins (optimum temp. – shade temp.) for diurnal lizards (Huey et al. 2009. Proc R Soc B.)



…and **elevational ranges** are less in the tropics in ectotherms, again suggesting a narrower range of thermal tolerance

McCain 2009 *Ecology Letters*



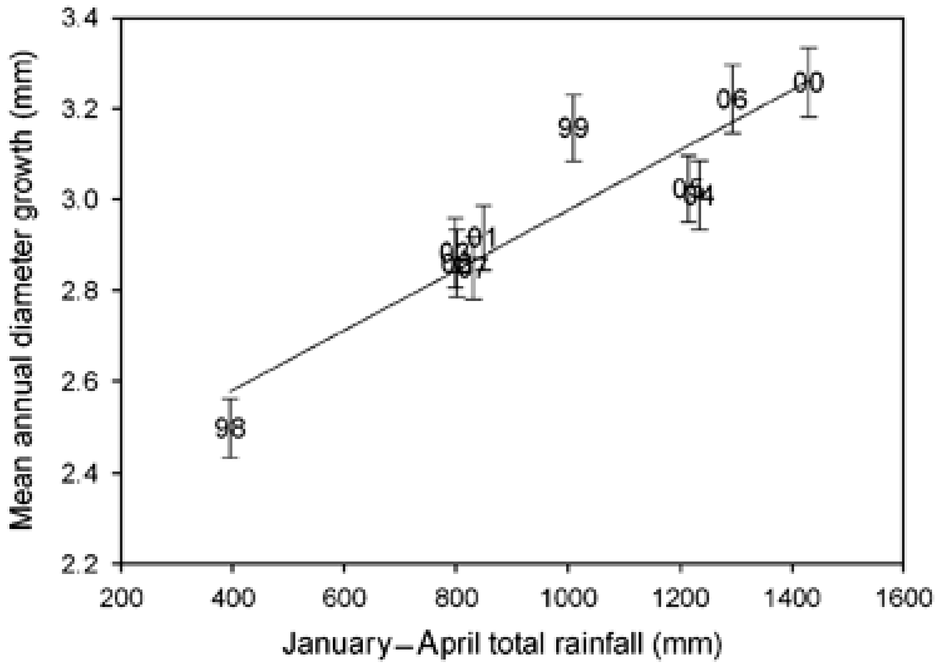
…but this is less consistent in <u>endo</u>therms

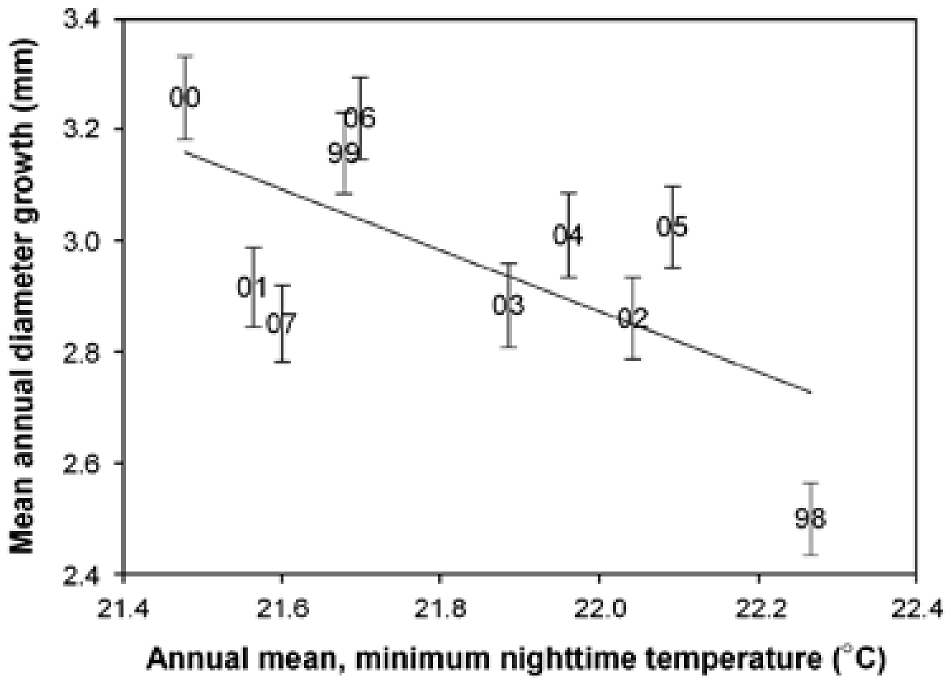
McCain 2009 *Ecology Letters*

Plants?

Also ‘ectotherms’

There is a variety of evidence that net carbon uptake is *reduced* in relatively warm and/or dry periods, but it is possibly being *increased* by rising CO_2 levels.



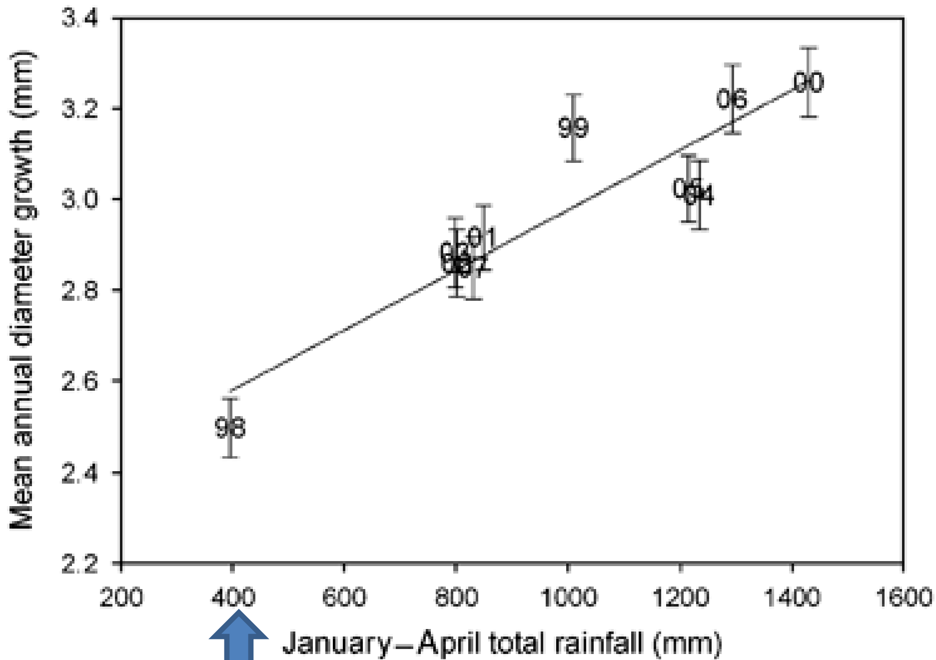


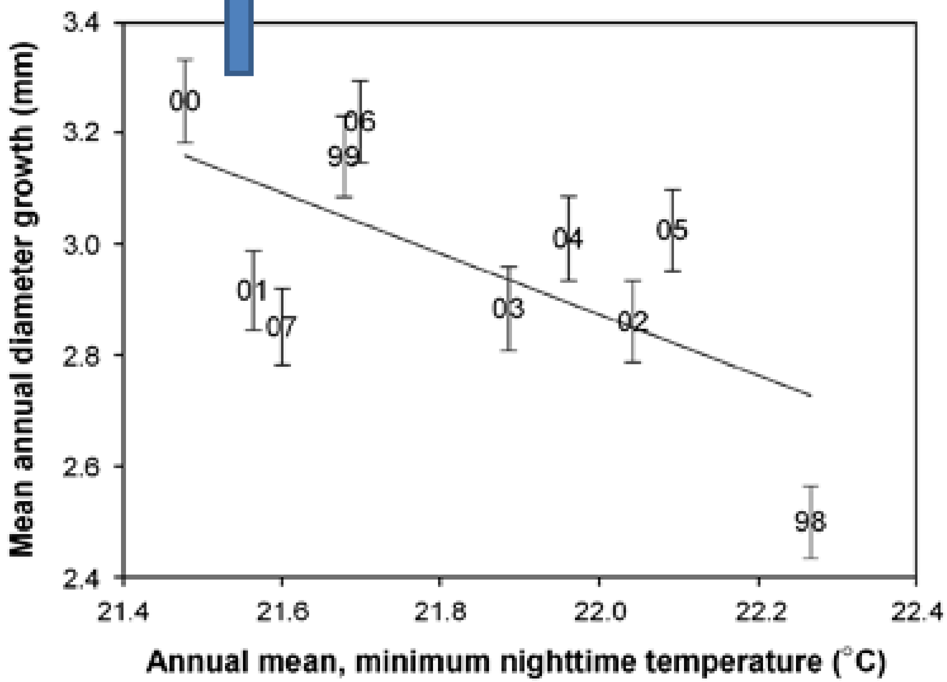
Tree growth in a Costa Rican rainforest 1997-2007: 91% of the variation explained by "**drier" season rainfall** and **minimum nighttime temperature.**

Suggests tree growth will be substantially reduced by even small **increases in temperature** or **decreases in rainfall**.

No sign of a $C0_2$ fertilization effect!

Clark et al. 2009 Global Change Biology





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Plant movements are of most concern since any failure to track changing climate (‘migration lag’) will have implications for carbon storage and animals.

Species movements in response to climate change

In Europe and North America, the **majority** of plant and animals species for which there are good records have responded to climate change in recent decades by **northward** or **upwards** movements

Outside the tropics: 10 km north ≈ 10 m upwards.

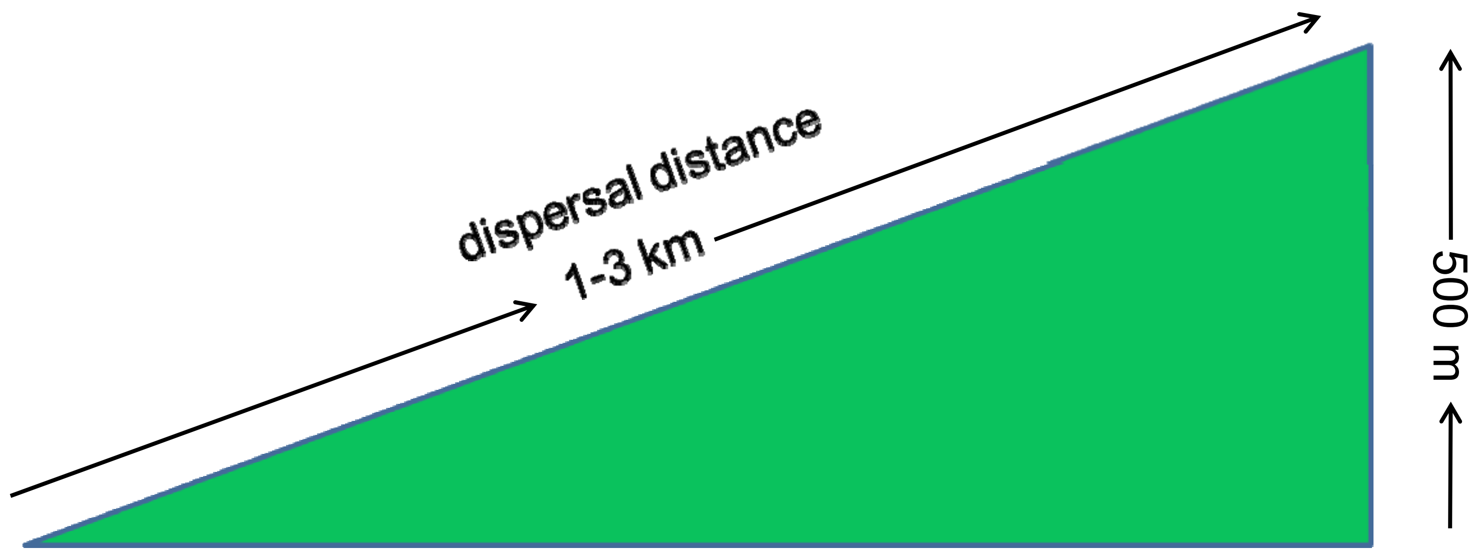
There is very little comparable data from the **tropics**

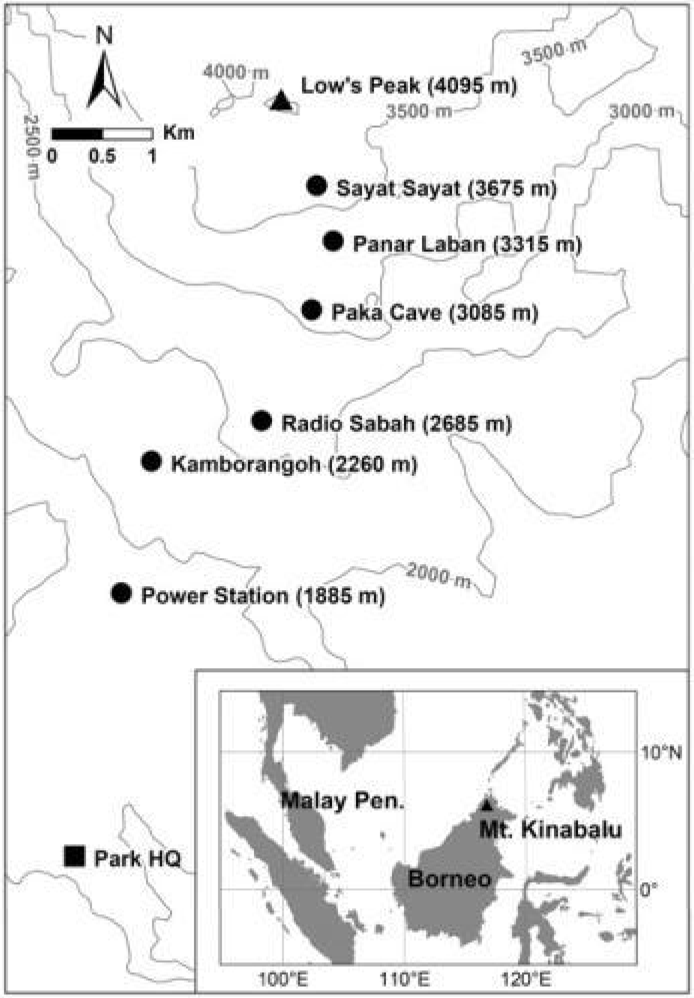
.

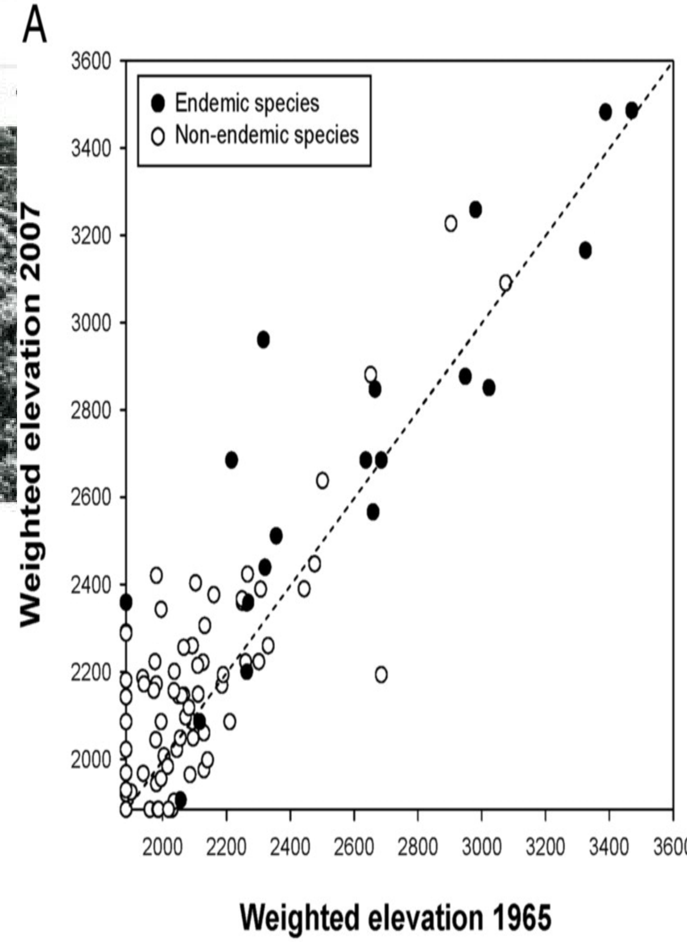
How far do species need to move?

Prediction is easiest for **mountainous** regions, where heat stress can be avoided by **movement uphill**, e.g. 500 m increase in altitude could compensate for 3ºC of warming.

= c. **1-3 km** horizontal movement in typical topography







Chen et al. (2009, 2010) re-sampled moths after 42 years along an elevation gradient on Mt Kinabalu and found an average increase in elevation of 84 m in 42 years.

How far do species need to move?

Prediction is much more difficult for the **lowland** tropics:

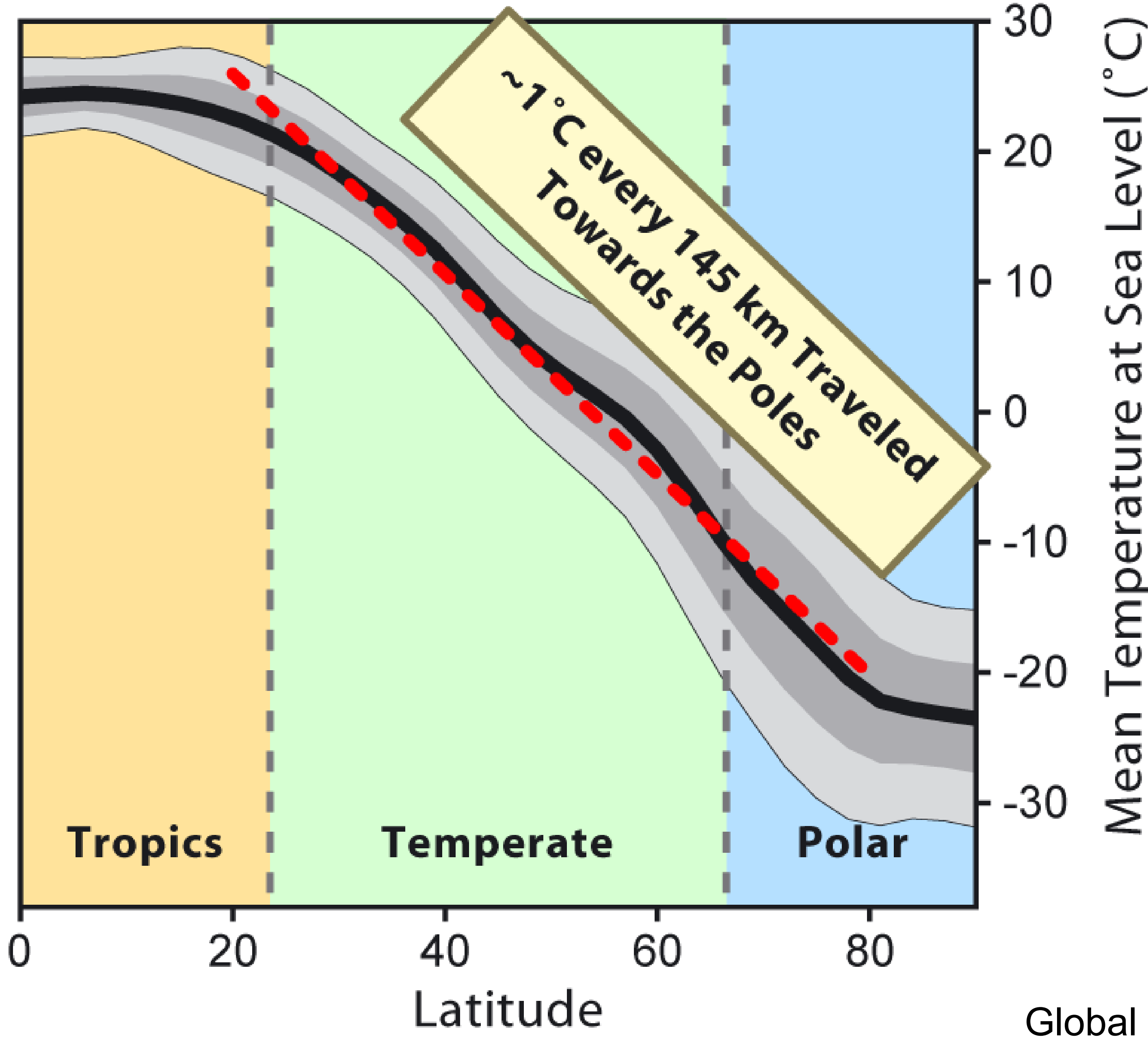
1. +/- **flat thermal gradient** means avoiding heat stress will need latitudinal movements of 100s of km

2. Changes in **rainfall** will be at least as important

3. Lowland ecosystems are **highly fragmented**

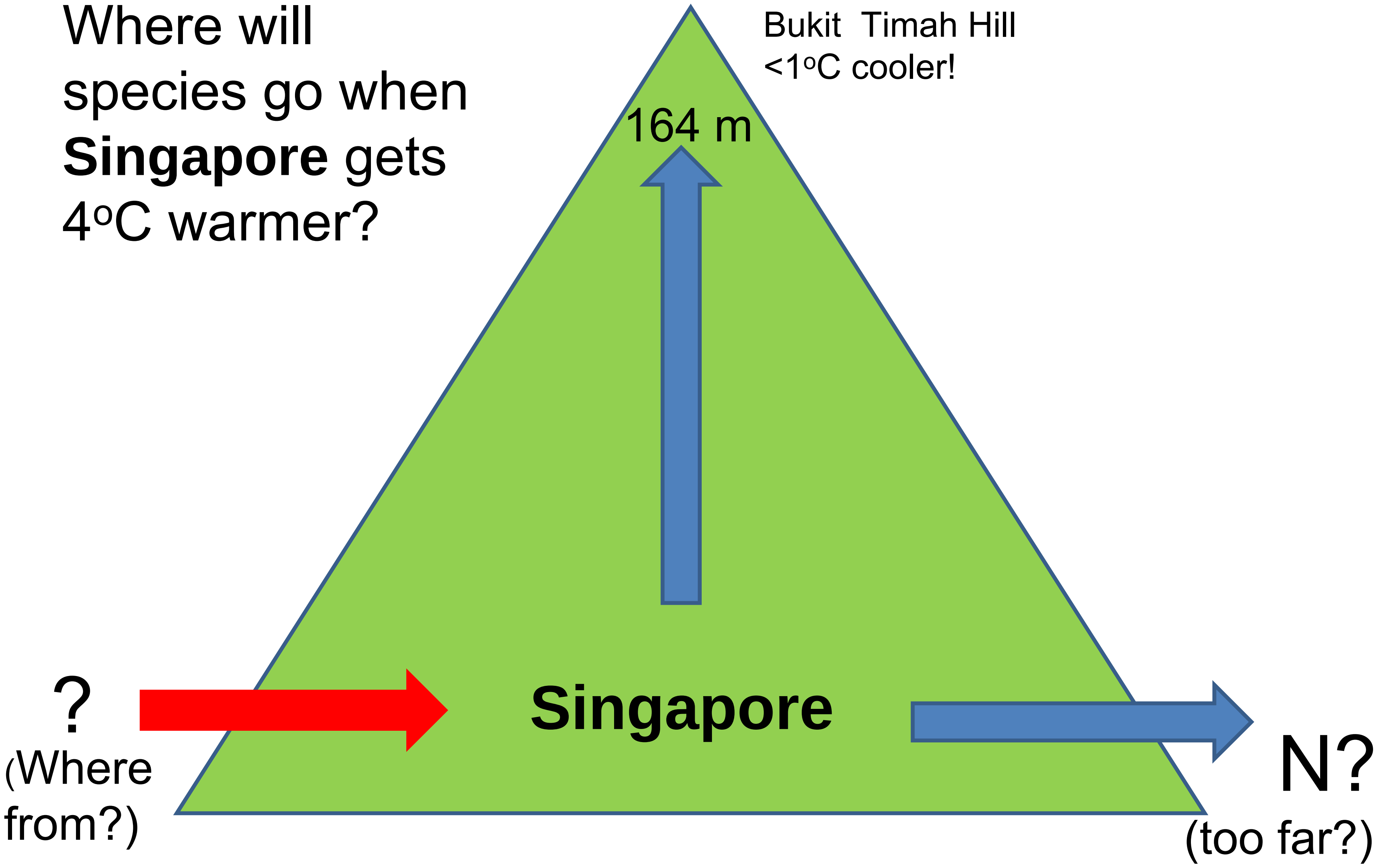
i.e. species will need to move **100s of km** across densely populated, fragmented landscapes

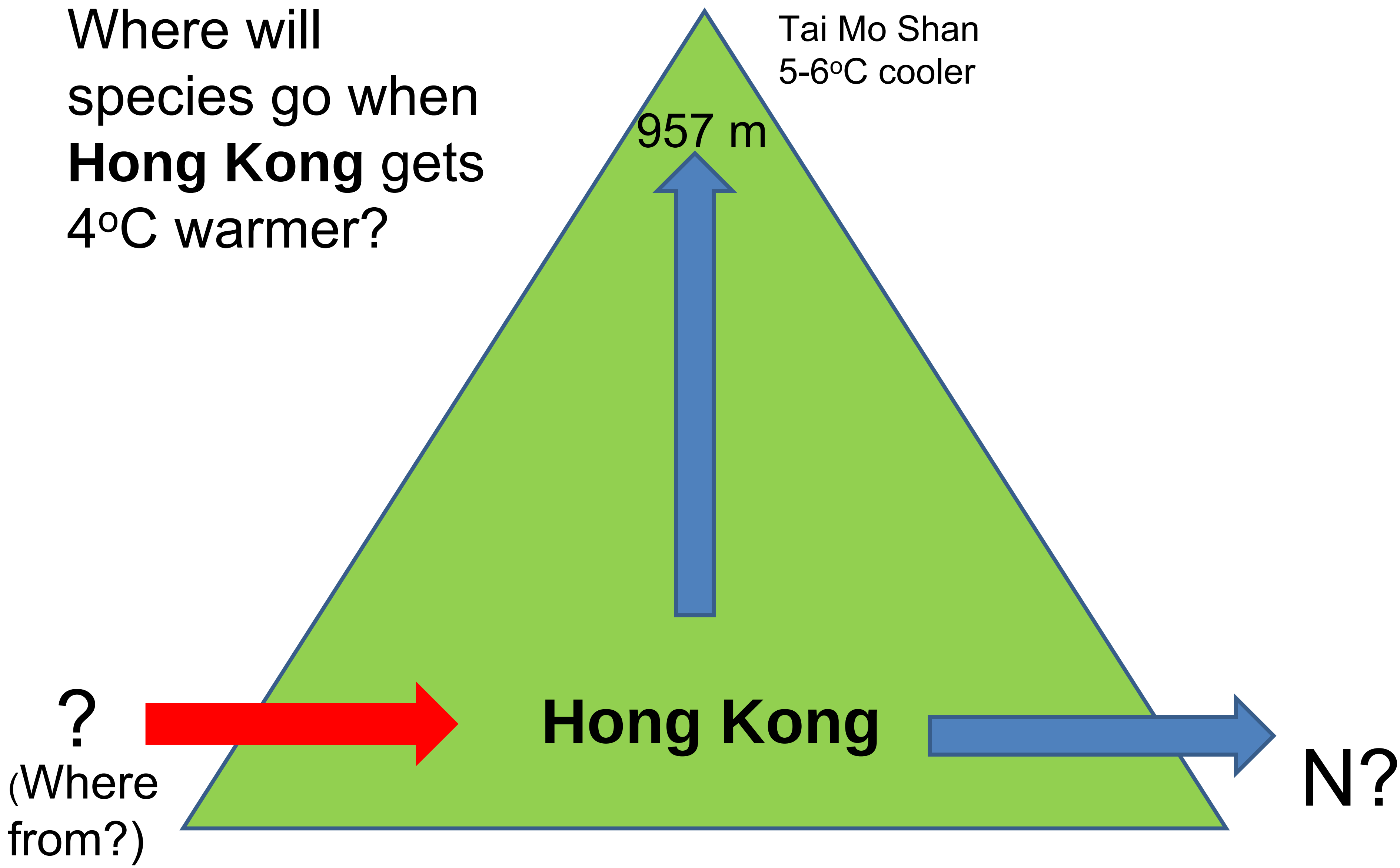
Surface Temperature versus Latitude

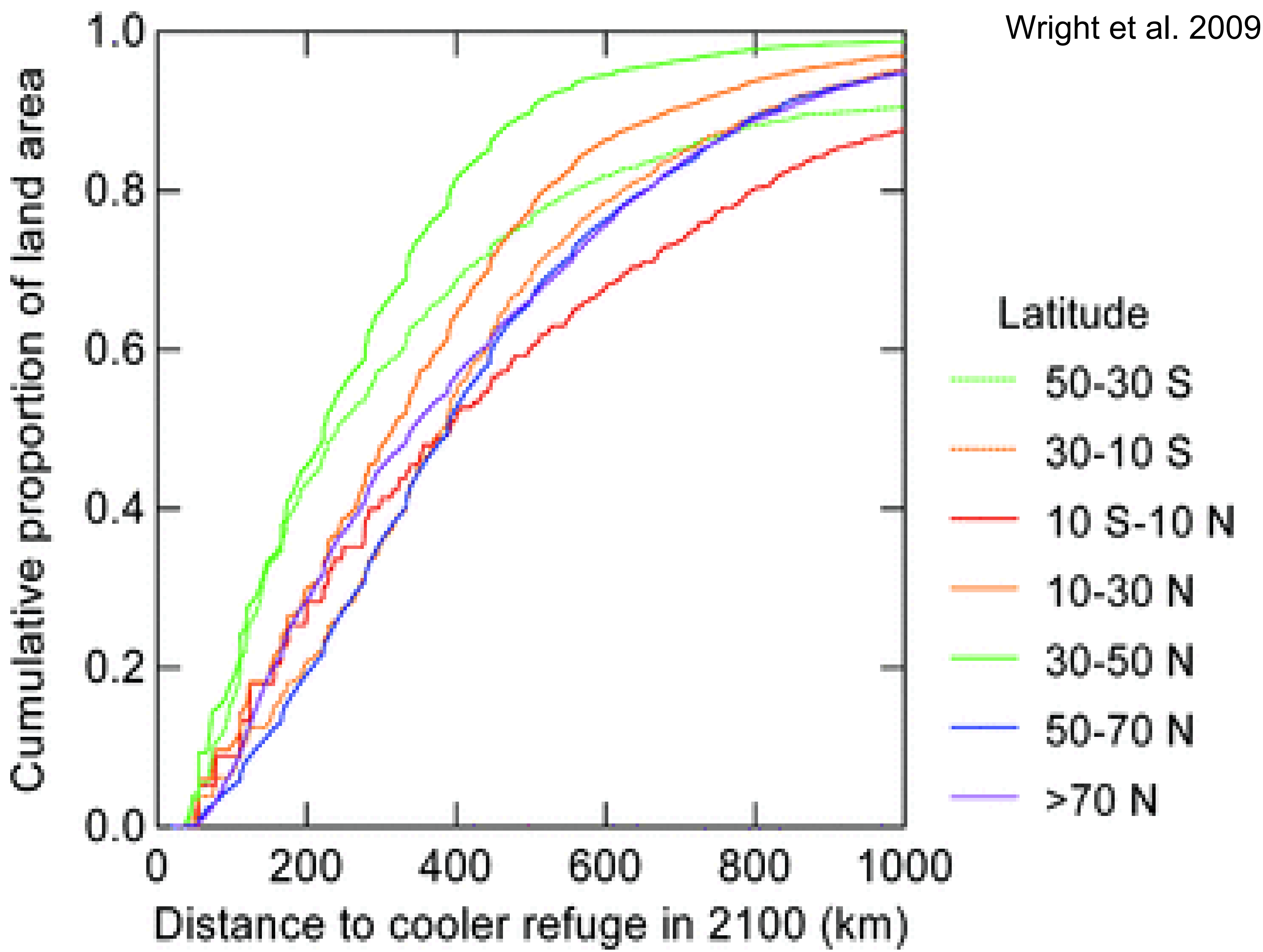


Global Warming Ar

Where will species go when **Singapore** gets 4^{o}C warmer?



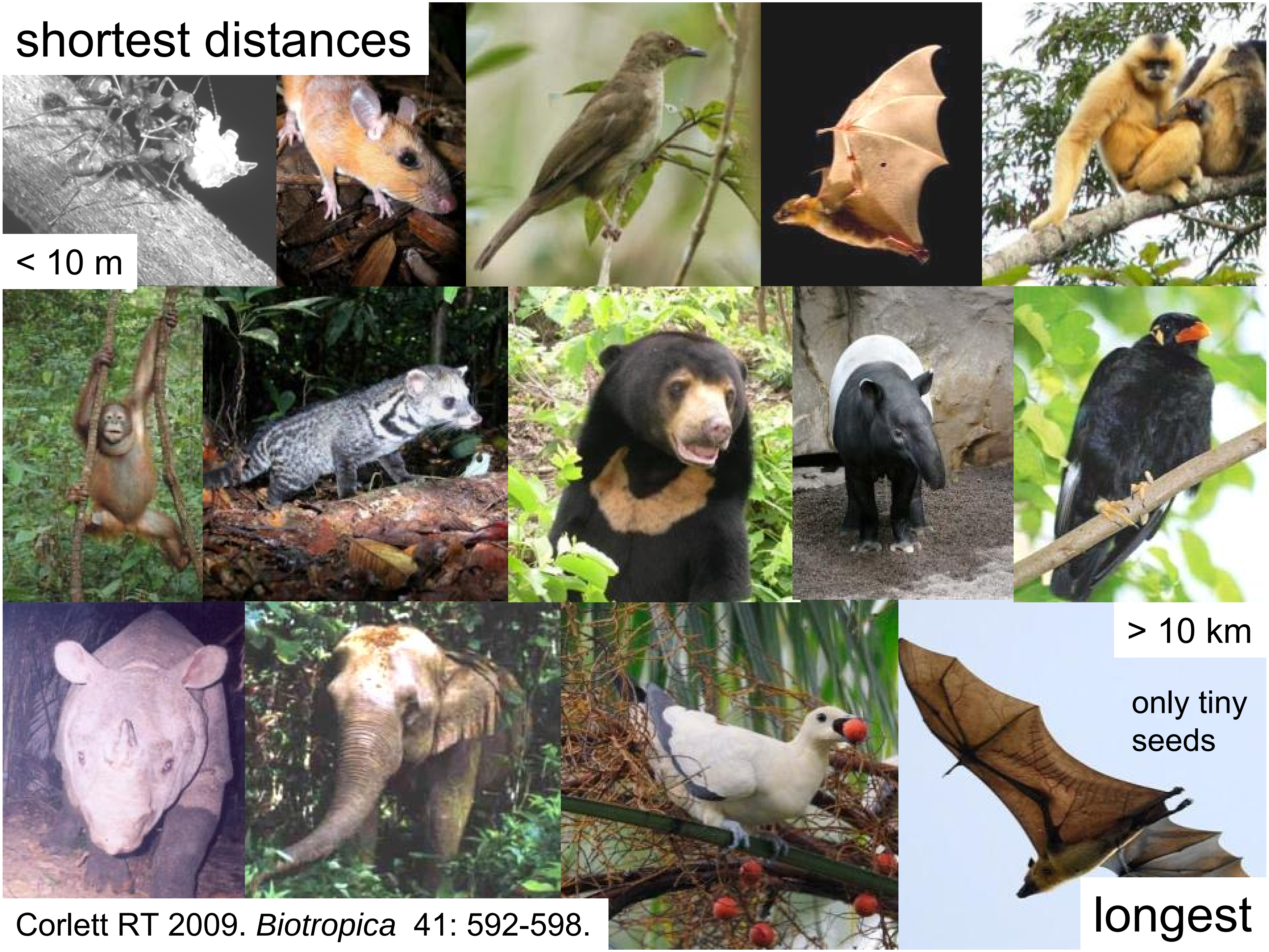

Where will species go when **Hong Kong** gets 4°C warmer?
Tai Mo Shan
5-6°C cooler
957 m
Hong Kong
?
(Where from?)
N?


Wright et al. 2009
Cumulative proportion of land area
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
Distance to cooler refuge in 2100 (km)
Latitude
50-30 S
30-10 S
10 S-10 N
10-30 N
30-50 N
50-70 N
>70 N

Plant movements in the tropics largely occur as seeds in the guts of animals.

The key question therefore is:

How far do fruit-eating animals move in the time it takes a seed to pass through their guts?



Corlett RT 2009. *Biotropica* 41: 592-598.


Not hunted
only tiny seeds
Hunted


Gap-crossing

Conclusions:

1. Tropical East Asia will warm by 3-4(-6?)^{o}C over the next 100 years and there will be less predictable changes in rainfall and other climate variables

2. The ability of tropical lowland species to tolerate these changes without movement is largely unknown.

3. Maximum seed dispersal distances for various plant-animal combinations range from <10 m to >10 km

4. In steep topography this may be enough for many plant species to compensate partly or fully for projected temperature increases, but not in the lowlands.

Conclusions:

5.Hunting is currently selectively eliminating the best long-distance seed dispersal agents.

Synergies between climate change and other human impacts will inevitably lead to considerable “lowland biotic attrition” and probably to accelerating release of carbon dioxide in **equatorial regions**, but the magnitude of these impacts cannot yet be predicted.

Conclusions:

5.Hunting is currently selectively eliminating the best long-distance seed dispersal agents.

Synergies between climate change and other human impacts will inevitably lead to considerable “lowland biotic attrition” and probably to accelerating release of carbon dioxide in **equatorial regions**, but the magnitude of these impacts cannot yet be predicted.

Steeper climatic gradients on **the edge of the tropics** may reduce vulnerability *in theory*, but higher human population densities and greater habitat fragmentation will have the opposite effect.

Key references:

Chen, I.-C et al. (2009) Elevation increases in moth assemblages over 42 years on a tropical mountain. *PNAS*

Clark, DB et al. (2009) Annual wood production in a tropical rain forest in NE Costa Rica linked to climatic variation but not to increasing CO_2. *Global Change Biology* 16: 747-759.

Cleveland et al. (2010). Experimental drought…. *Ecology* 91: 2313-2323.

Colwell, RK et al. (2008) Global warming, elevational range shifts, and lowland biotic attrition in the wet tropics. *Science* 322: 258-261.

Corlett, RT (2009a) Seed dispersal distances and plant migration potential in tropical East Asia. *Biotropica* 41: 592-598

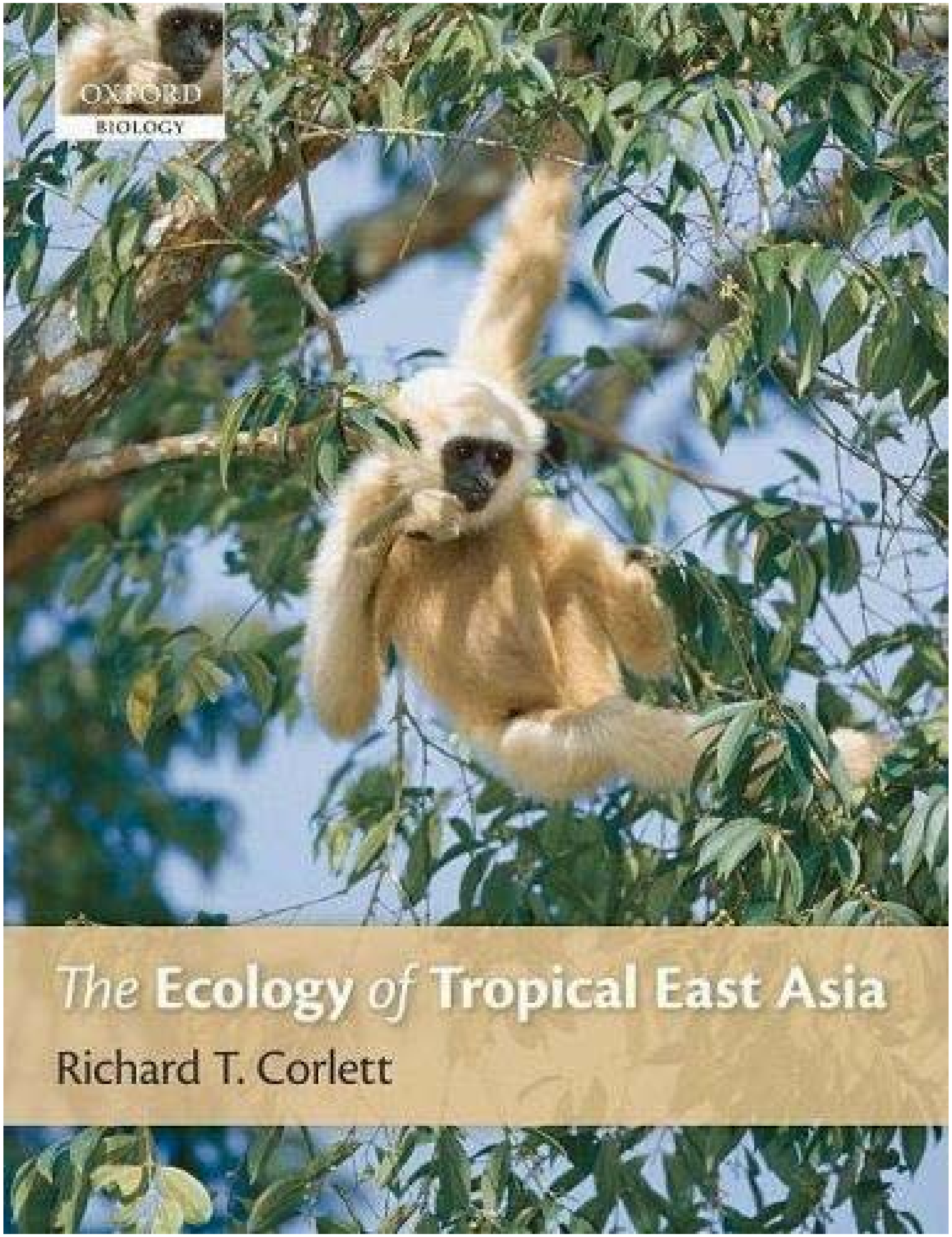
Deutsch, CA et al.(2009) Impacts of climate warming on terrestrial ectotherms across latitude. *PNAS* 105: 6668-6672.

Feeley, KJ et al. (2007) Decelerating growth in tropical forest trees. *Ecology Letters* 10: 461-469

Gonzalez et al. (2010) Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change. *Global Ecol. Biogeogr.* on-line

Huey, RB et al.(2009) Why tropical lizards are vulnerable to climate warming. *Proc Roy Soc B* 276: 1939-1948.

Wright, SJ et al. (2009) The future of tropical species on a warmer planet. *Conservation Biology* 23: 1418-1426.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BIOLOGY
The Ecology of Tropical East Asia
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Thank you!

ATBC – Asia Pacific Chapter annual meeting 2011

“*The biodiversity crisis in tropical Asia*”

Venue
12 to 15 March 2011
At the Siam City Hotel, **Bangkok, Thailand**

Deadlines

Registration open	20 Sep 2010
Symposia proposal deadline	30 Nov 2010
Abstract Deadline	31 Dec 2010
Early registration deadline	31 Dec 2010
Late registration deadline	15 Feb 2011