

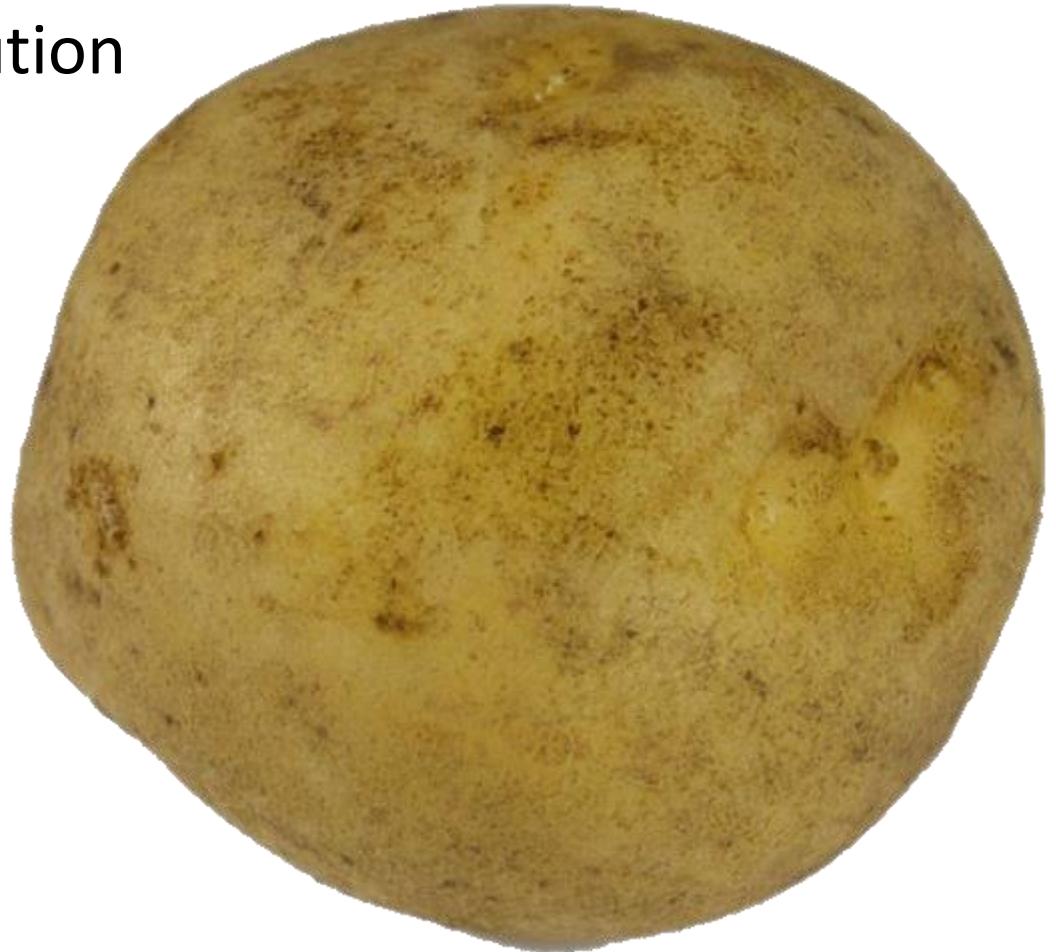
# Famine: the Geography of Scarcity

## Agricultural revolutions



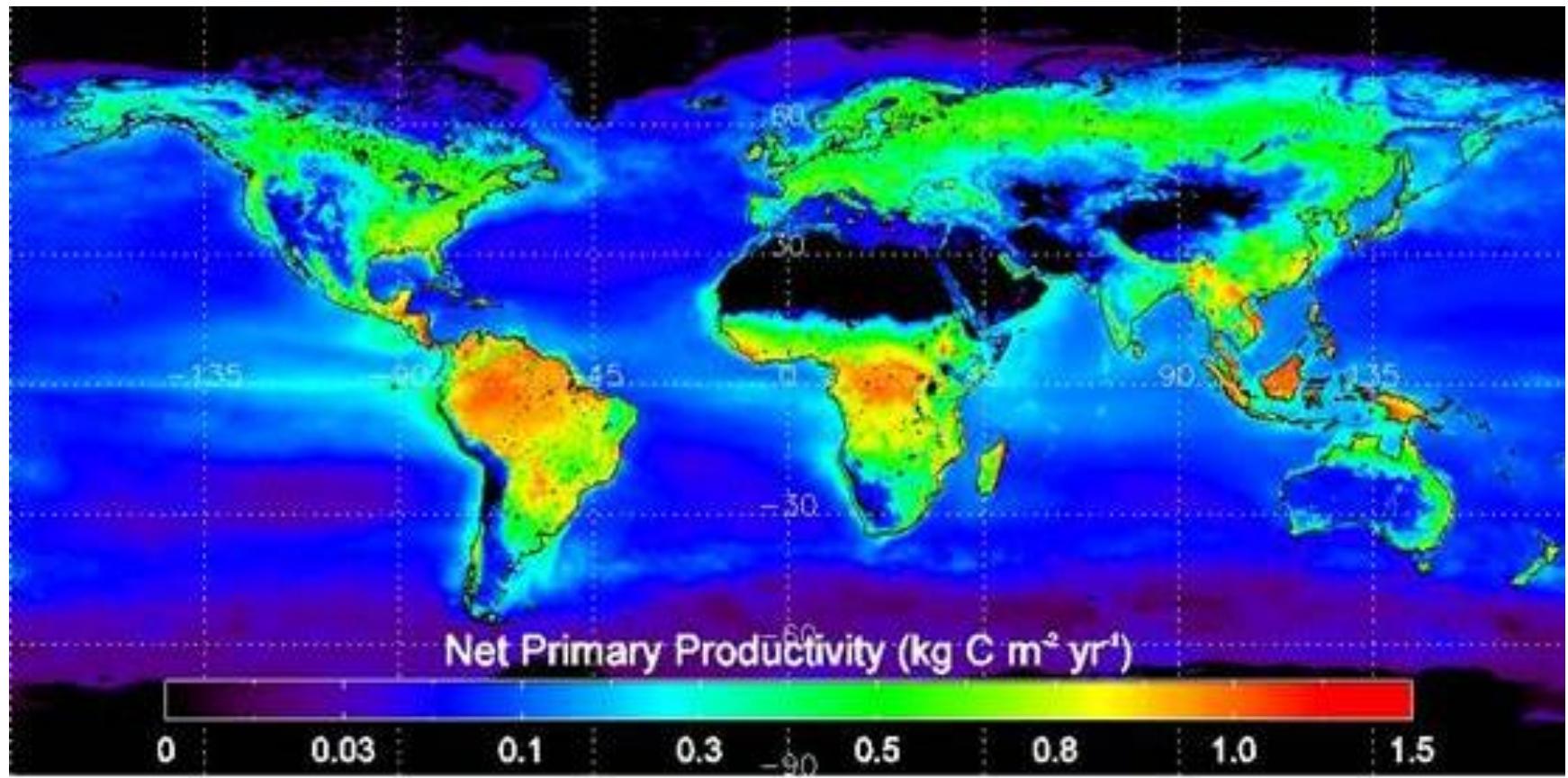
# Today's lecture

- Biogeography and biodiversity basics
- The Neolithic Revolution
- The humble potato



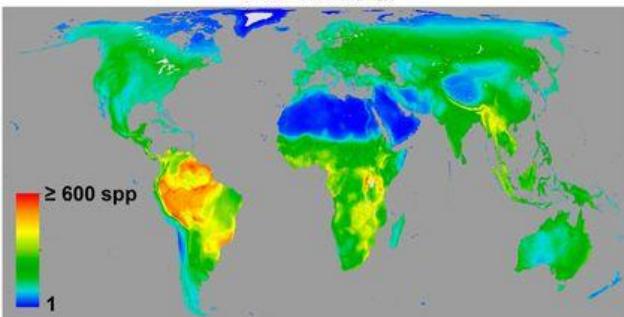
# Biogeography and climate

- Climate is a key control over the distribution and diversity of species (...there are many others!)

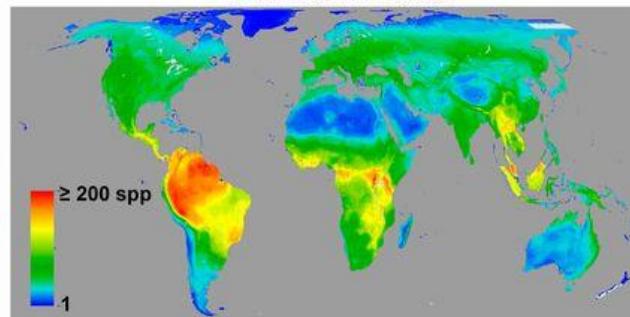


Jenkins et al. (2013) PNAS

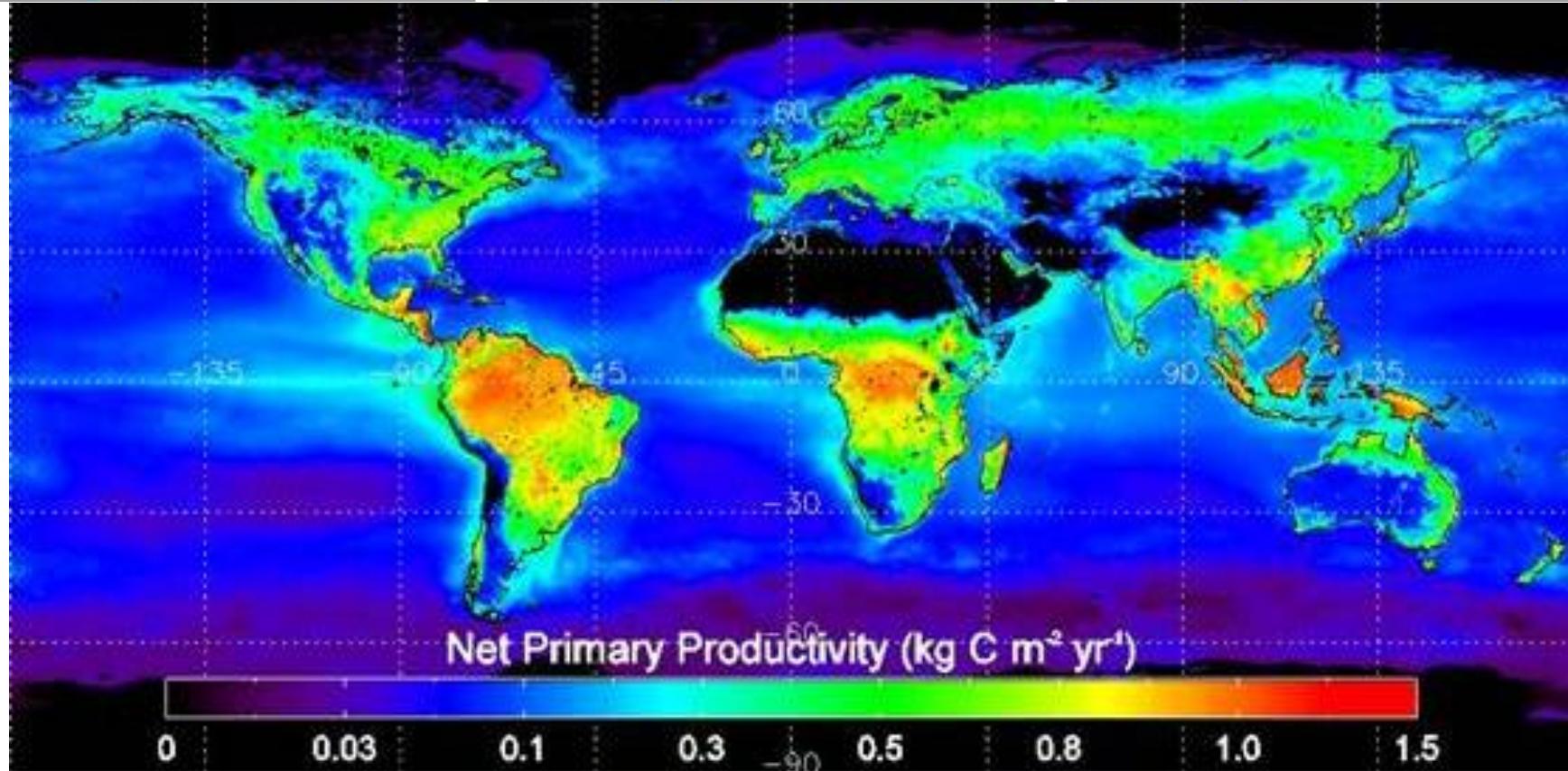
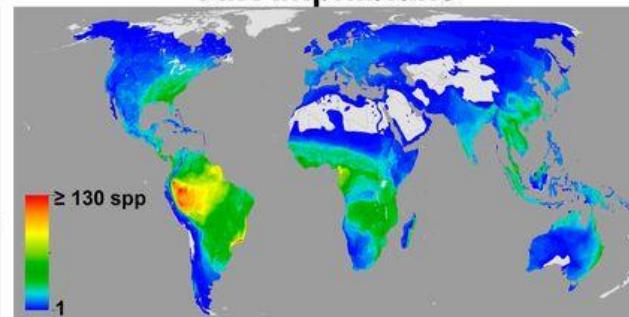
All Birds



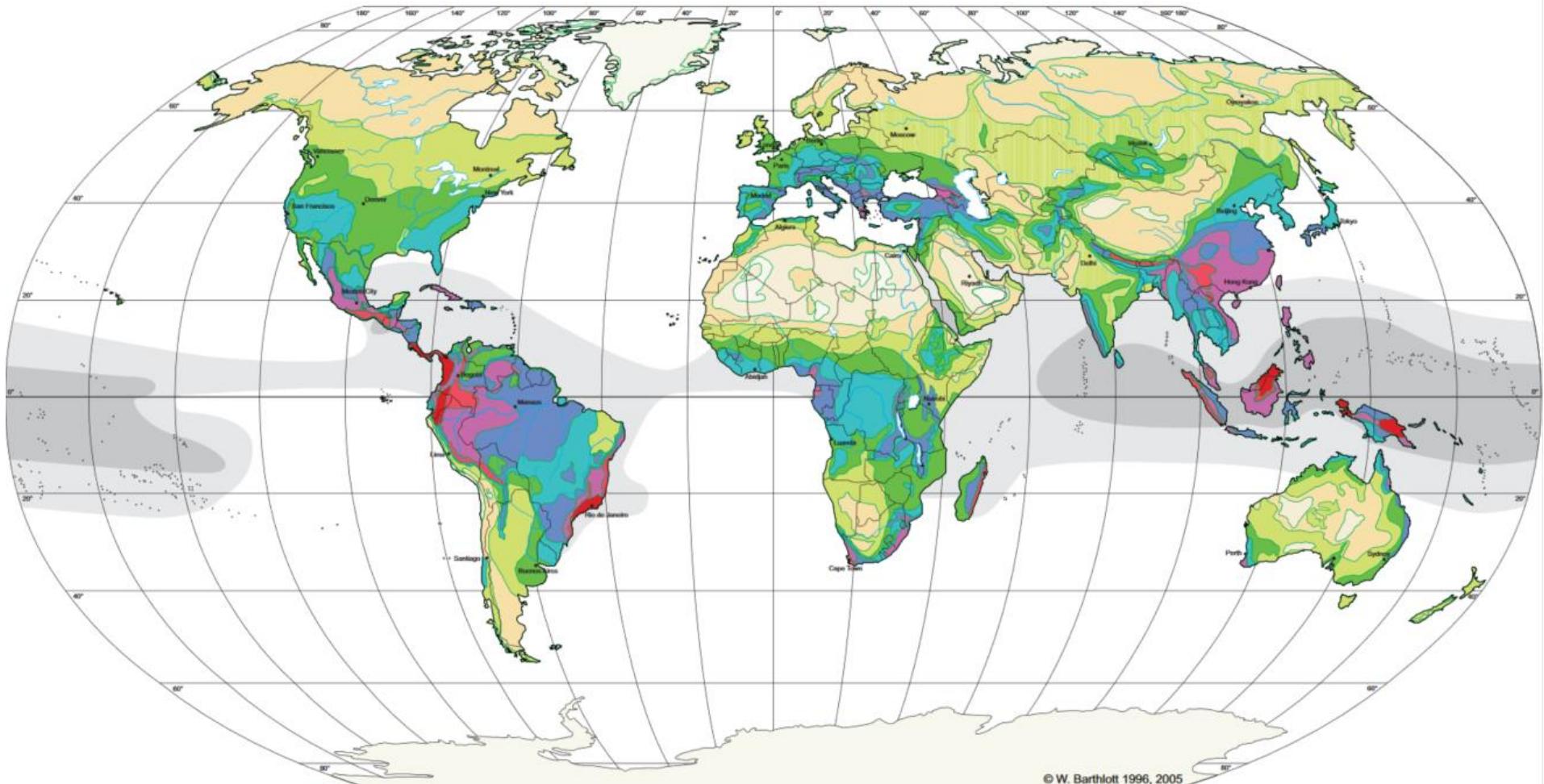
All Mammals



All Amphibians



# GLOBAL BIODIVERSITY: SPECIES NUMBERS OF VASCULAR PLANTS



Robinson Projection  
Standard Parallels 38°N und 38°S

Diversity Zones (DZ): Number of species per 10 000km<sup>2</sup>

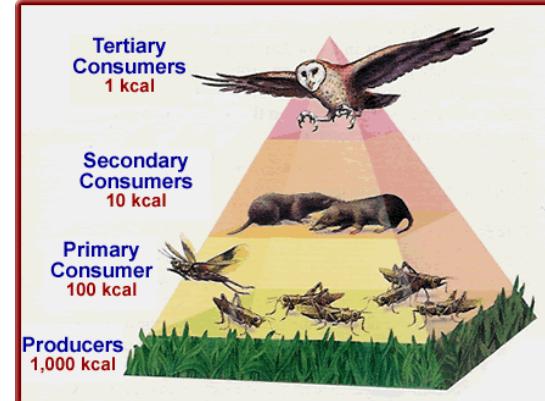
DZ 1 (<100)	DZ 5 (1000 - 1500)	DZ 9 (4000 - 5000)
DZ 2 (100 - 200)	DZ 6 (1500 - 2000)	DZ 10 (> 5000)
DZ 3 (200 - 500)	DZ 7 (2000 - 3000)	
DZ 4 (500 - 1000)	DZ 8 (3000 - 4000)	

sea surface temperature

>29°C
>27°C

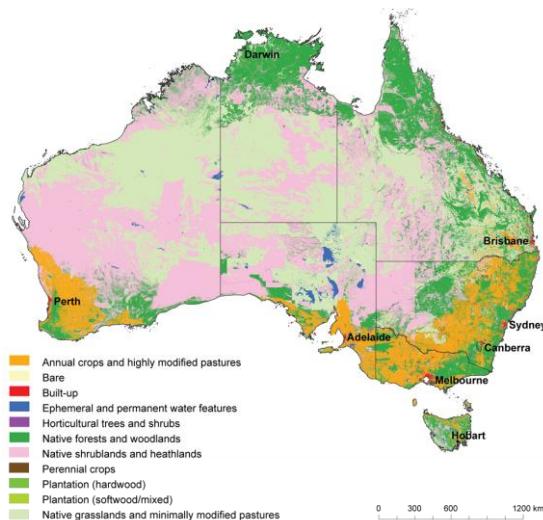
W. Barthlott, G. Kier, H. Kreft, W. Küper, D. Rafiqpoor,  
& J. Mutke 2005  
modified after  
W. Barthlott, W. Lauer & A. Placke 1996  
Nees Institute for Biodiversity of Plants  
University of Bonn

# What biodiversity does



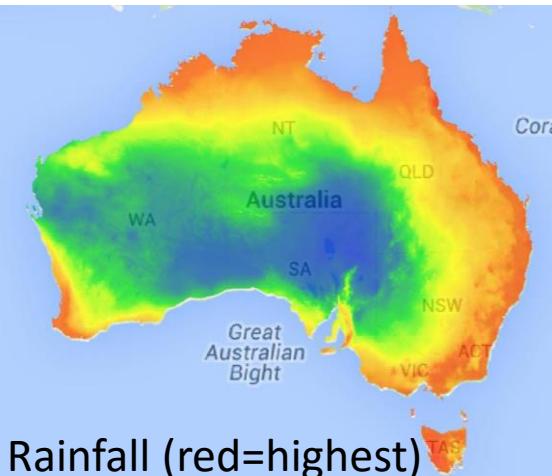
1. Biodiversity lends stability to ecosystems
2. Diverse communities are more productive because they can access more resources
3. Biodiversity loss impedes ecosystem function
4. Biodiversity loss causes non-linear change
5. Biggest impacts from losses across trophic levels
6. Ecological impacts of extinctions depend on functional traits of individual species

# Food production varies spatially

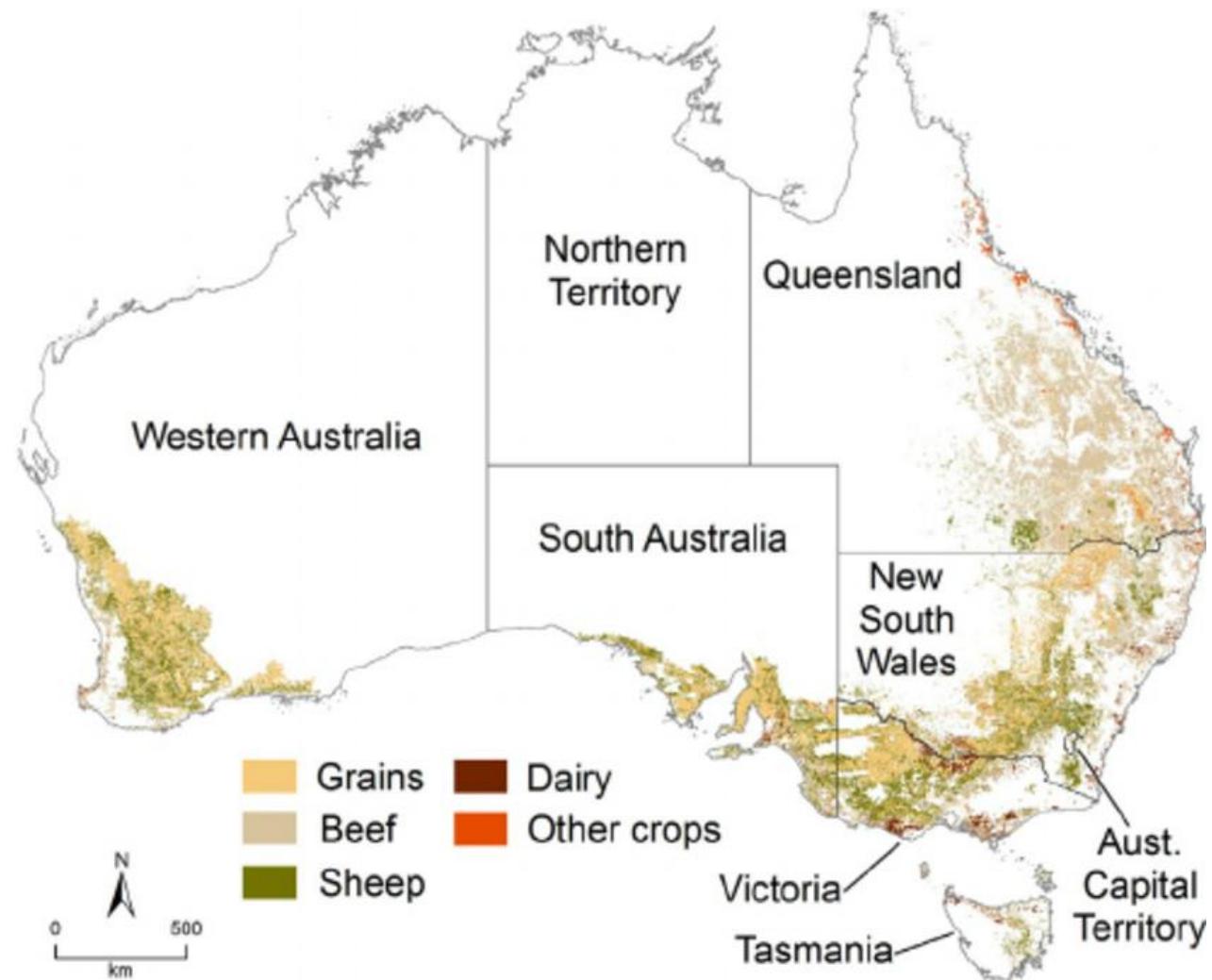


Source: Australian Bureau of Agricultural and Resource Economics and Sciences<sup>18</sup>

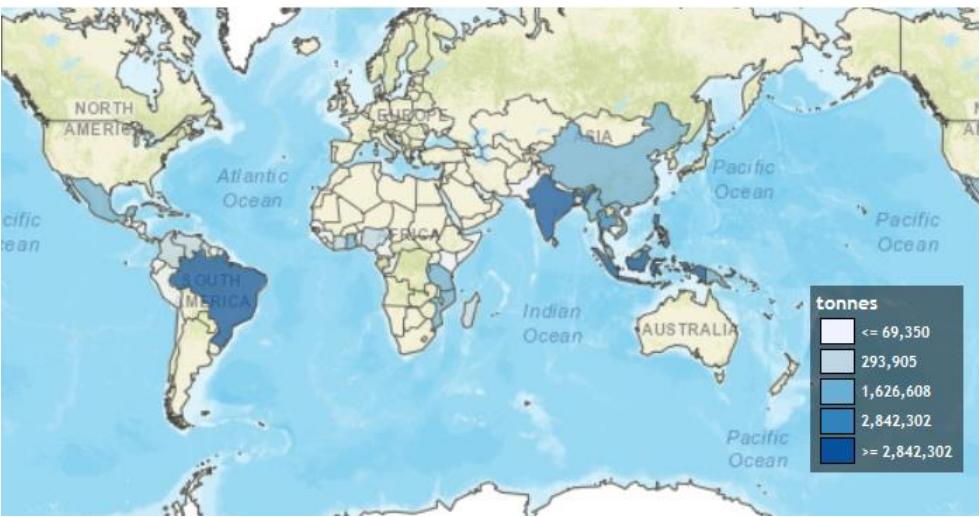
Land-use (orange=crops)



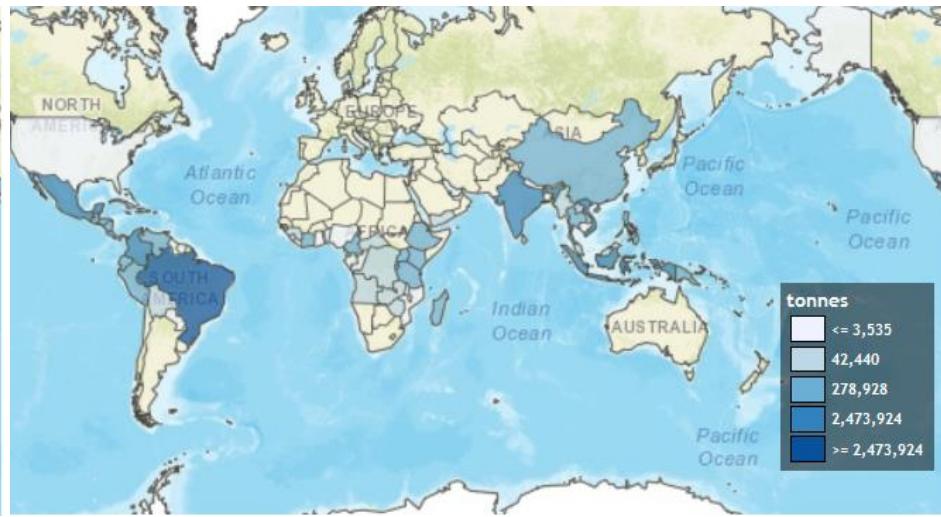
Rainfall (red=highest)



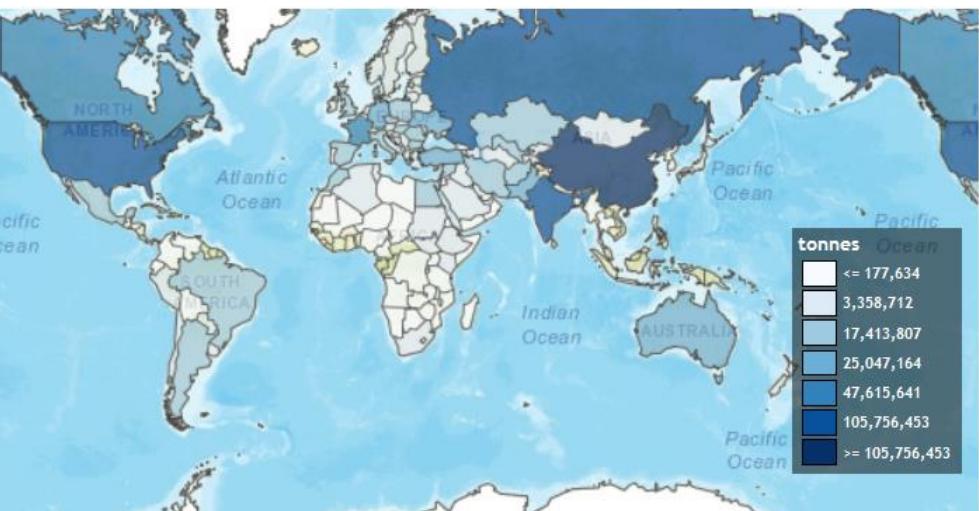
Grundy et al. (2016) Agric. Systems



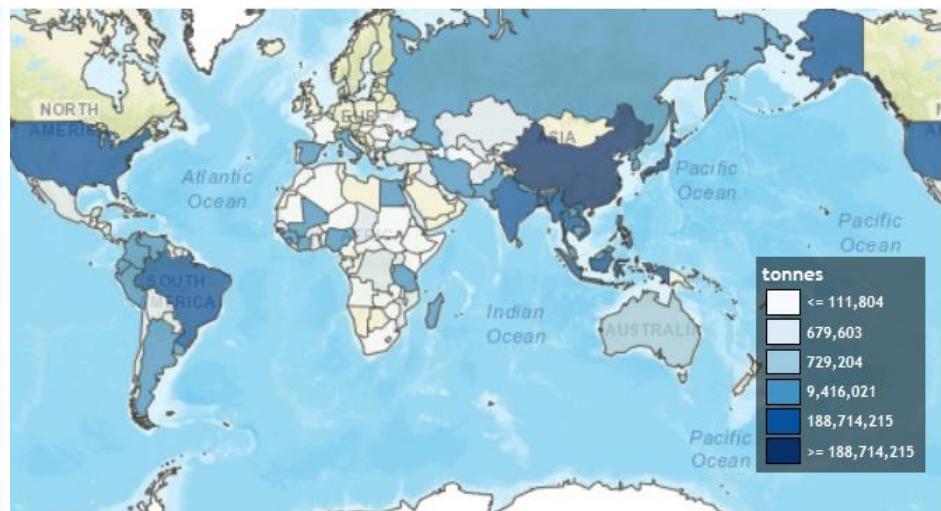
**Coconuts**



**Coffee**



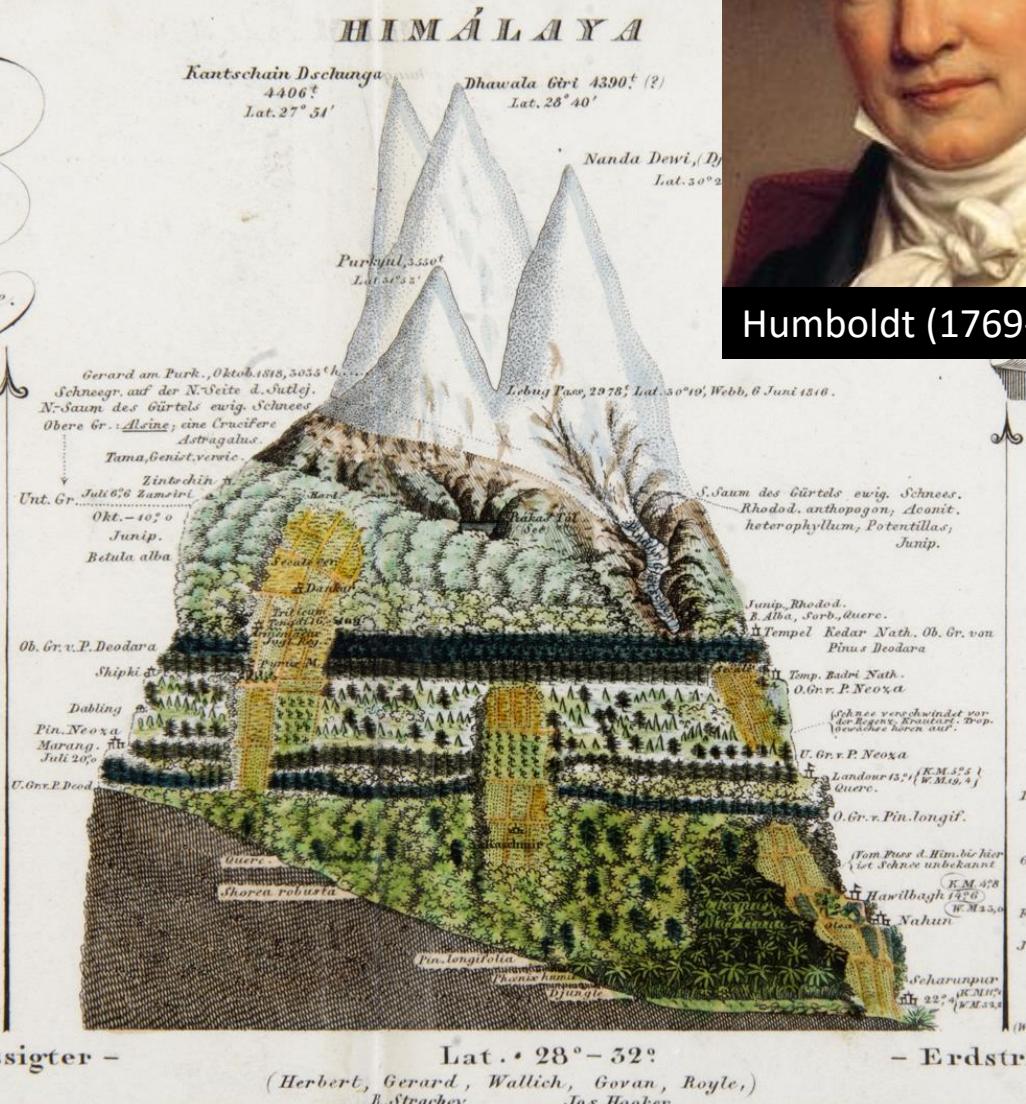
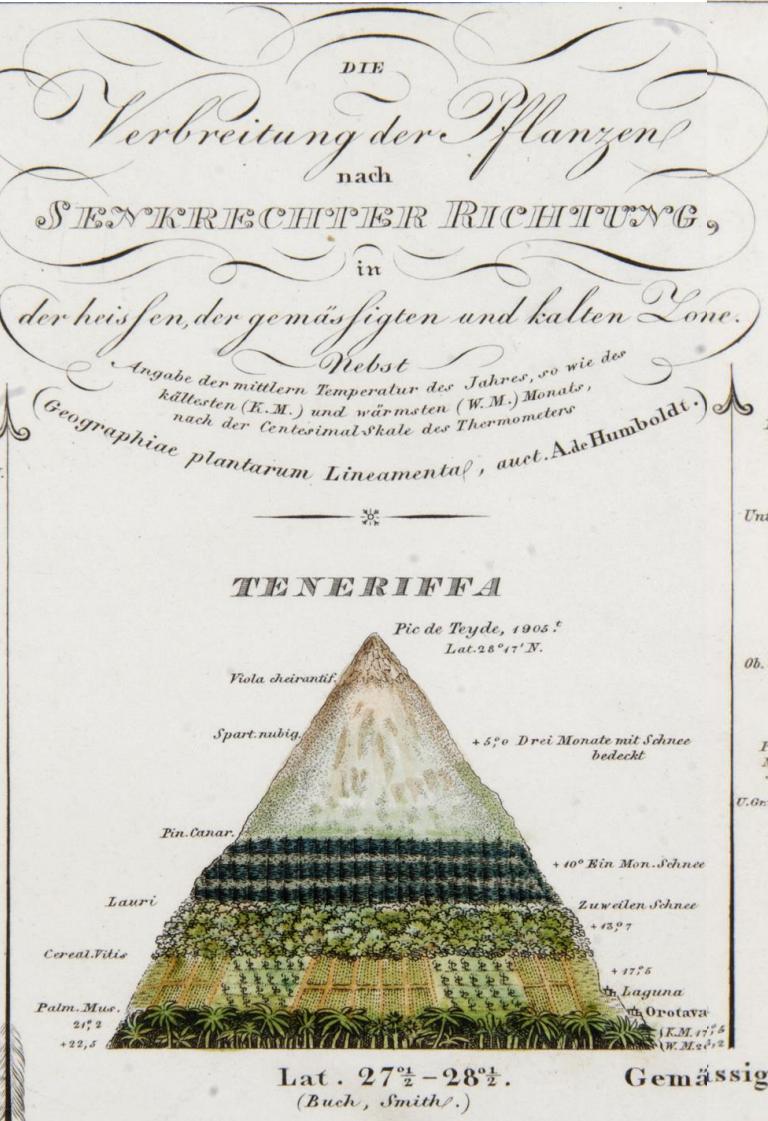
**Wheat**



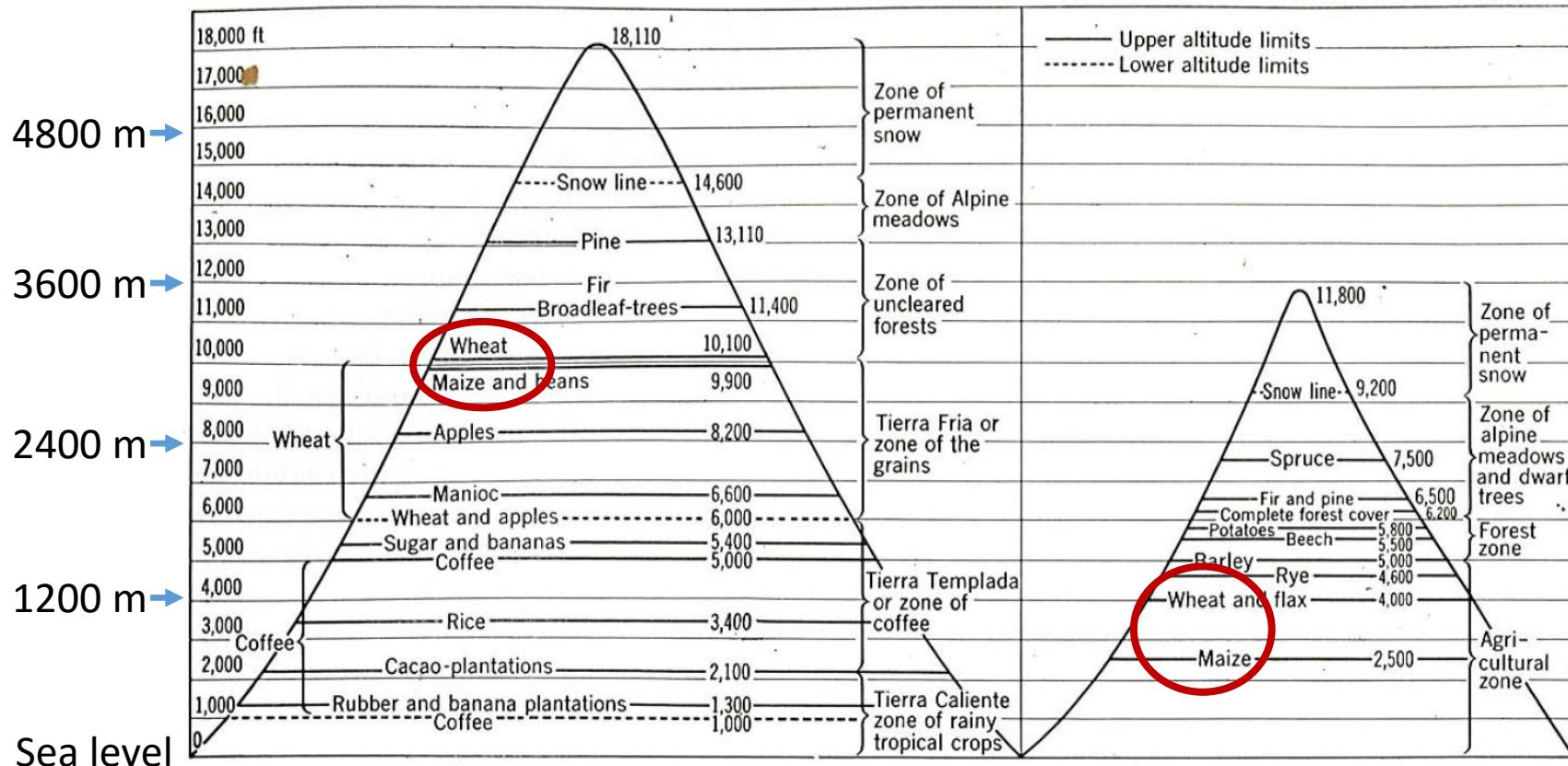
**Rice**

[http://faostat3.fao.org/browse/Q/\\*/](http://faostat3.fao.org/browse/Q/*/)

...and altitudinally

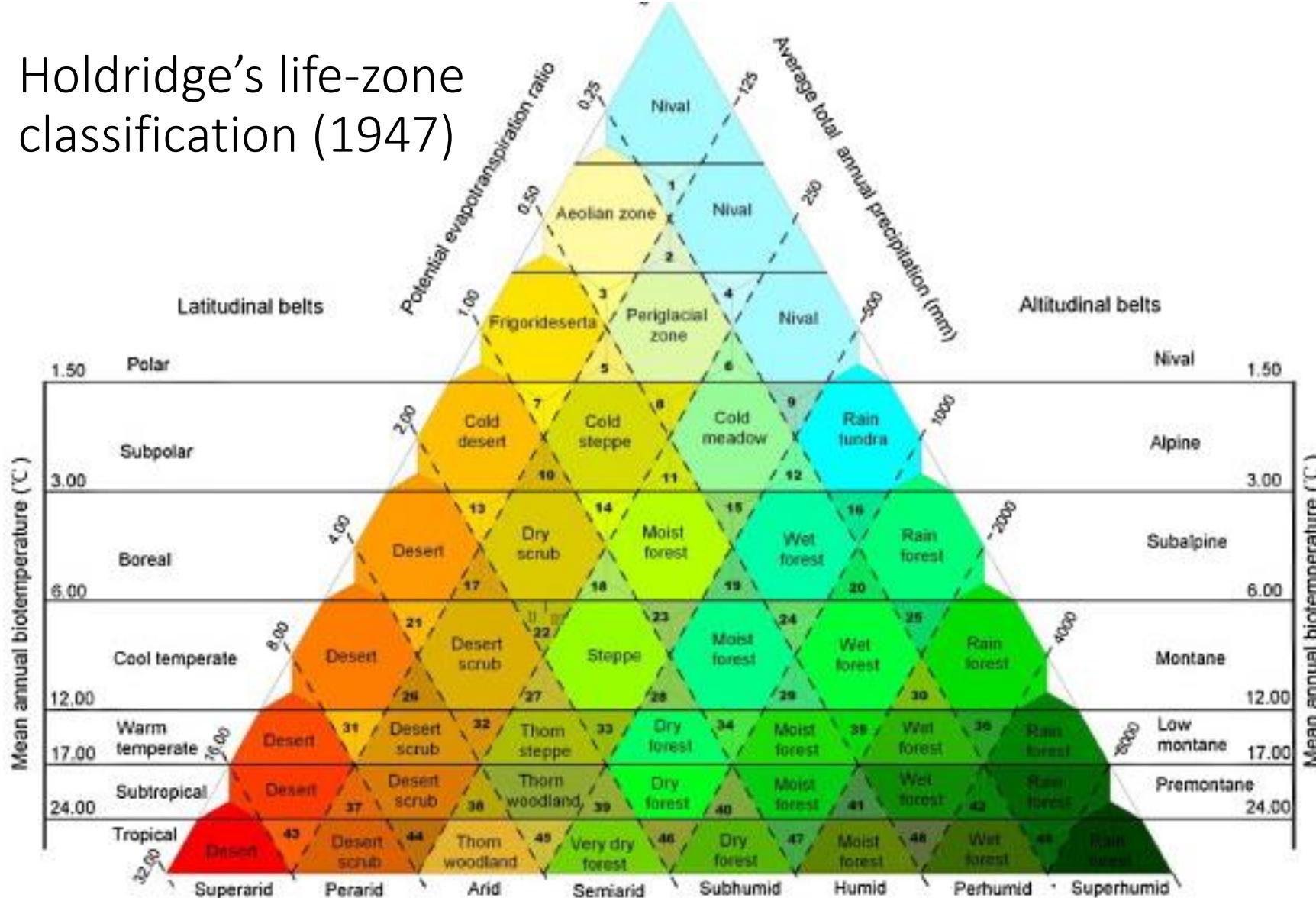


## Tropical Andes



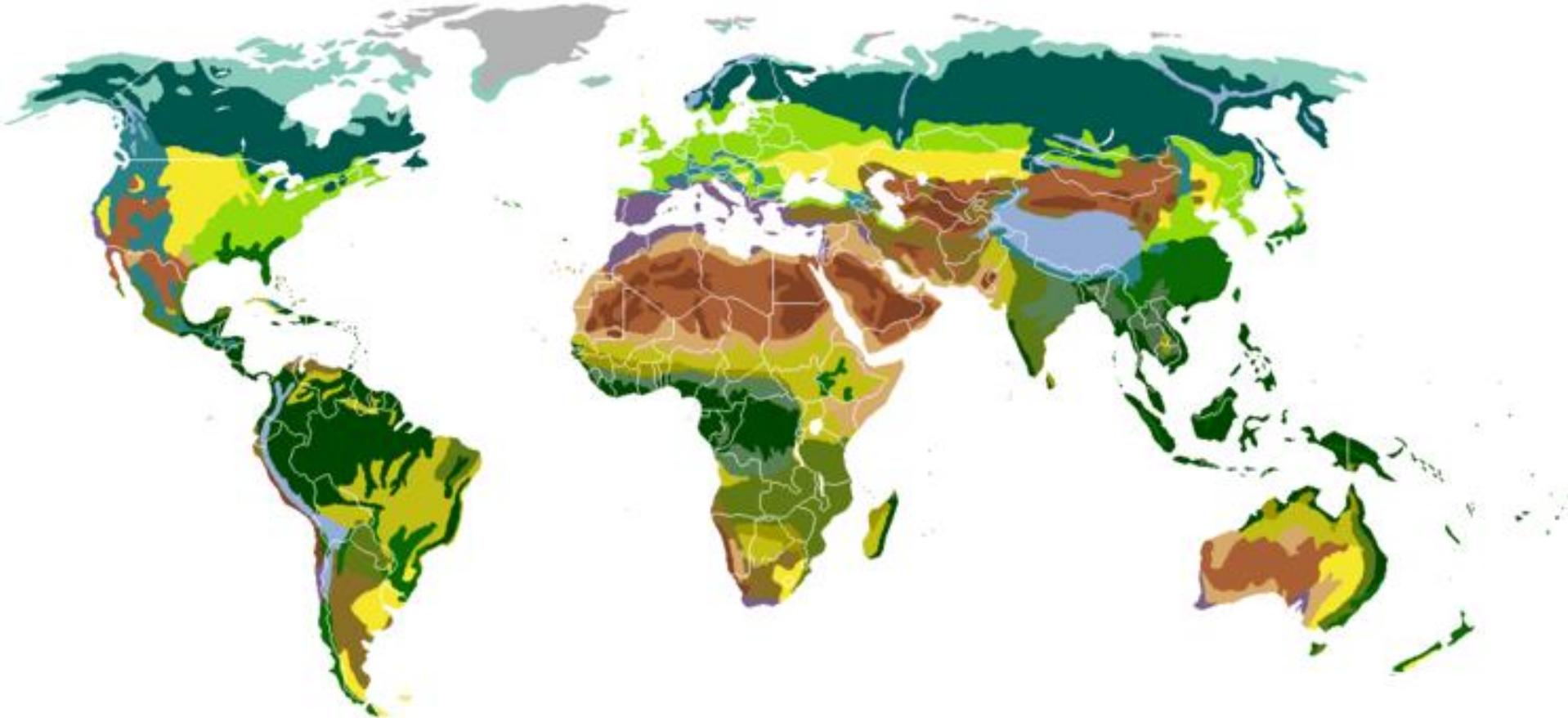
# Environmental controls on biomes

Holdridge's life-zone classification (1947)



Graphic from Fan et al. (2013) *Ecological Modelling*

# Biomes of the world



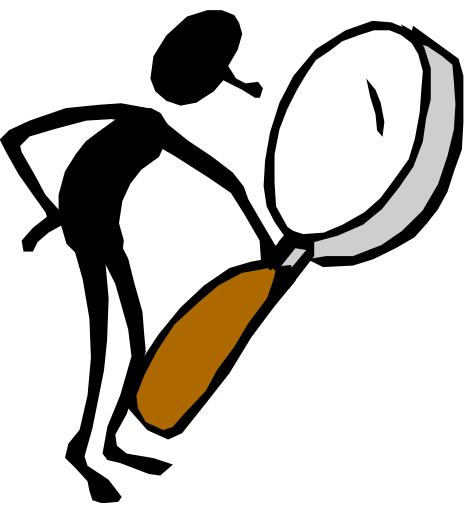
# Domestication



- Few of the world's species have been domesticated
- Some species are more amenable to domestication
- Today's domestic species are the product of genetic accidents 1000s of years ago, plus careful selection and breeding by subsequent generations
- Peoples' choices around plants are influenced by:
  - Environmental constraints
  - Technological developments
  - Cultural motivations (including historical precedents)
- Time for a quiz... laptops closed!

# The Very Useful

# Plant Quiz!



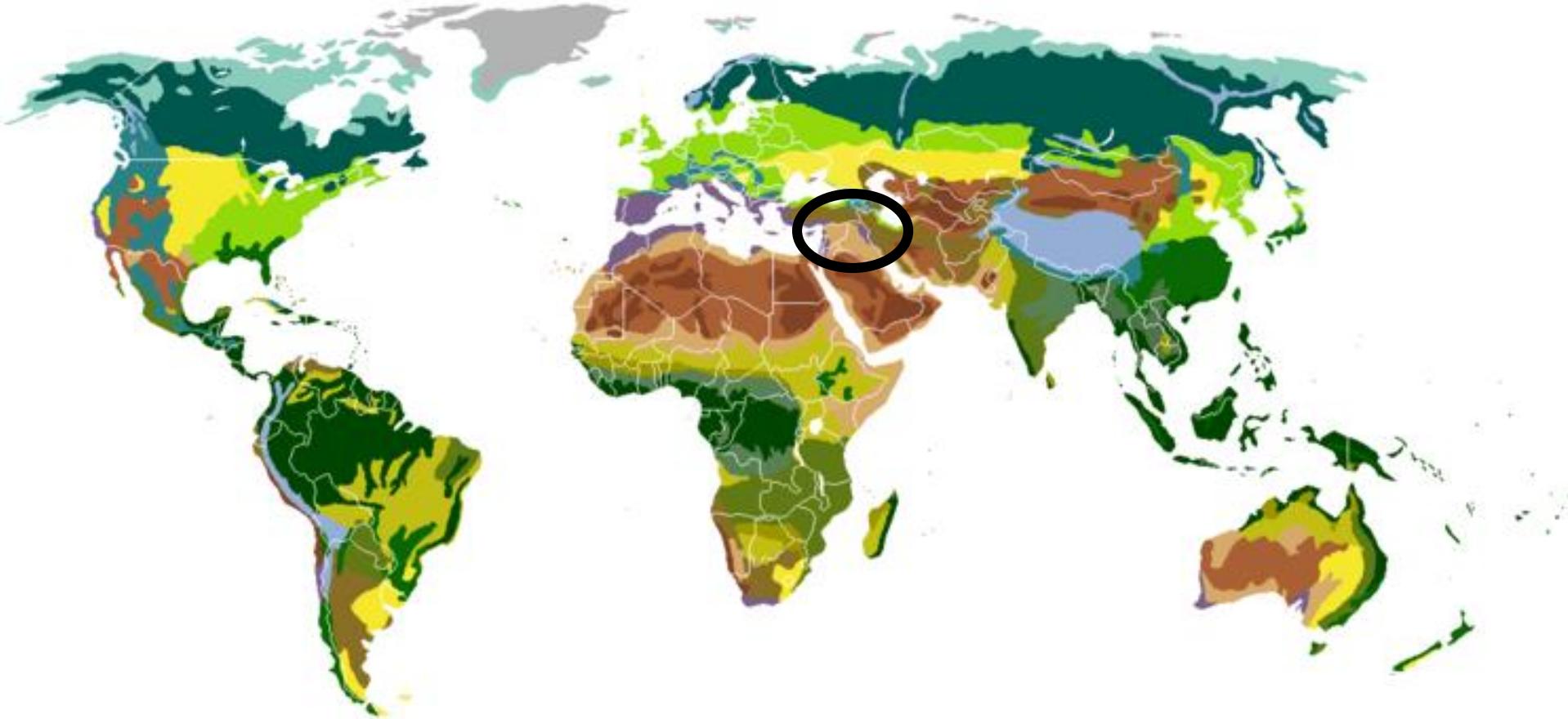
# Who am I?



# Where do I come from?



# *Triticum aestivum* (Poaceae)



Area of origin and domestication supported by archaeological and molecular data



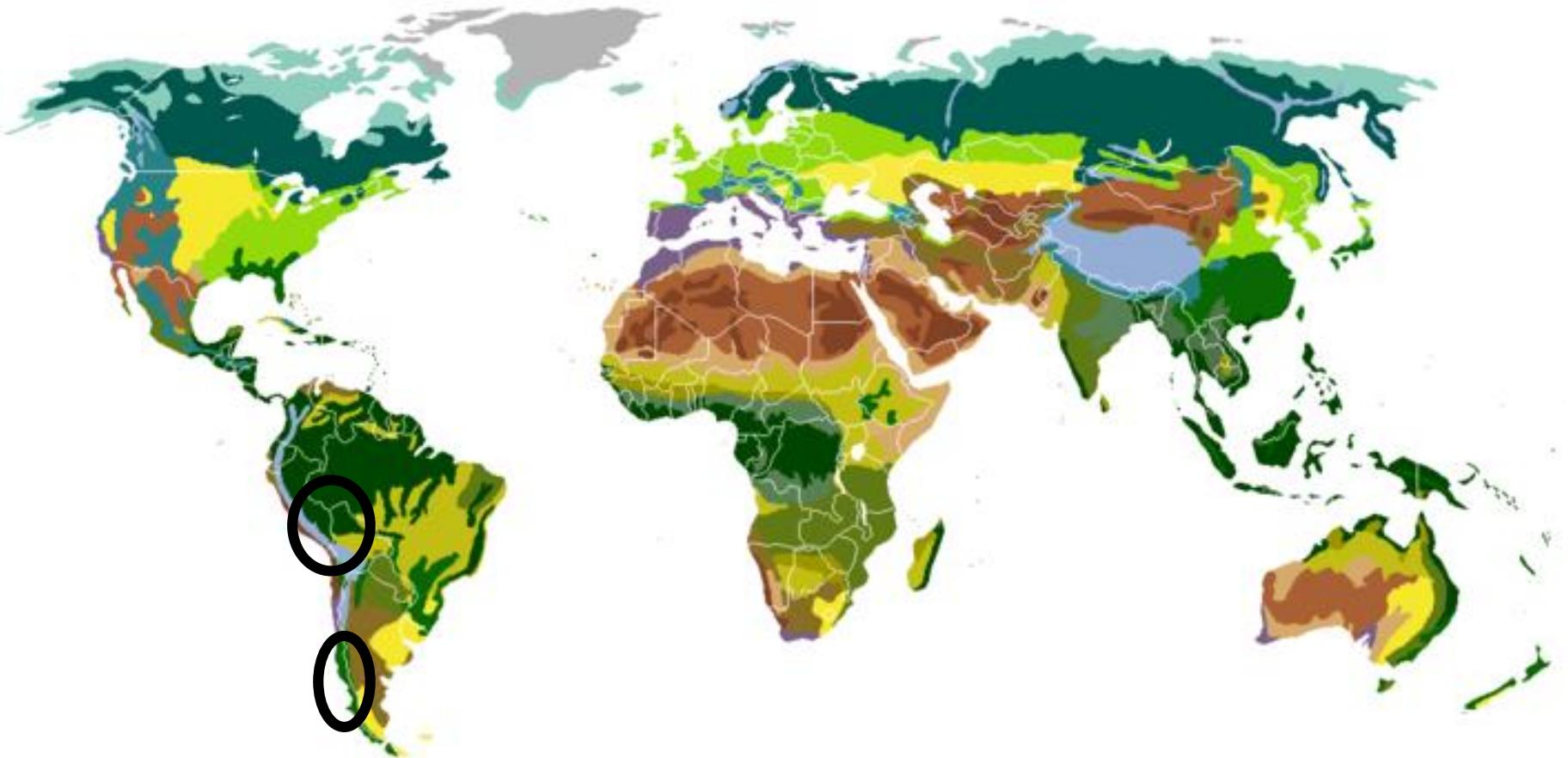
# Who am I?



# Where do I come from?



# *Solanum tuberosum* (Solanaceae)



Potato has 2 origins: high Andes & lowland Chile <http://www.amjbot.org/content/95/2/252.short>



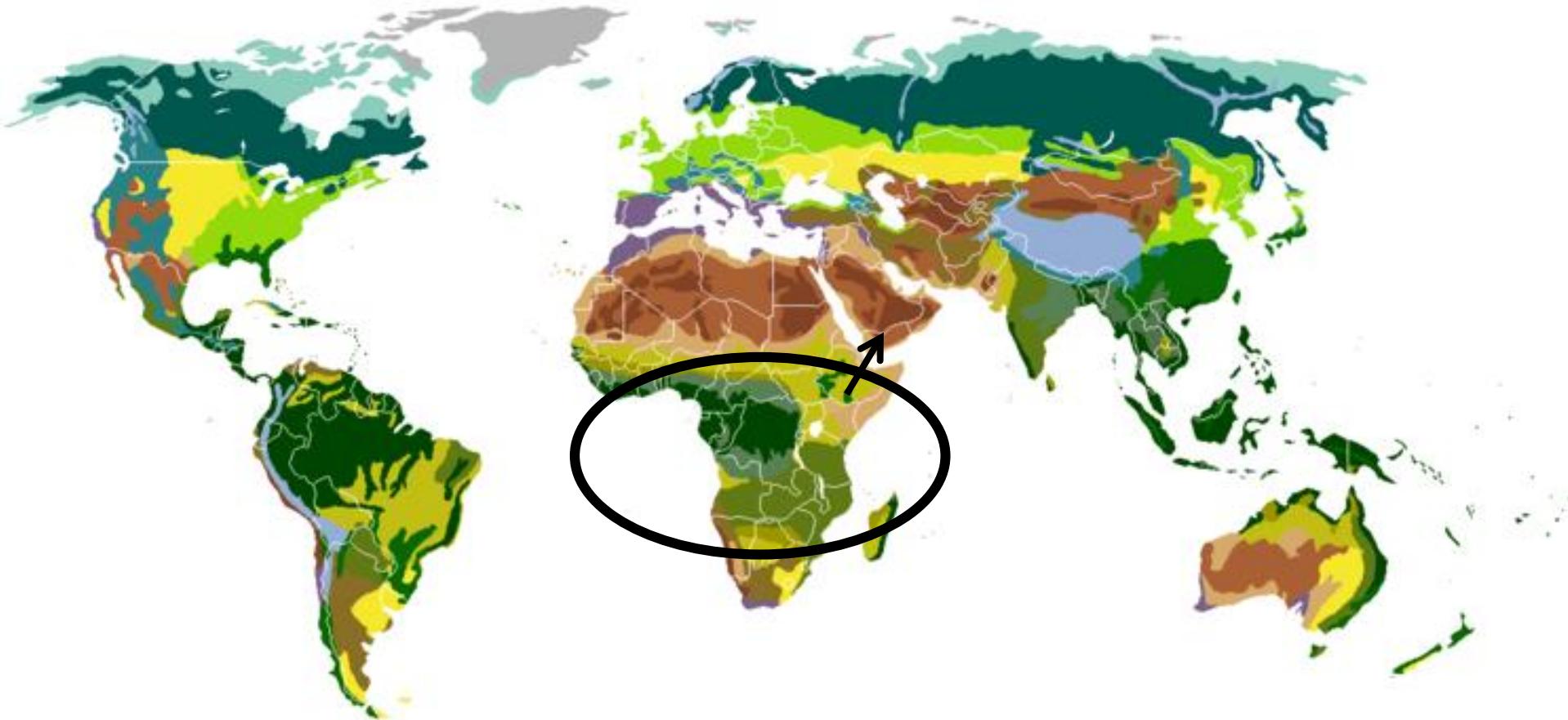
# Who am I?



# Where do I come from?



# *Coffea arabica* (Rubiaceae)



Today's coffee introduced from Ethiopia via Yemen [www.dx.doi.org/10.1007/s00122-001-0798-8](http://www.dx.doi.org/10.1007/s00122-001-0798-8)



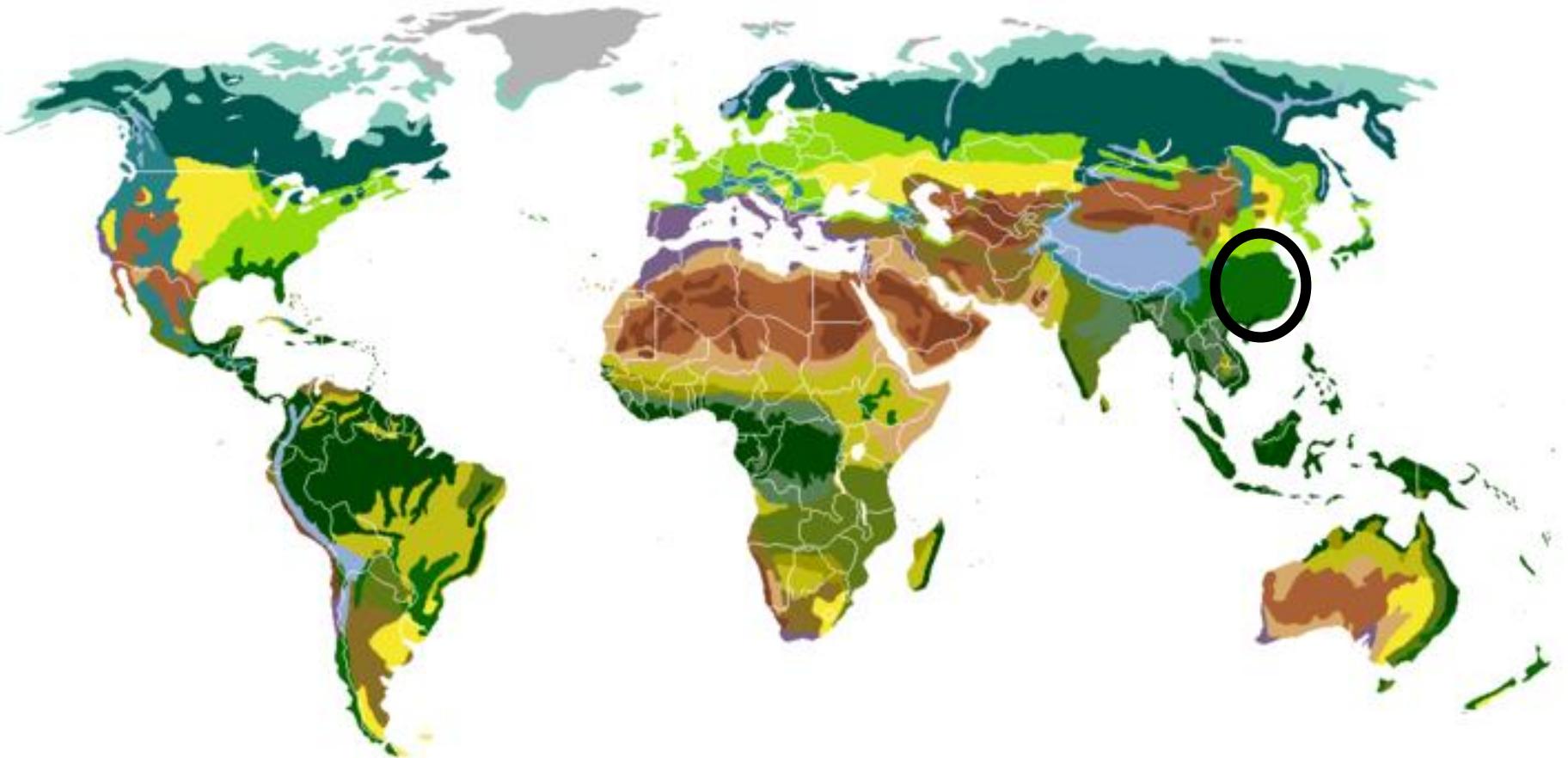
# Who am I?



# Where do I come from?



# *Actinidia deliciosa* (Actinidiaceae)



Was kiwifruit derived from a single *A. chinensis* ancestor or multiple species?

ice sheet and polar desert	temperate steppe	arid desert	grass savanna	alpine tundra
tundra	subtropical moist forest	xeric shrubland	tree savanna	mountain forest
taiga	Mediterranean vegetation	dry steppe	subtropical dry forest	
temperate broadleaf forest	monsoon forest	semiarid desert	tropical rainforest	

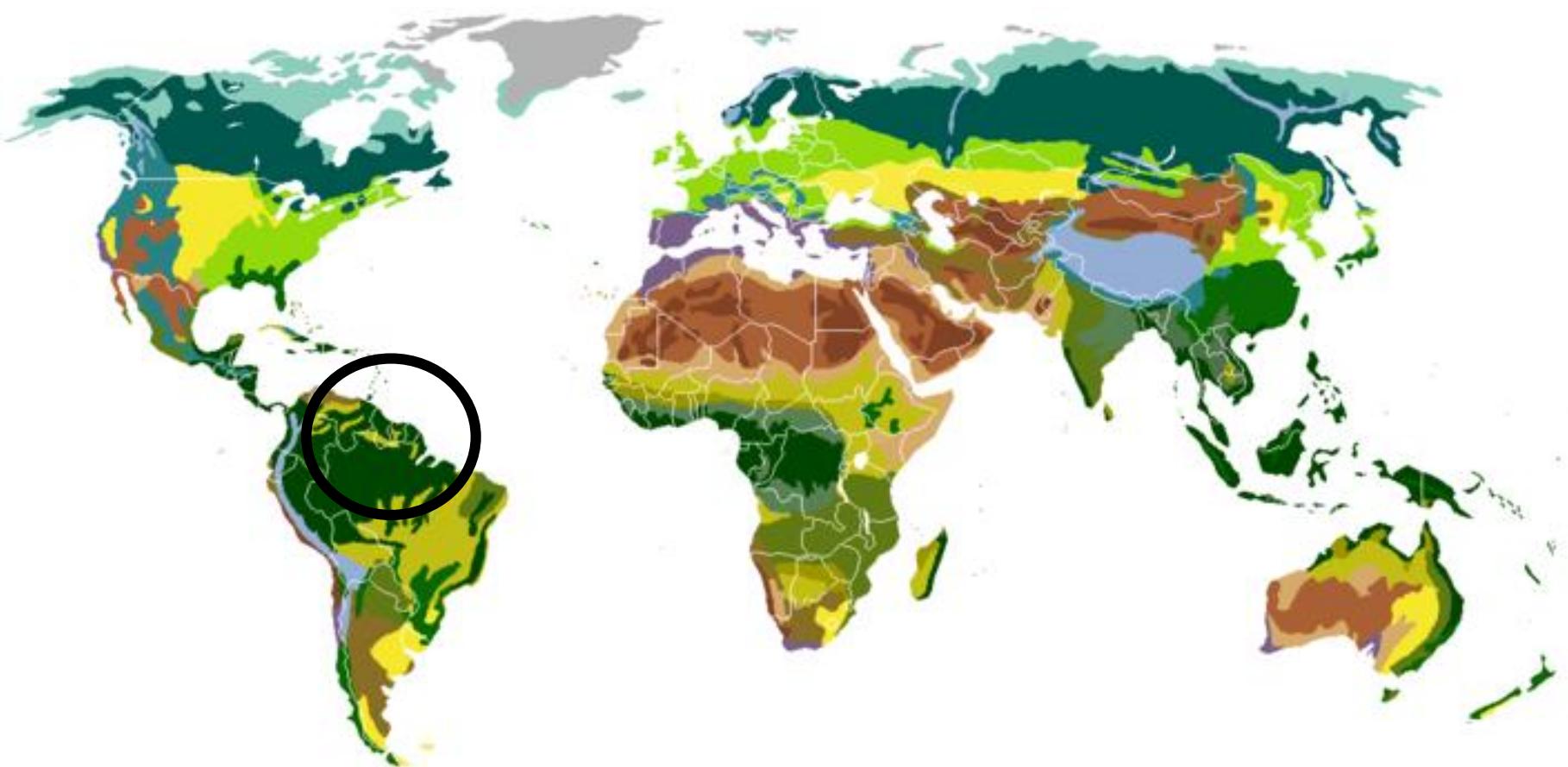
# Who am I?



# Where do I come from?



# *Anacardium occidentale* (Anacardiaceae)



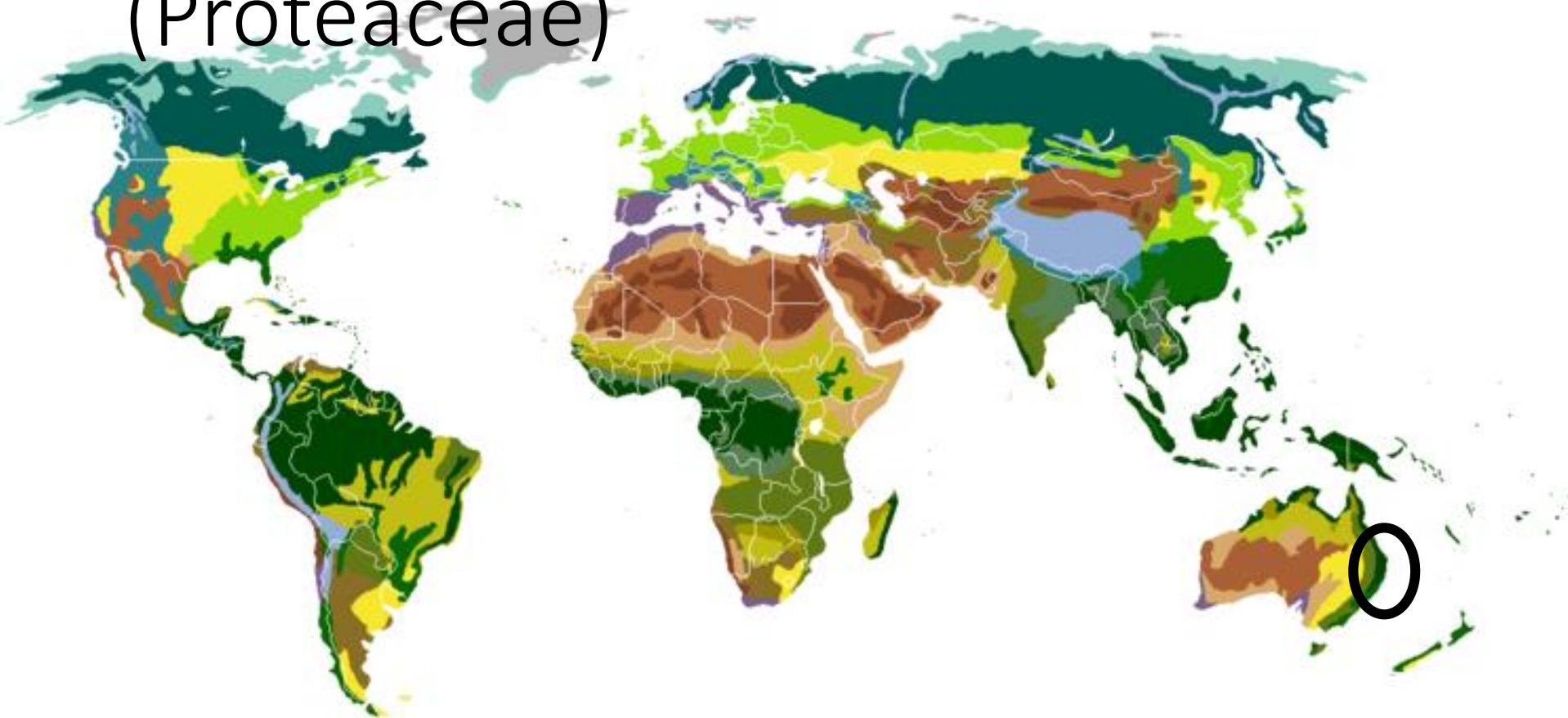
# Who am I?



# Where do I come from?



# *Macadamia integrifolia* (Proteaceae)



[http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon\\_id=7326](http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=7326)



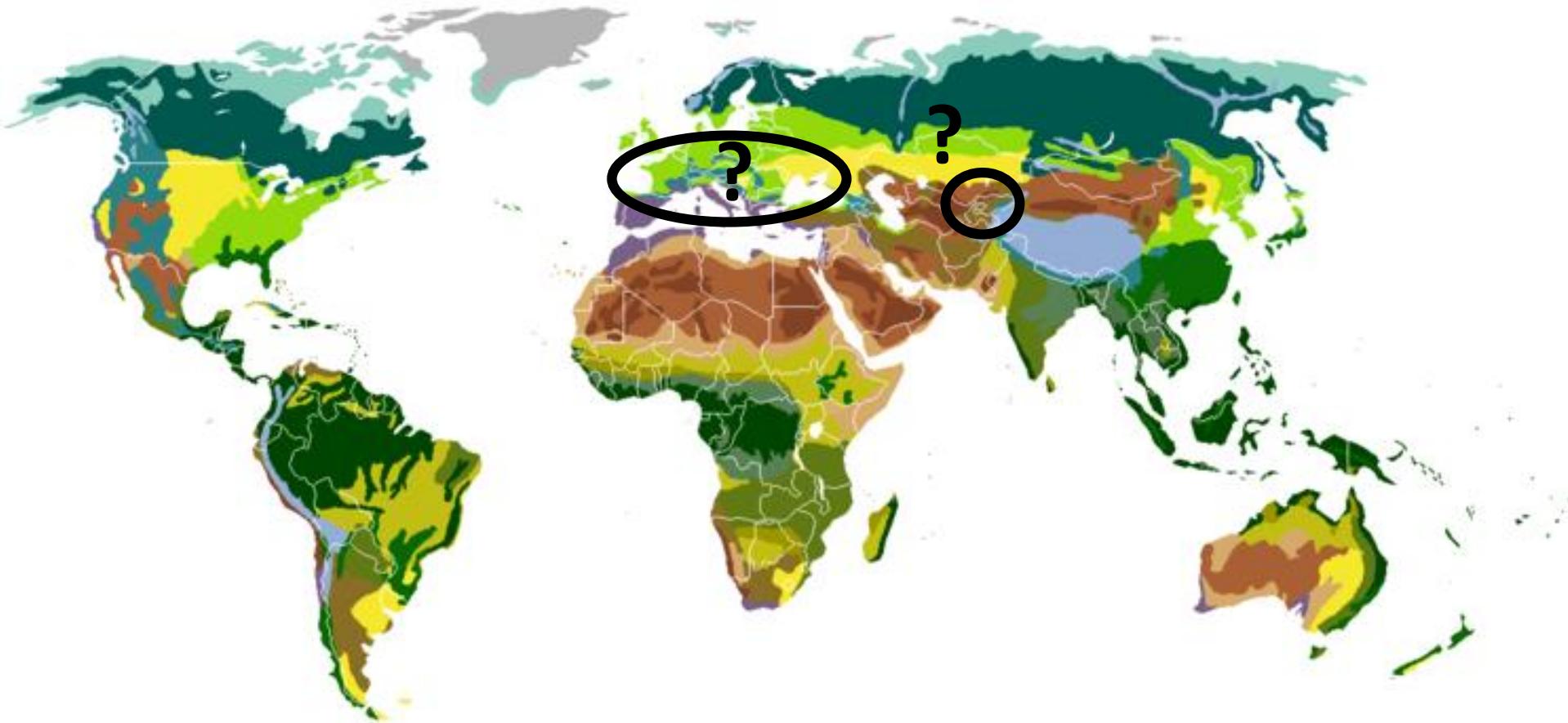
# Who am I?



# Where do I come from?



# *Malus domestica* (Rosaceae)



Origins in Europe or Kazakhstan? [www.dx.doi.org/10.1111/j.1365-294X.2006.02924.x](http://www.dx.doi.org/10.1111/j.1365-294X.2006.02924.x)



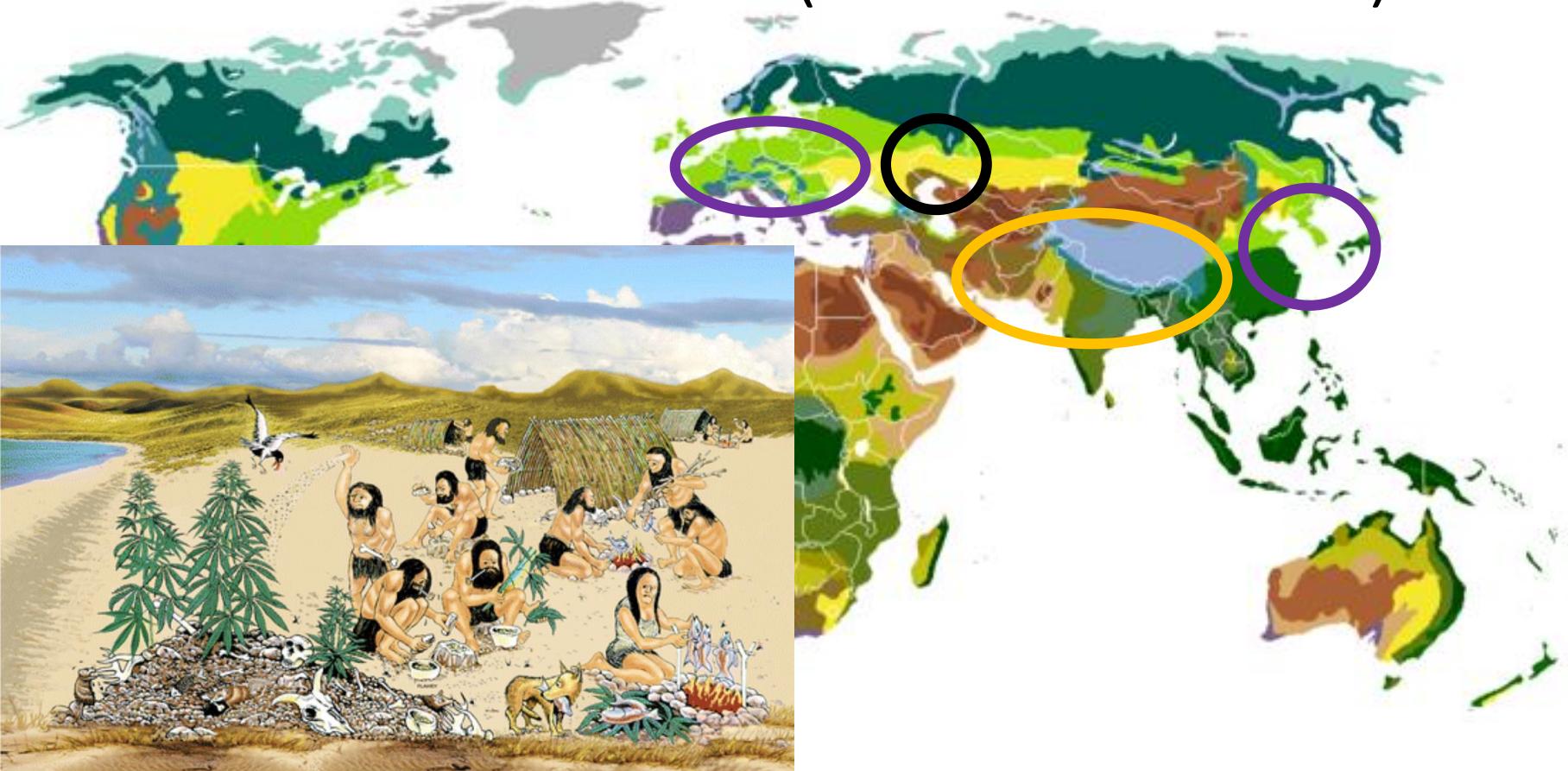
# Who am I?



# Where do I come from?



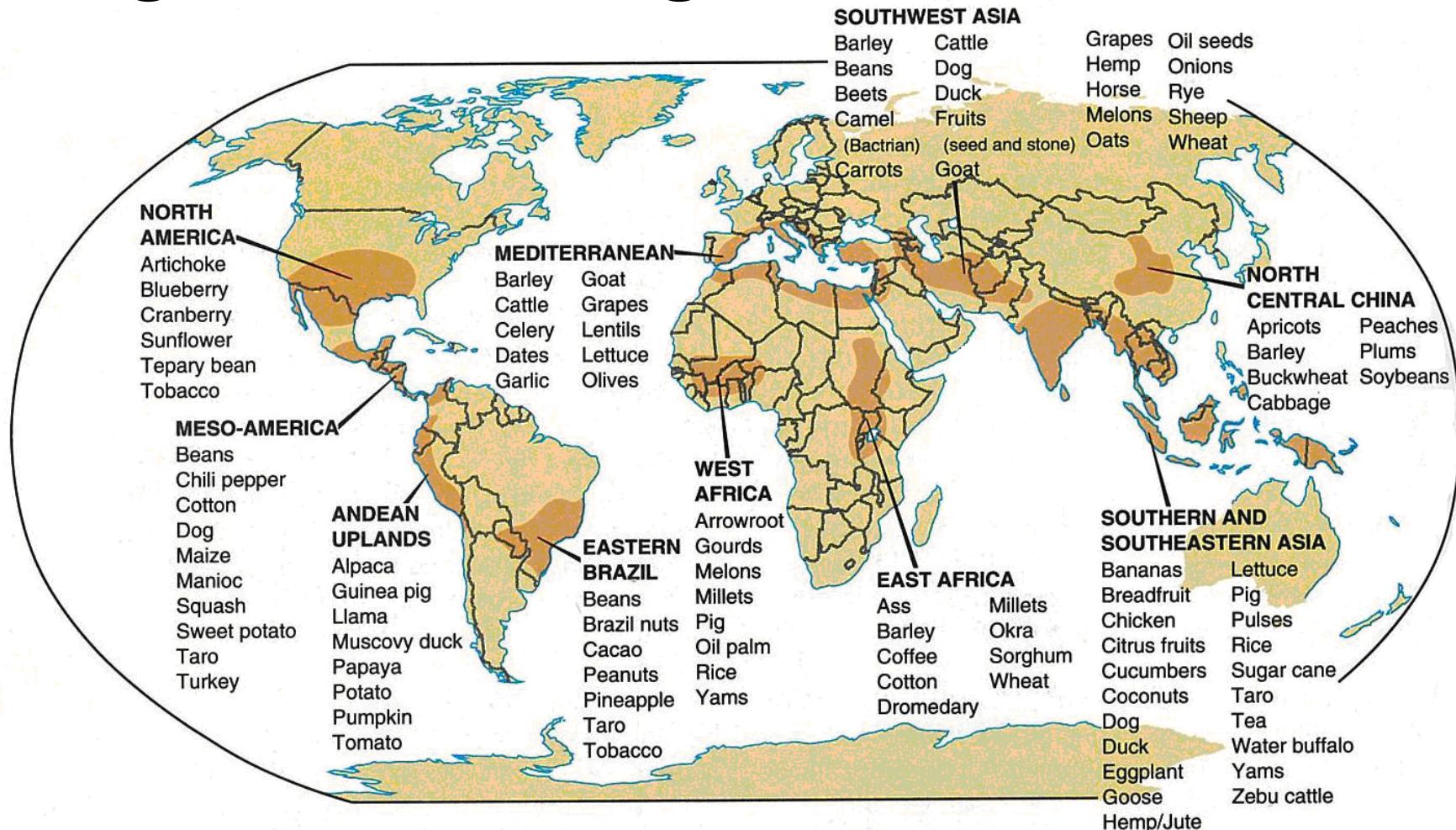
# *Cannabis sativa* (Cannabaceae)



Small (2015) *The Botanical Review*: <http://dx.doi.org/10.1007/s12229-015-9157-3>

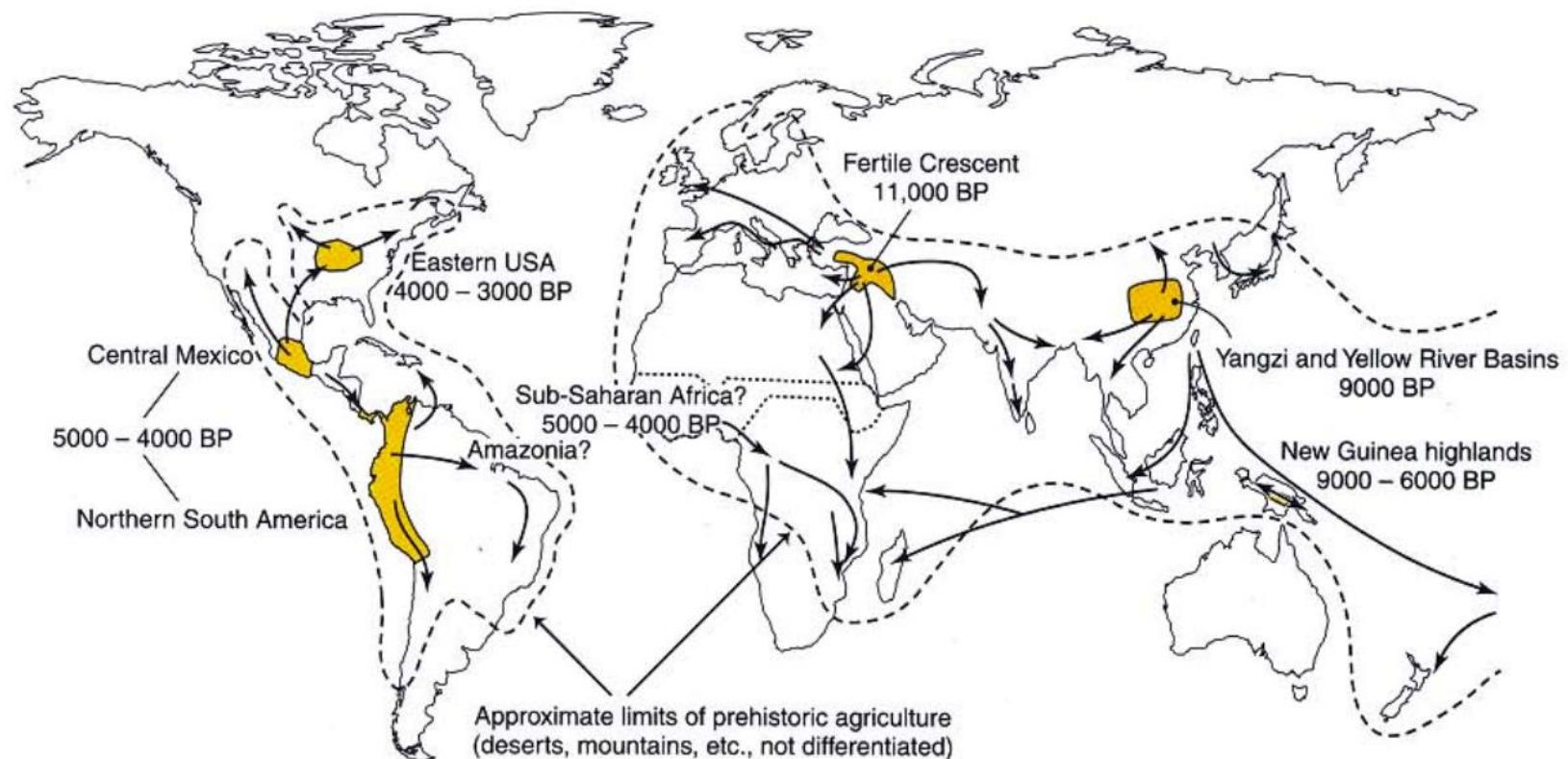


# Agricultural origins – where?



**Figure 7–1.** This map shows the origins of the world's food crops and domesticated animals. These plants and animals have been so widely redistributed, however, that today's leading producers of many of these are not the same as the areas in which they were first domesticated.

# Agricultural origins – when?



BP = Before Present

Diamond & Bellwood (2003) Science 300: 597



Neolithic sickles from Karanovo (~6000 BC)





**Charred seeds**

Willcox (2014) Encyclopedia of Global Archaeology

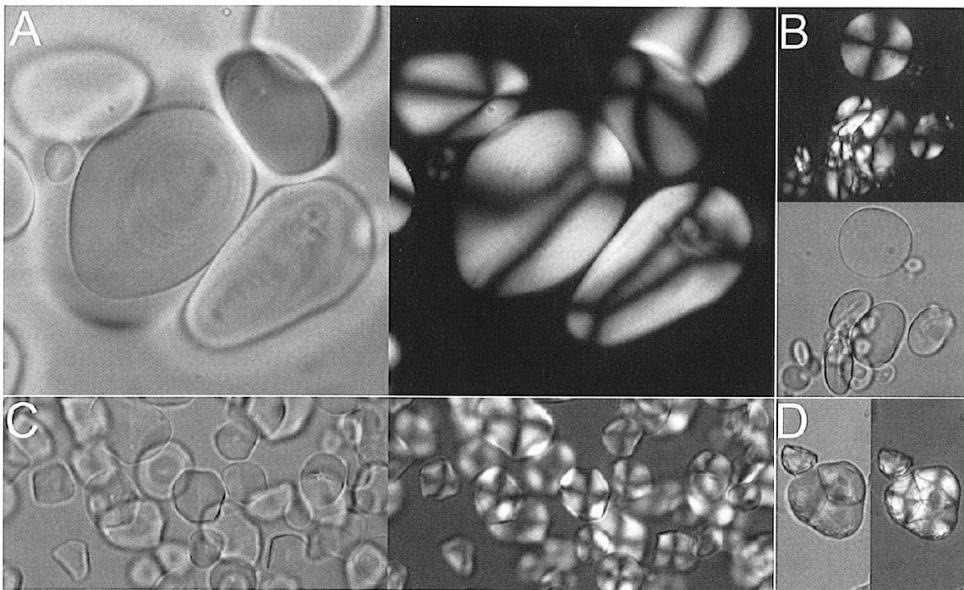


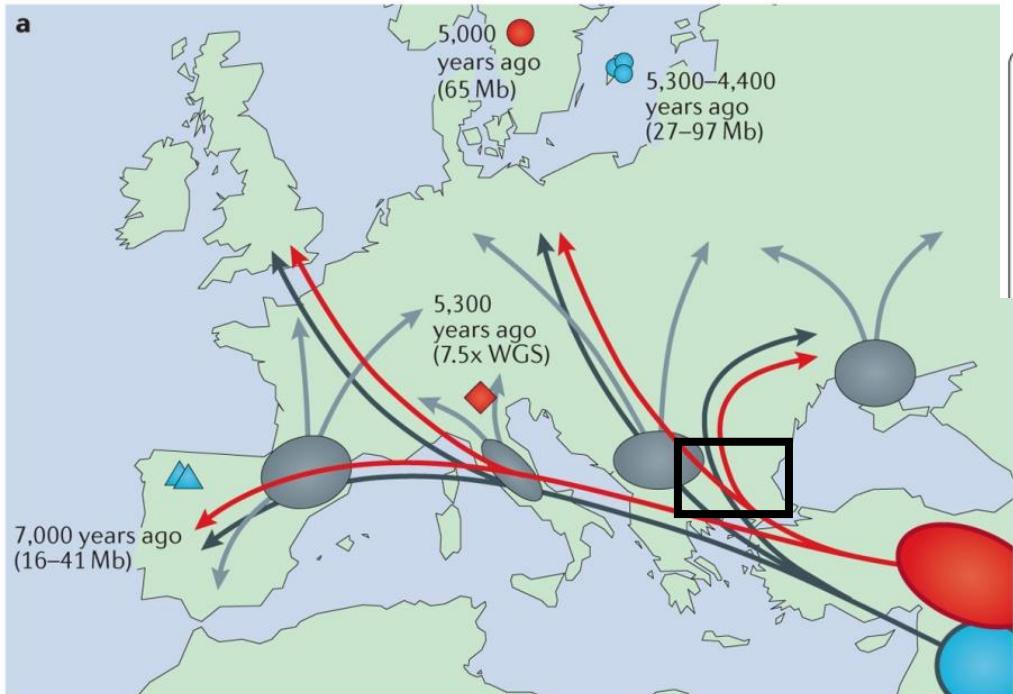
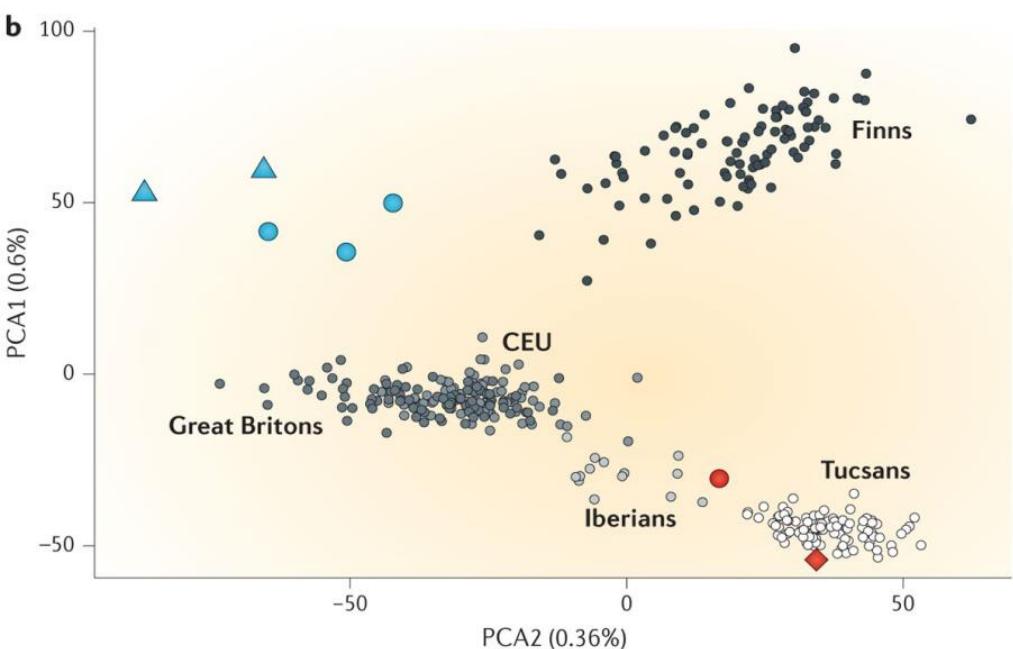
Fig. 2.3. Starch grains of various plant species, each specimen in bright field illumination, and in polarised light: A) potato (*Solanum tuberosum* L.) stem tuber; B) bread wheat (*Triticum aestivum* L.); C) maize (*Zea mays* L.) grain; D) biscuit root (*Lomatium* sp.) root tuber.

## Phytoliths

Cummings (2014)

## Pollen grains



**a****b**

Veeramah &amp; Hammer (2014)

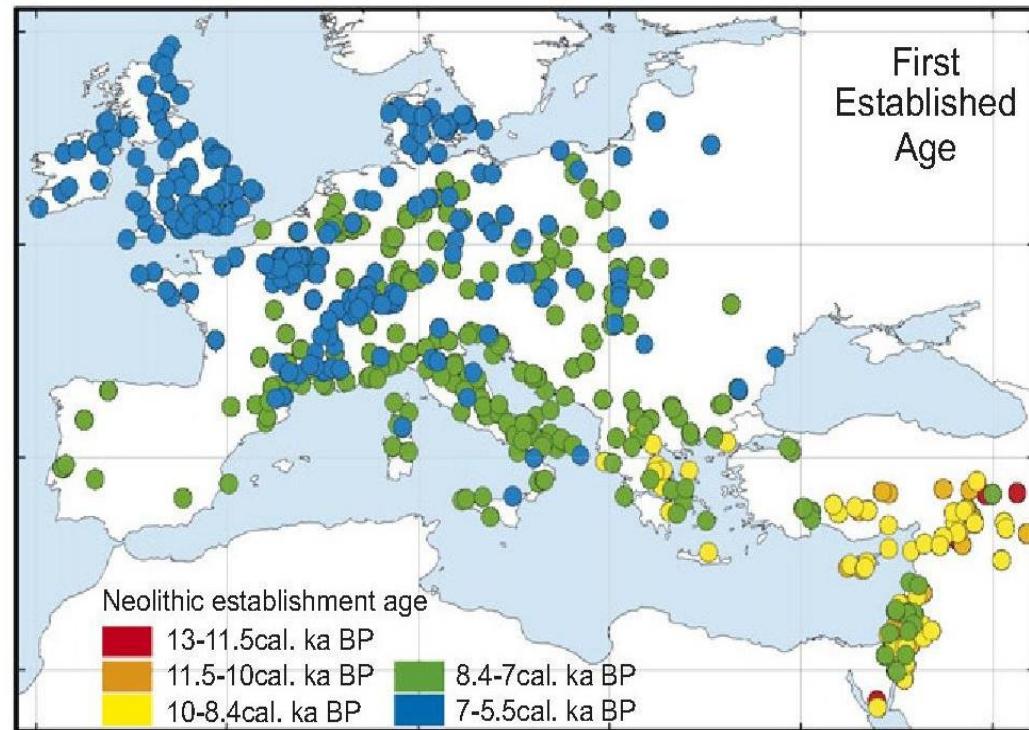
# The impact of whole-genome sequencing on the reconstruction of human population history

Krishna R. Veeramah<sup>1,2</sup> and Michael F. Hammer<sup>1</sup>

- Blue = spread of hunter-gatherers
- Grey = glacial refugia – places where humans are thought to have survived the ice ages
- Red = spread of first agriculturalists around 9000 years ago

# Early agriculture in Europe

- Arrived in Greece ~9200 cal. BP (~7250 BC)
- No new sites until ~8300 cal. BP (~6350 BC)
- Rapid expansion through the Balkans from 8200 cal. BP (6250 BC)
- Pushed by flooding?
- Slowed by aridity?
- Cultural factors?



Quaternary Science Reviews 26 (2007) 2036–2041

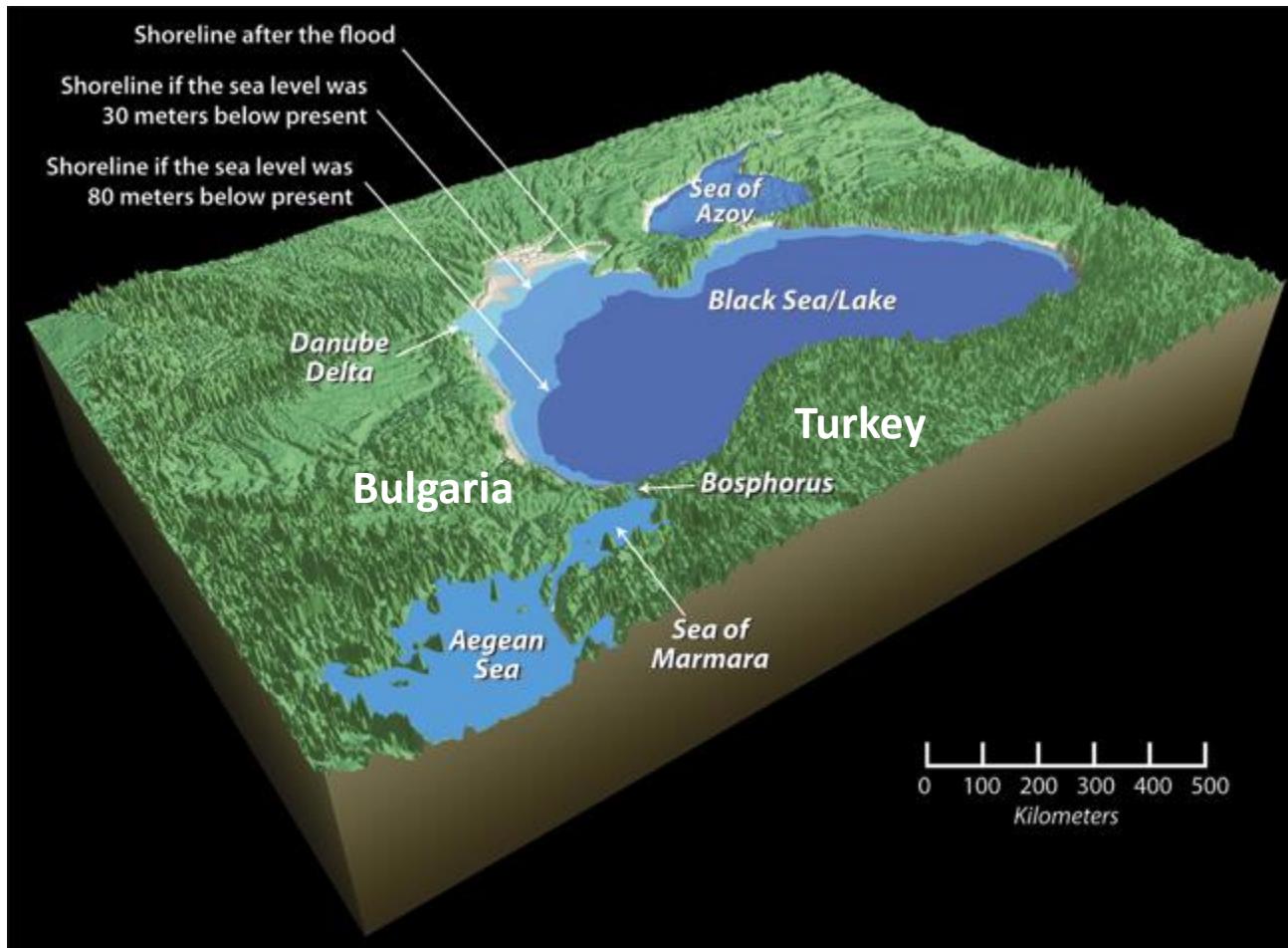


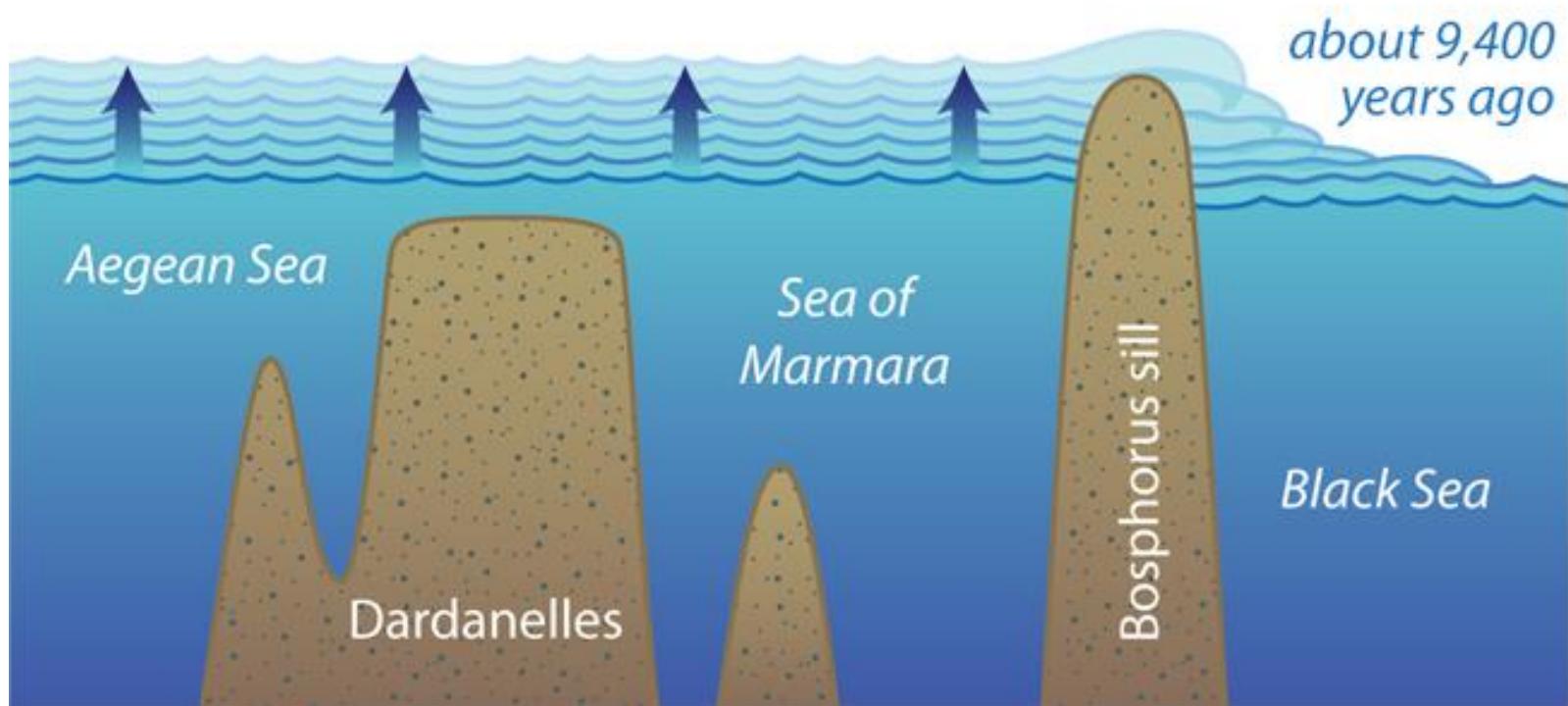
Rapid communication

Catastrophic early Holocene sea level rise, human migration and the Neolithic transition in Europe

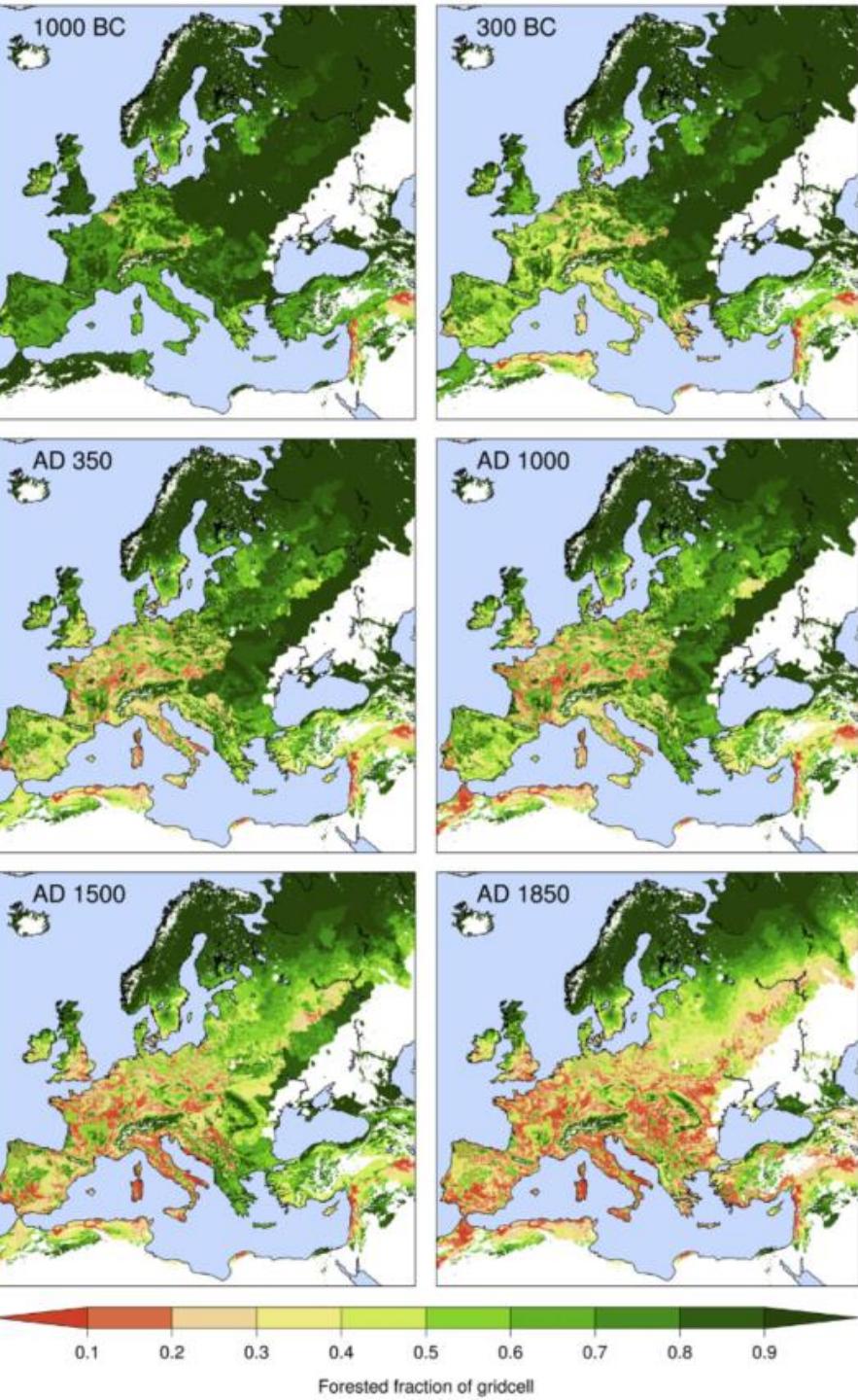
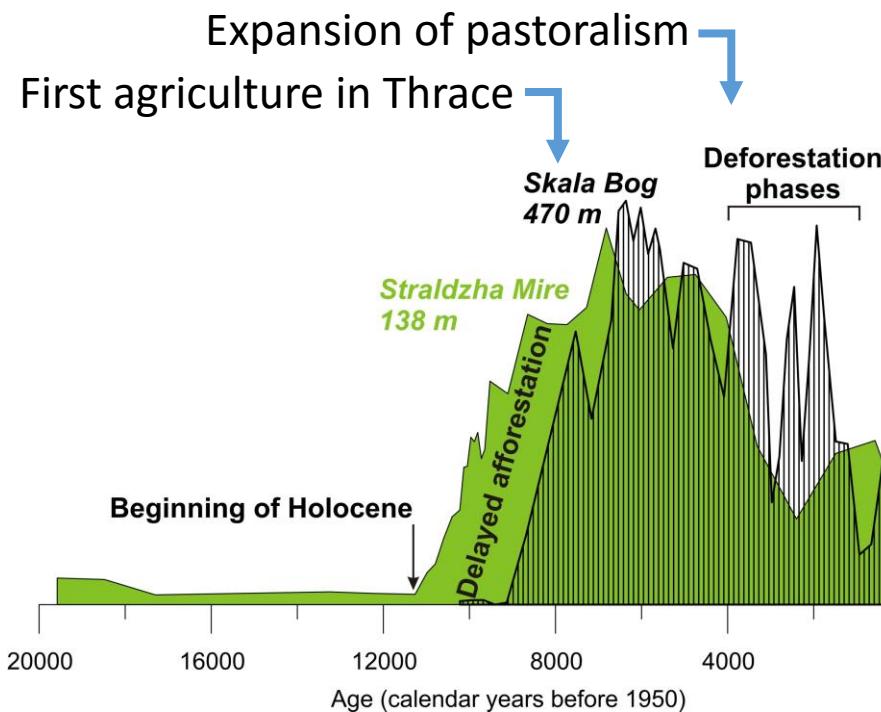
Chris S.M. Turney<sup>a,b,\*</sup>, Heidi Brown

# Black Sea flood





# Environmental effects: Deforestation



# Environmental effects: Erosion

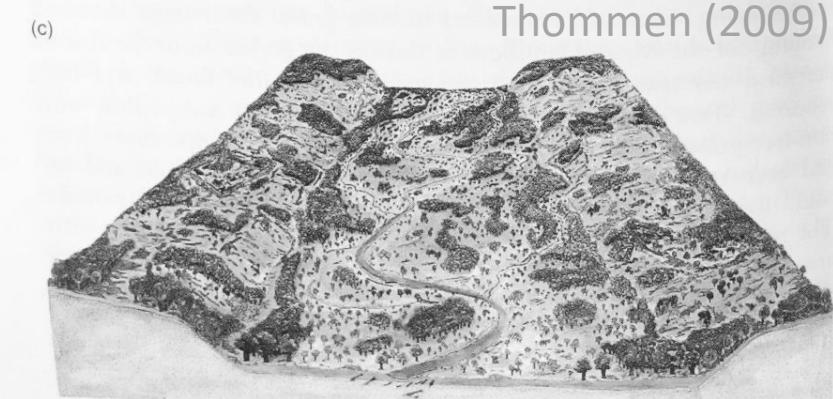
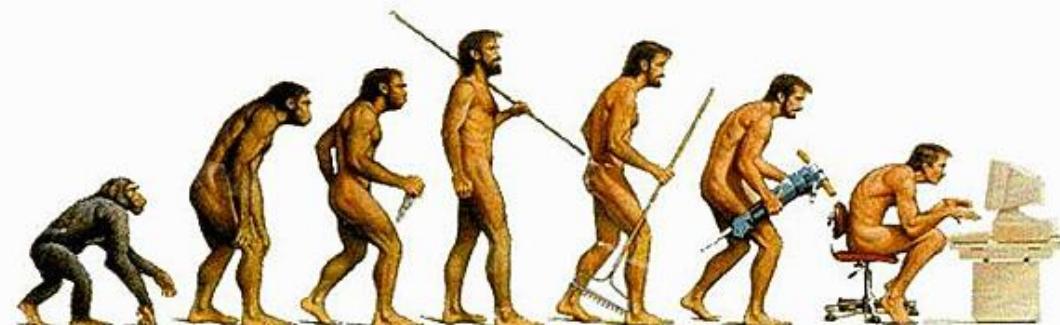


Fig. 13 Changes in wooded valley meadows due to Roman settlement in south-western Germany (pre-Roman times; Roman period; era of the Great Migration).

**OVERVIEW  
OF MILETUS**  
(Modern shoreline)

# Social effects

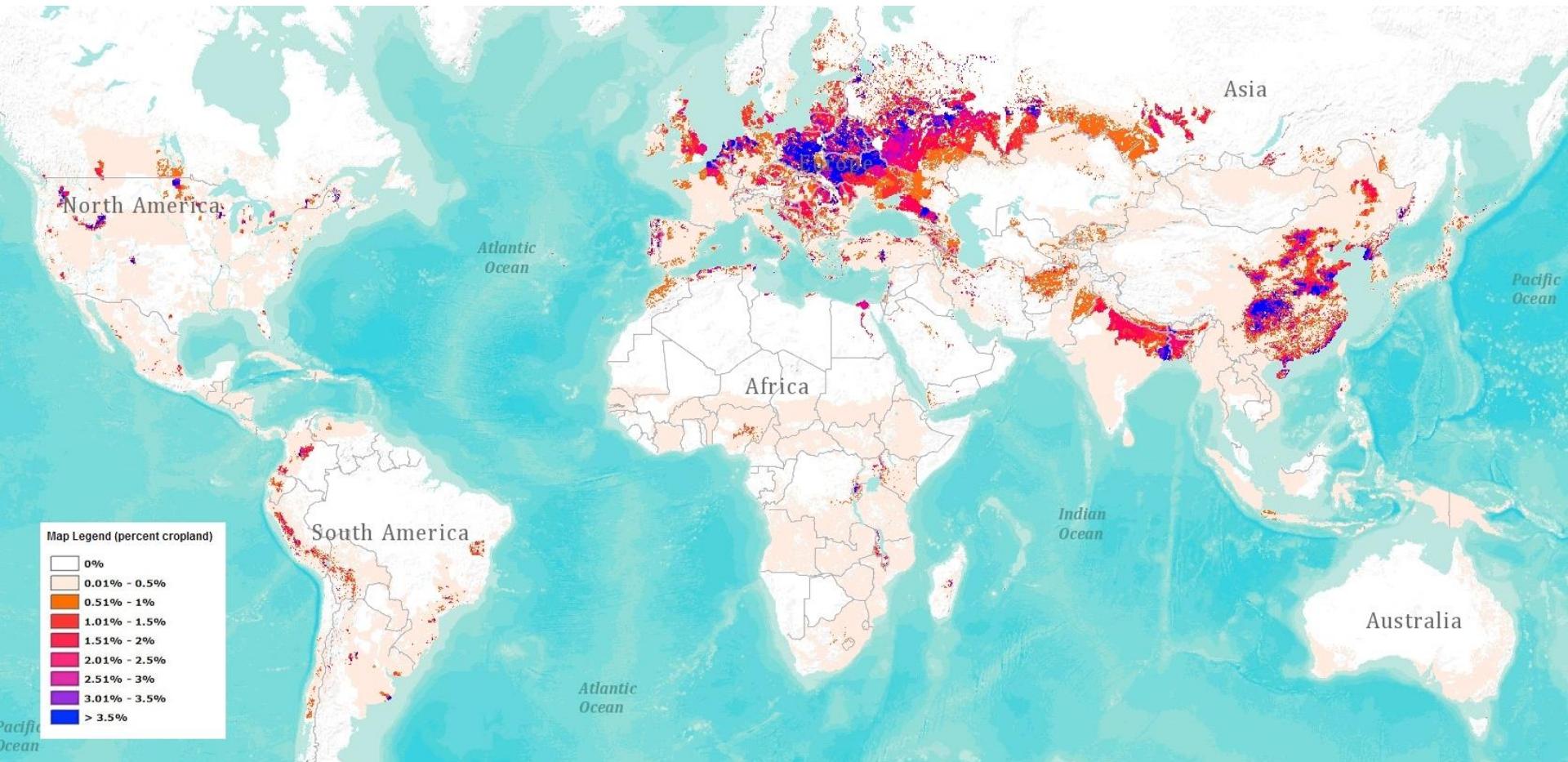


- Ability to gather surplus
- Accumulation of wealth
- Development of artisans/technology
- Centralisation of populations and power
- Appropriation of common land
- Dispersal of agriculturalists' languages and genes
- Dietary restriction
- Susceptibility to crop failure and disease, especially in monoculture

# The humble potato

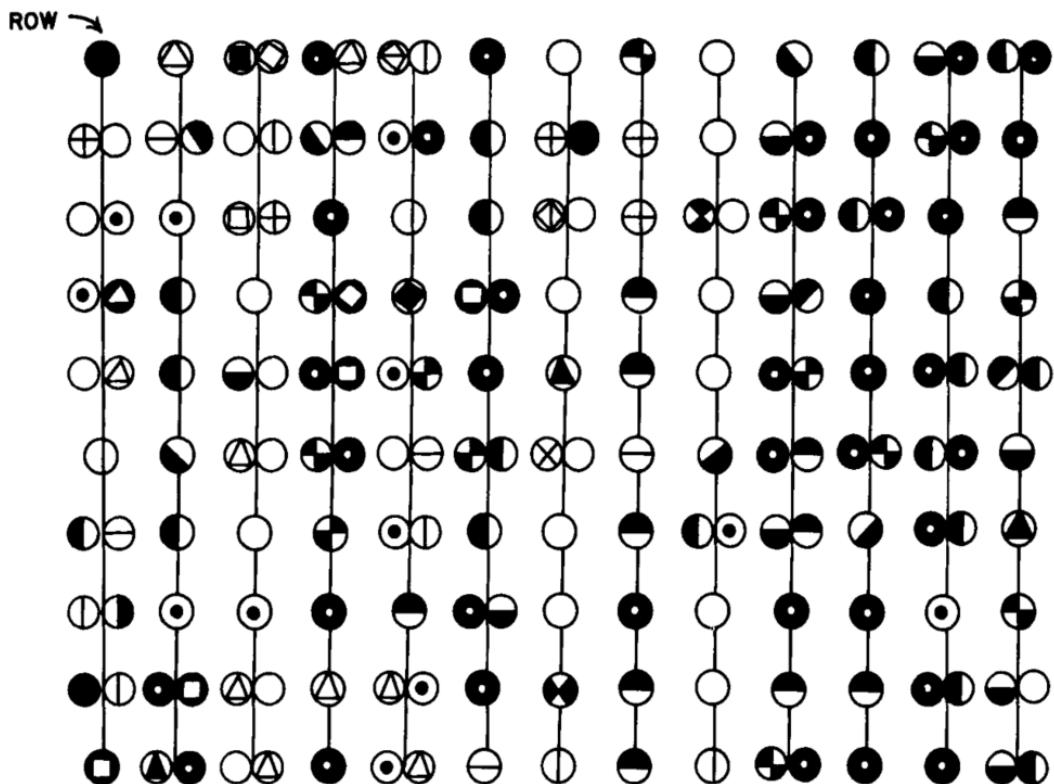


# Global potato cultivation



# Andean potato cultivation

- 4000 varieties
- Planted together to mitigate effects of climate variability, pests and disease
- Proximity to wild varieties adds vigour to the gene pool



A field in Cuzco - 46 different varieties!

# High plant diversity = resilience

- 1) *akshu*: cultivated non-bitter potatoes with little or no frost resistance.
- 2) *shiri-akshu*: cultivated bitter potatoes which must be processed by freeze-drying to remove glycoalkaloids before eating; frost resistant.
- 3) *kurao-akshu*: edible, semidomesticated (uncultivated) potatoes found in mid-altitude maize fields; no processing required and not frost resistant.
- 4) *atoqpa-akshu*: unedible, wild potatoes; some frost resistant. Literally, “fox’s potato,” perhaps to distinguish them from cultivated potatoes that are sometimes fed to dogs.

Brush et al. (1981)



# Irish Potato Famine

- 1845-1849 AD
- 1 million died, 1 million emigrated
- Ostensibly caused by *Phytophthora* fungal blight arriving from North America
- 40% of population relied on the ‘Lumper’ potato
- Question must be asked why?
  - English land-grabs led to large peasant class
  - Food exports to England raised prices in Ireland
  - Malthusian doctrine used to justify doing nothing



“ No possible sacrifices of the rich, particularly in money, could for any time prevent the recurrence of distress among the lower members of society, whoever they were.<sup>20</sup> ”

## African demography

# The young continent

With fertility rates falling more slowly than anywhere else, Africa faces a population explosion

Dec 12th 2015 | MERTULE MARIAM, ETHIOPIA | From the print edition

Timekeeper

Like 4.5K

Tweet



Getty Images

ON A trolley in a government clinic in rural Ethiopia lies Debalke Jemberu. As a medic and a nurse winkle the sperm-carrying tubes out of his testicles, he explains why he decided to have a vasectomy. He is a farmer, growing wheat, sorghum and a local staple grain called teff. But his plot is barely a quarter of a hectare. He already has four children, and has often struggled to provide for them. "I couldn't feed more children," he says.

# 20<sup>th</sup> C. agricultural revolutions

- Soviet collectivisation and modernisation
- The Green Revolution
- Biotechnology and the New Green Revolution
- Alternatives



# Reminder

- No lecture next Monday (ANZAC Day, 25 April)
- No tutes on Monday (weekly reflections still due)
- Lecture this Friday

