Humans as the Earth's Greatest Evolutionary Force

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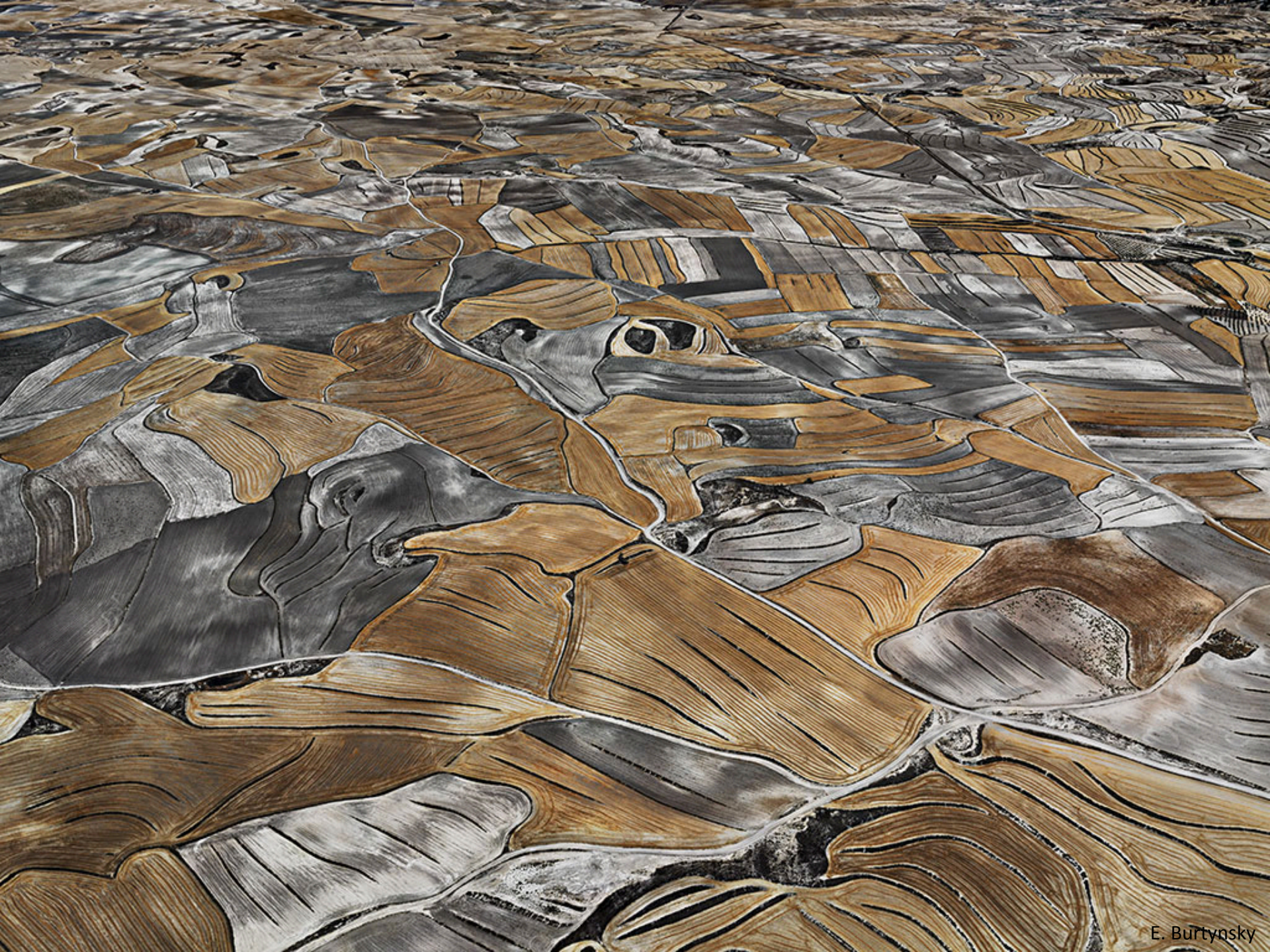
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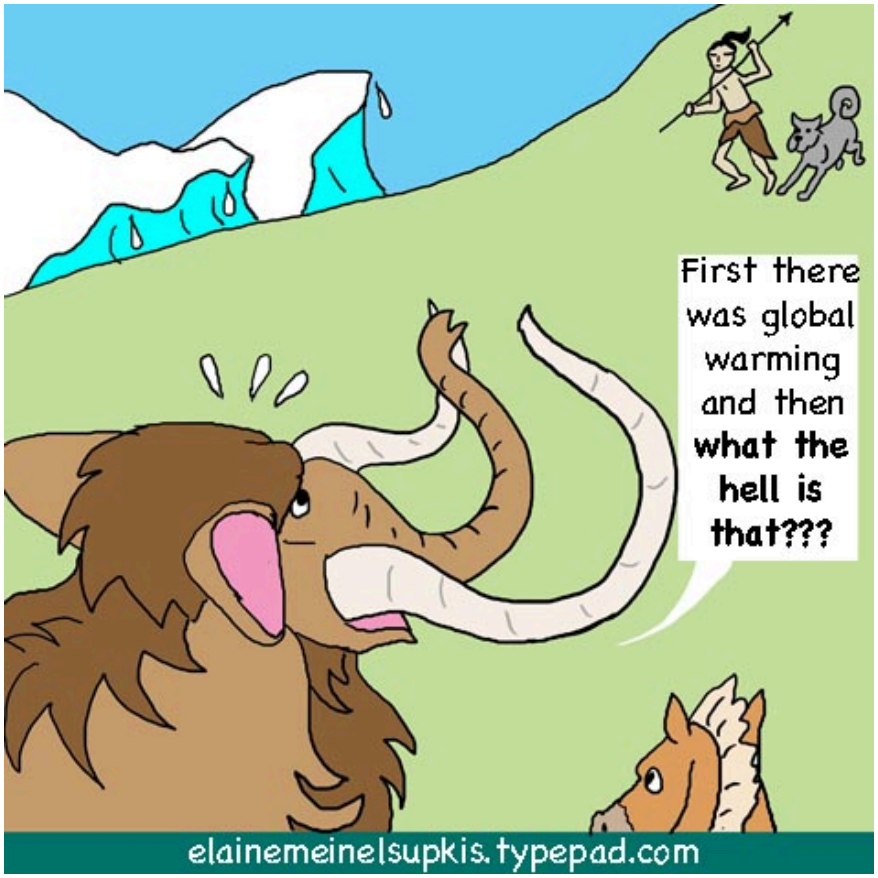
How does the environment shape us, and how do we shape the environment?

Watermark – Baichwal, Burtynsky

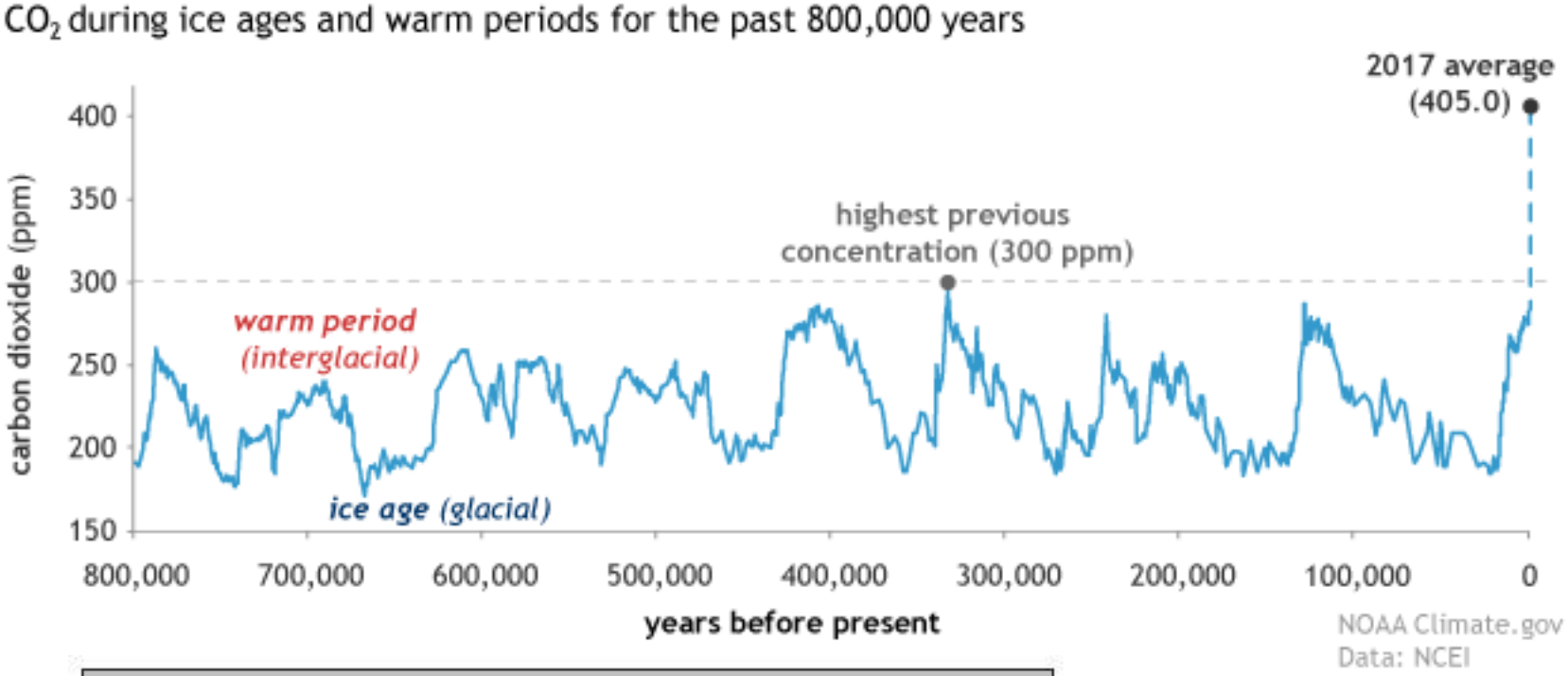
Ed Burtynsky TED Talk

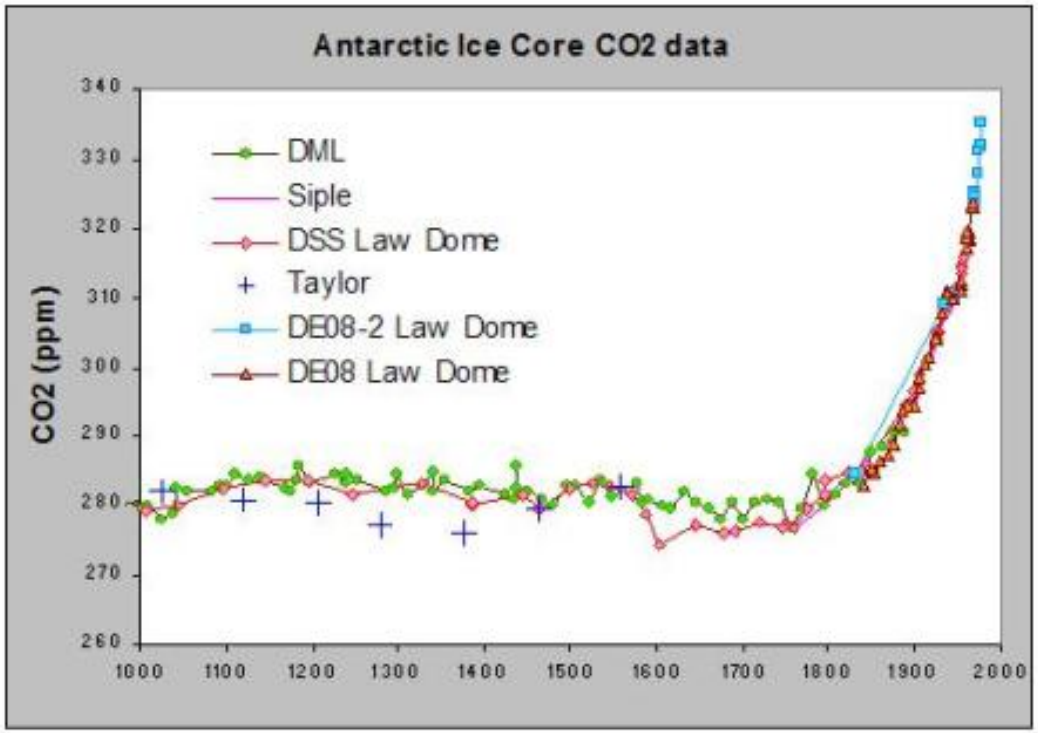
Early human-induced environmental change



Anthropocene?

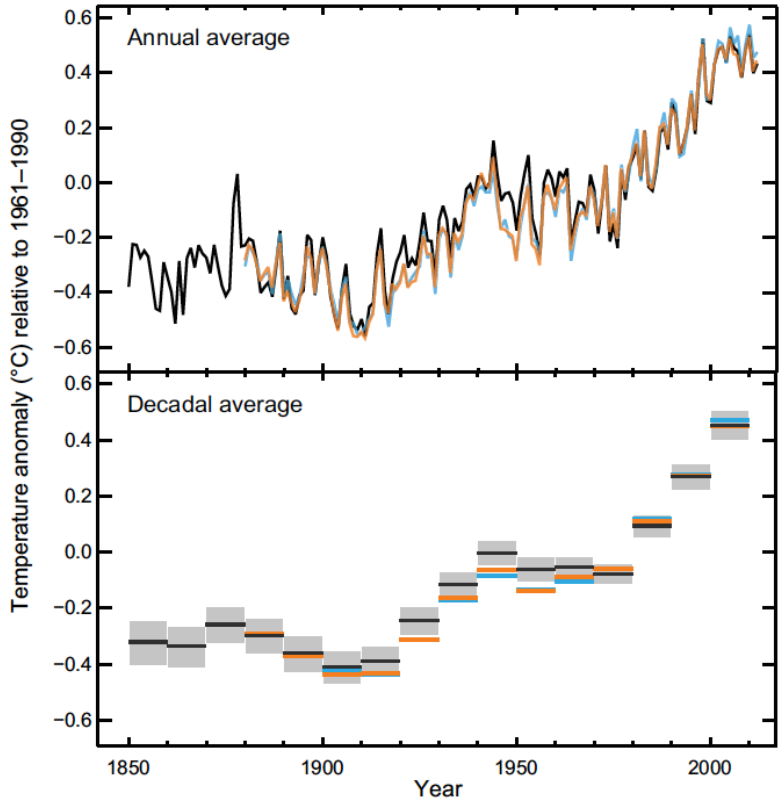
What is it?
How to define it?
What are the hallmarks?



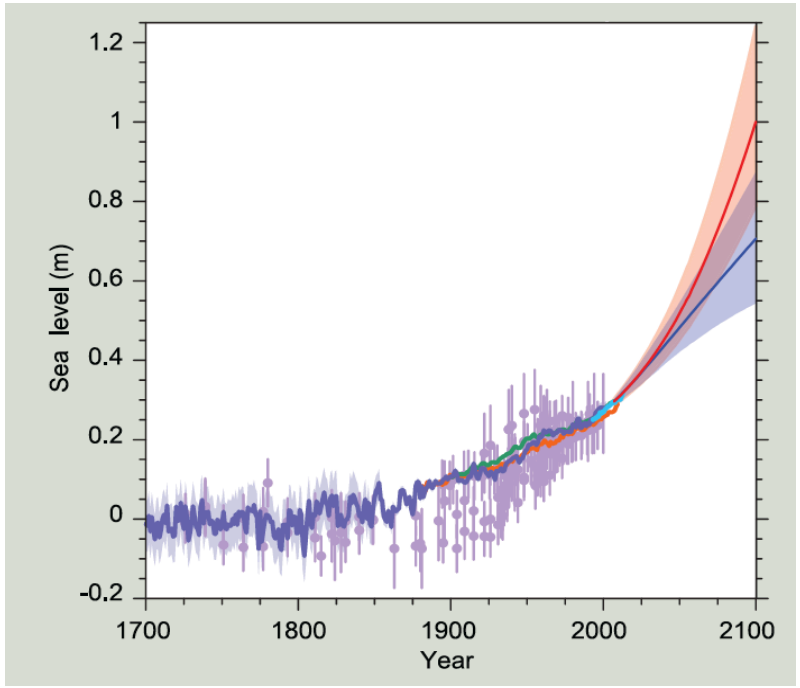


Carbon dioxide pumphandle
https://www.youtube.com/watch?feature=youtu.be&v=Yb3NsMJ-YQ8&app=desktop

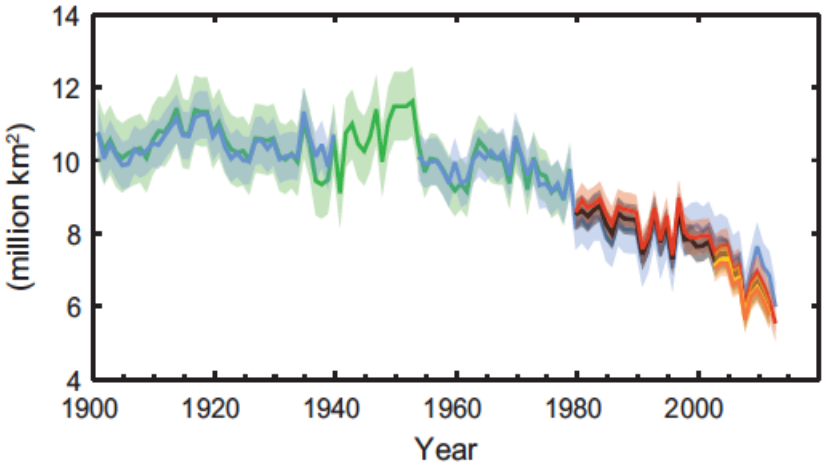
Surface Temperature



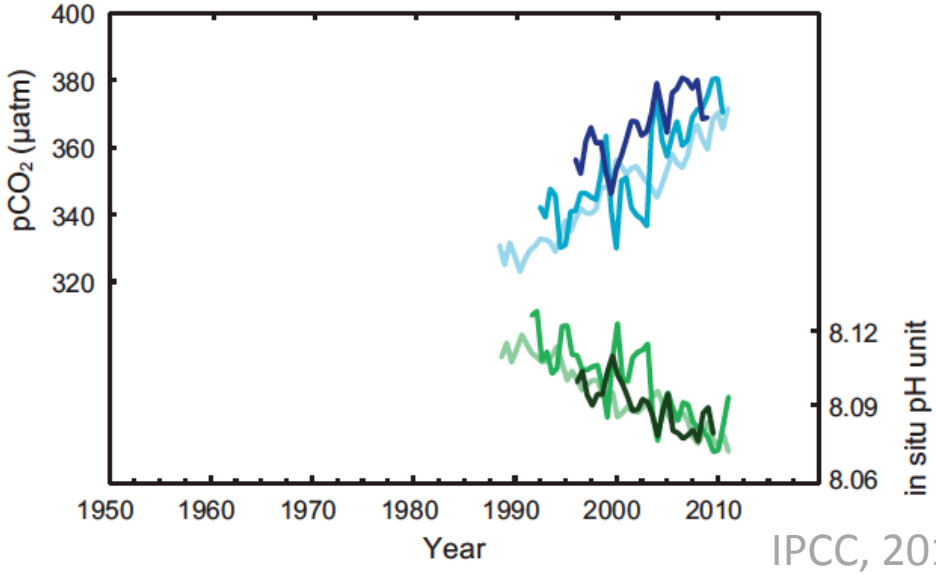
Sea Level



Arctic summer sea ice extent



Surface ocean CO_2 and pH



IPCC, 2013

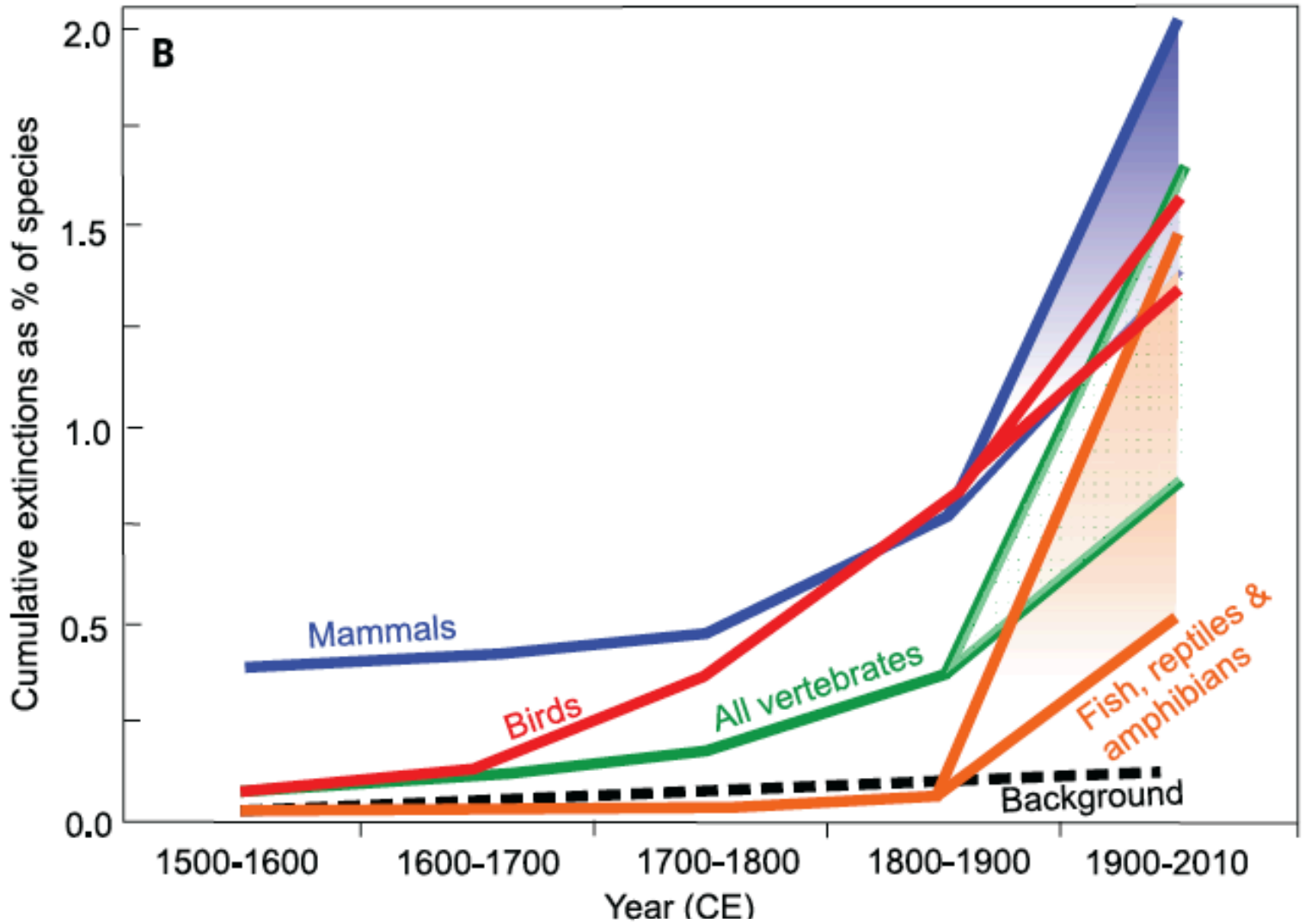
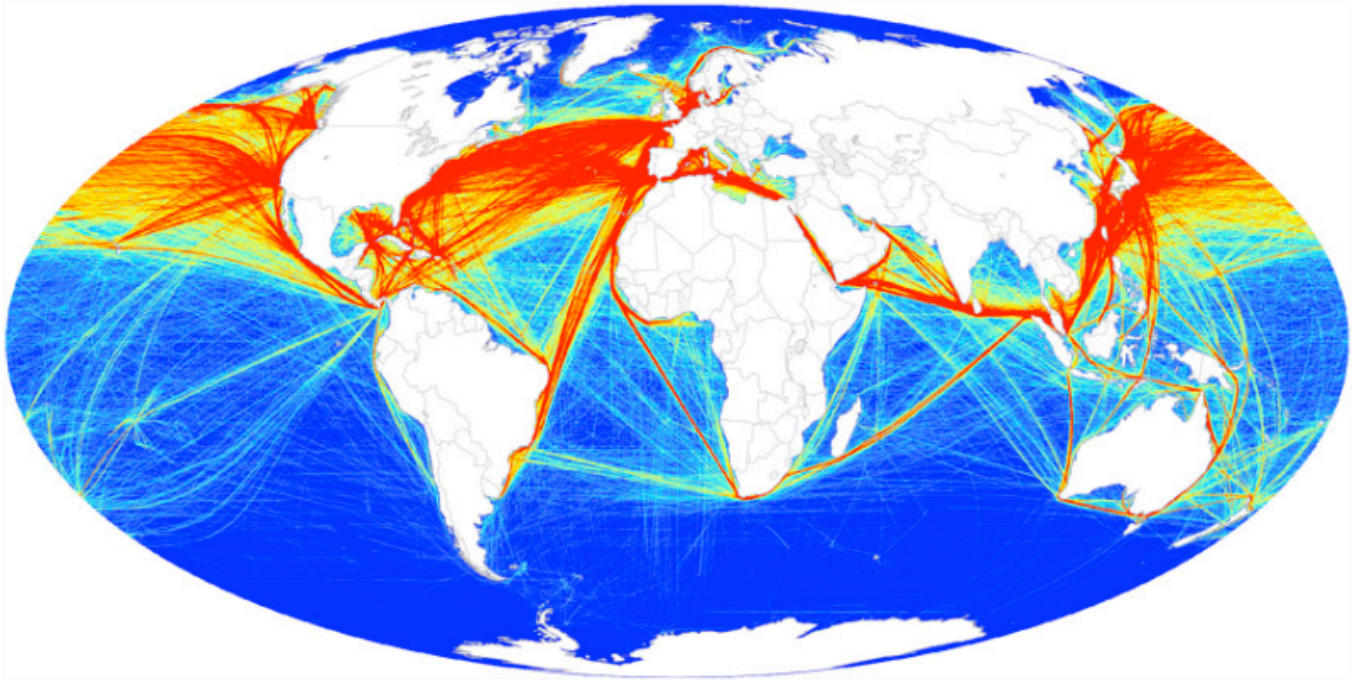


Fig. 7. Increased rates of vertebrate extinctions.

Water et al., 2016

Shipping

Lines show the routes followed by 3,374 commercial and research vessels over one year, beginning October 2004. Ships included in the map represent about 11 percent of merchant ships at sea in 2005.



High

Low

Invasive Species

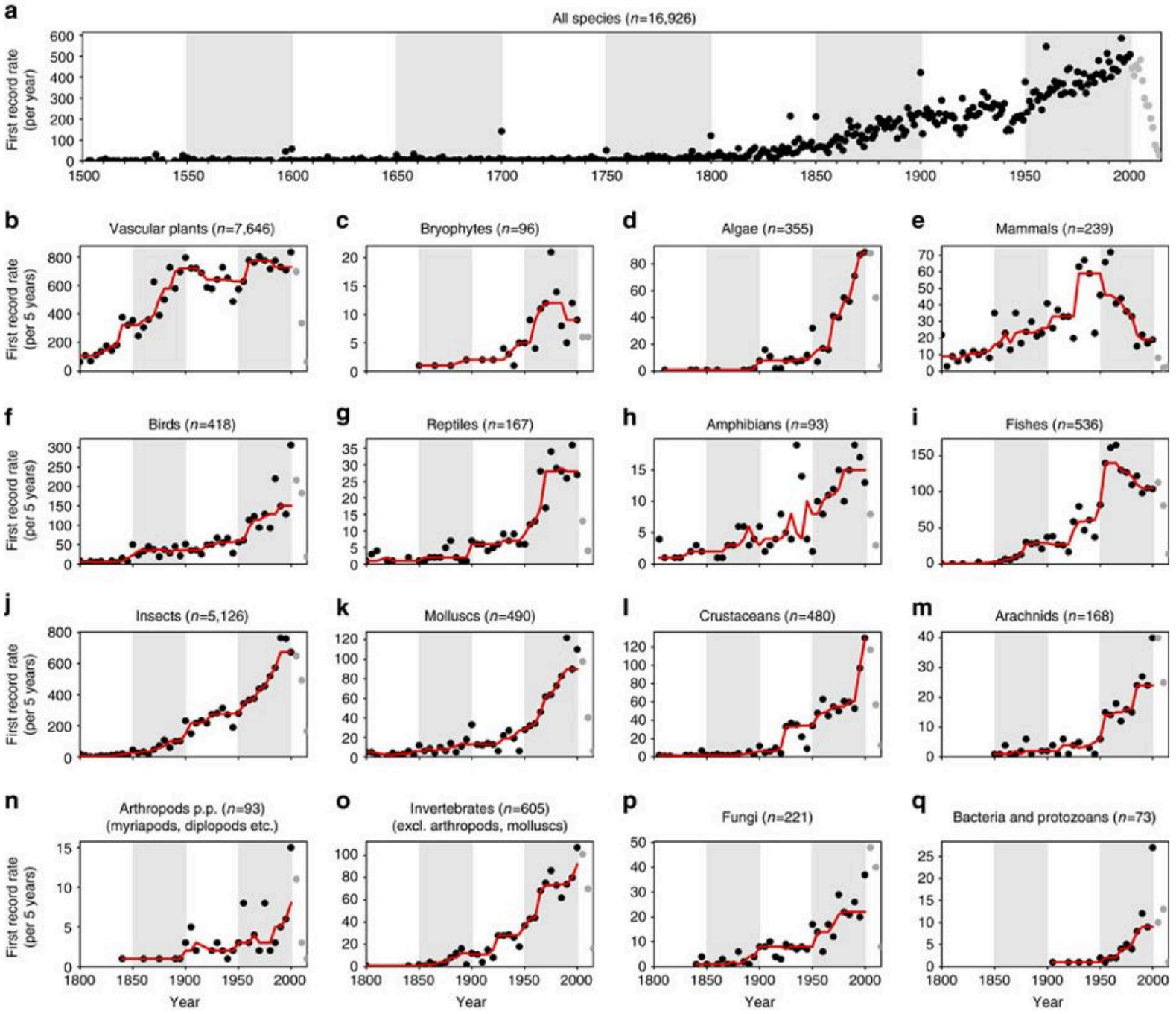
The map shows the estimated distribution of invasive marine species. Many marine organisms are carried in ballast water or on the hulls of ships.

High

Low

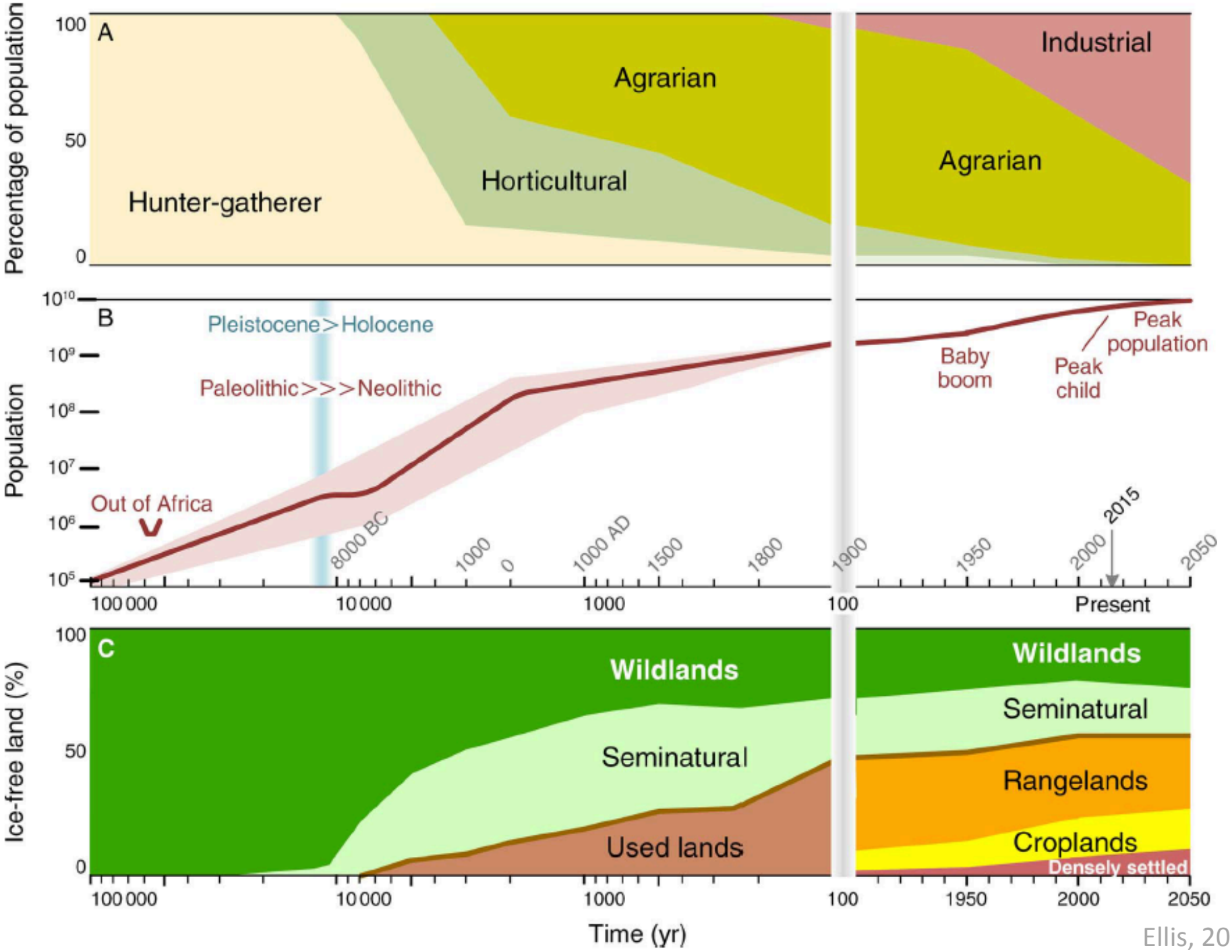
Sources: Benjamin S. Halpern, National Center for Ecological Analysis and Synthesis; Science

Graham Roberts, Jonathan Corum/The New York Times



Global temporal trends in first record rates (dots) for all species (**a**) and taxonomic groups (**b**–**q**)

Seebens et al., 2017


A
Percentage of population
100
50
0
Hunter-gatherer
Horticultural
Agrarian
Agrarian
Industrial
B
Population
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
Pleistocene > Holocene
Paleolithic >>> Neolithic
Out of Africa
Baby boom
Peak child
Peak population
8000 BC
1000
0
1000 AD
1500
1800
1900
1950
2000
2015
2050
100 000
10 000
1000
100
Present
C
Ice-free land (%)
100
50
0
Wildlands
Seminatural
Used lands
Wildlands
Seminatural
Rangelands
Croplands
Densely settled
100 000
10 000
1000
100
1950
2000
2050
Time (yr)

Ellis, 2015

Nuclear Weapons

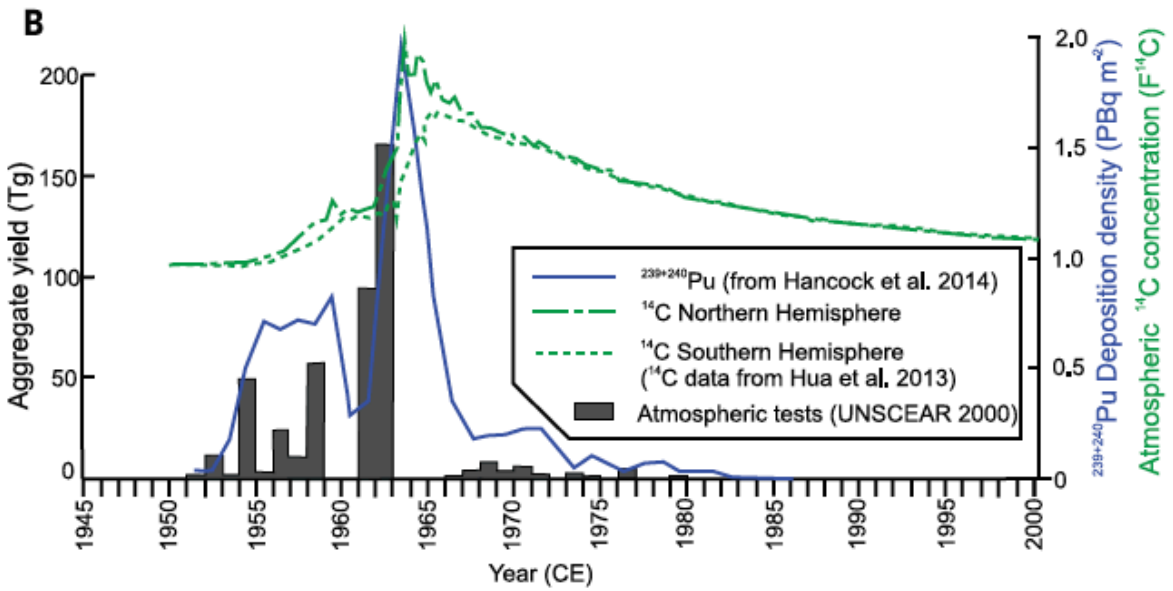


Fig. 4. Radiogenic fallout signals as a marker of the Anthropocene.

Synthetic Materials

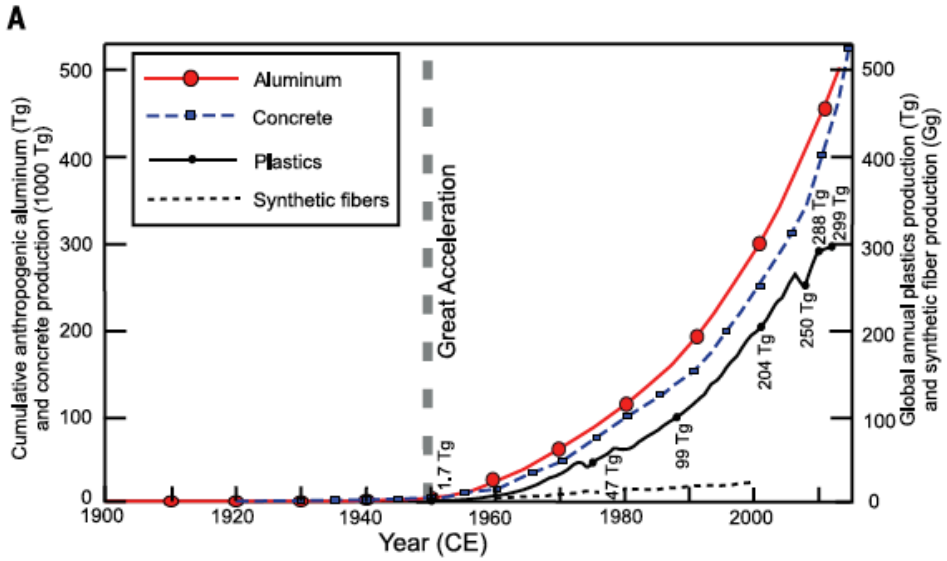


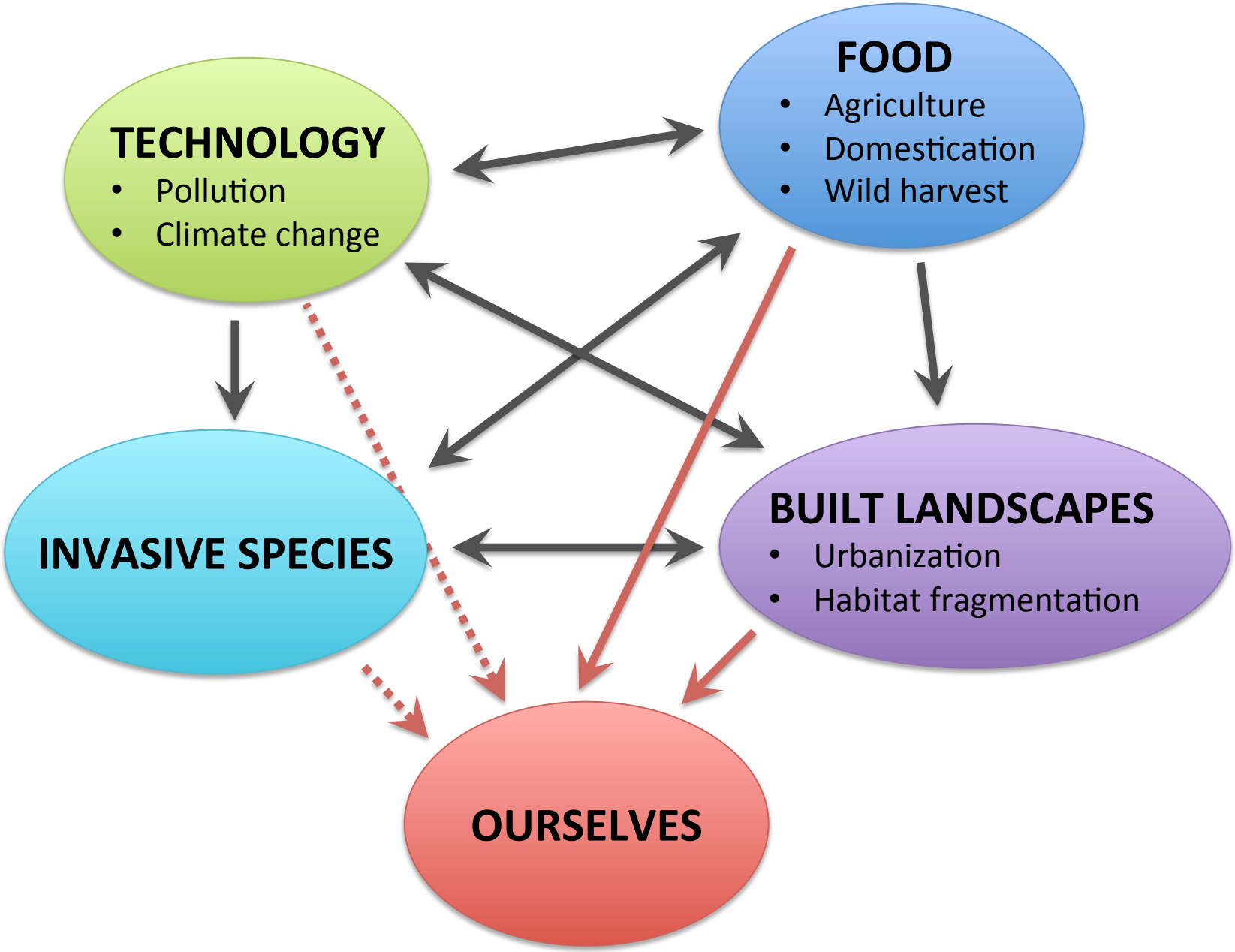
Fig. 2. The production of selected new anthropogenic materials.

Waters et al., 2016

Table 1 | Potential start dates for a formal Anthropocene Epoch

Event	Date	Geographical extent	Primary stratigraphic marker	Potential GSSP date*	Potential auxiliary stratotypes
Megafauna extinction	50,000–10,000 yr BP	Near-global	Fossil megafauna	None, diachronous over ~40,000 yr	Charcoal in lacustrine deposits
Origin of farming	~11,000 yr BP	Southwest Asia, becoming global	Fossil pollen or phytoliths	None, diachronous over ~5,000 yr	Fossil crop pollen, phytoliths, charcoal
Extensive farming	~8,000 yr BP to present	Eurasian event, global impact	CO_2 inflection in glacier ice	None, inflection too diffuse	Fossil crop pollen, phytoliths, charcoal, ceramic minerals
Rice production	6,500 yr BP to present	Southeast Asian event, global impact	CH_4 inflection in glacier ice	5,020 yr BP CH_4 minima	Stone axes, fossil domesticated ruminant remains
Anthropogenic soils	~3,000–500 yr BP	Local event, local impact, but widespread	Dark high organic matter soil	None, diachronous, not well preserved	Fossil crop pollen
New–Old World collision	1492–1800	Eurasian–Americas event, global impact	Low point of CO_2 in glacier ice	1610 CO_2 minima	Fossil pollen, phytoliths, charcoal, CH_4, speleothem $\delta^{18}O$, tephra†
Industrial Revolution	1760 to present	Northwest Europe event, local impact, becoming global	Fly ash from coal burning	~1900 (ref. 94); diachronous over ~200 yr	^{14}N:^{15}N ratio and diatom composition in lake sediments
Nuclear weapon detonation	1945 to present	Local events, global impact	Radionuclides (^{14}C) in tree-rings	1964 ^{14}C peak§	^{240}Pu: ^{239}Pu ratio, compounds from cement, plastic, lead and other metals
Persistent industrial chemicals	~1950 to present	Local events, global impact	For example, SF_6 peak in glacier ice	Peaks often very recent so difficult to accurately date§	Compounds from cement, plastic, lead and other metals

Lewis & Maslin, 2015


TECHNOLOGY
• Pollution
• Climate change
FOOD
• Agriculture
• Domestication
• Wild harvest
INVASIVE SPECIES
BUILT LANDSCAPES
• Urbanization
• Habitat fragmentation
OURSELVES

EVOLUTION & ADAPTATION

Trait change through **evolution**

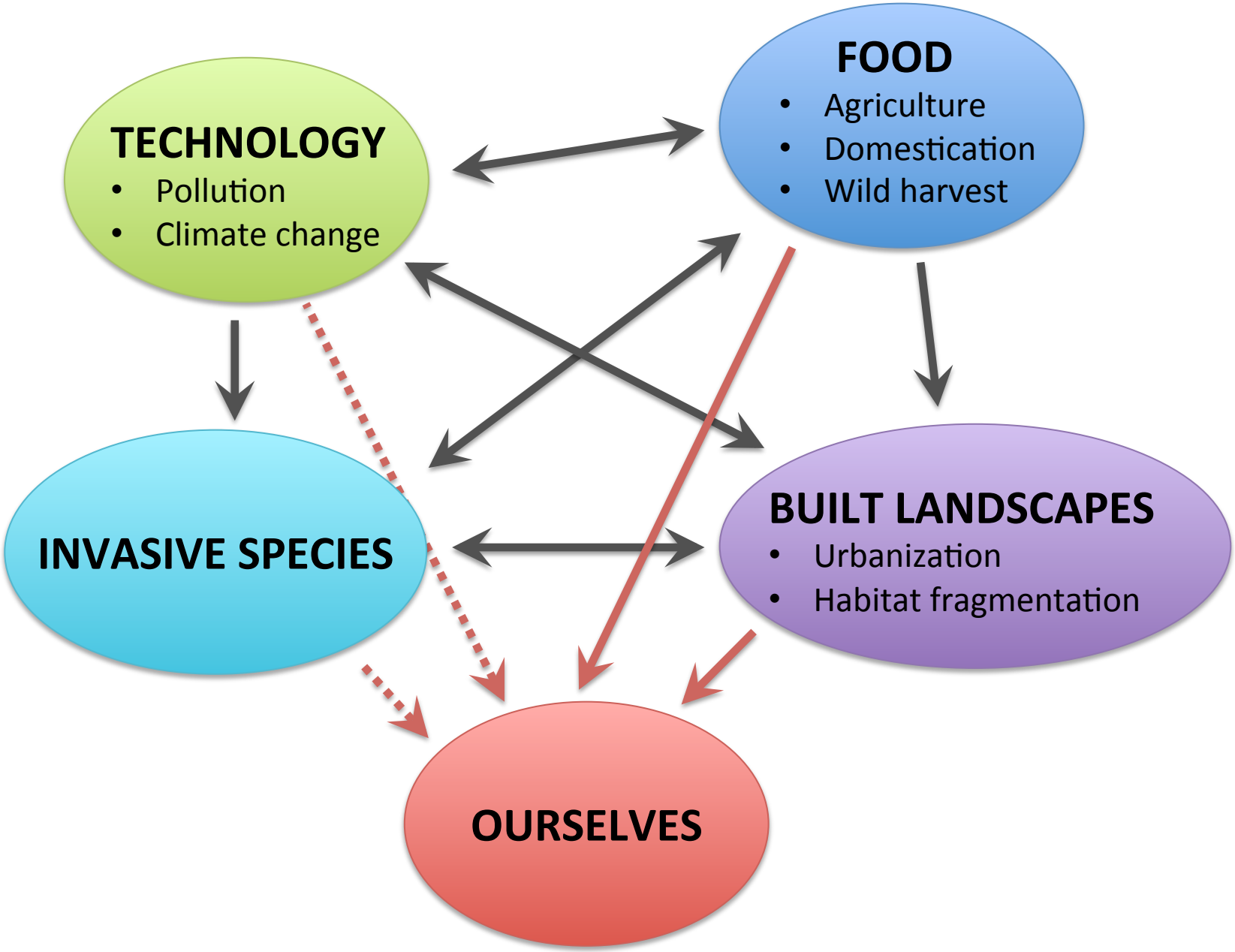
Change *over* *time* *by* *descent* *with* *modification*

Life is not static; neither is the environment

Some change takes long time, some short, but adaptation always lags behind environmental change

Heritability of traits is key

Evolution tinkers with variation that is at hand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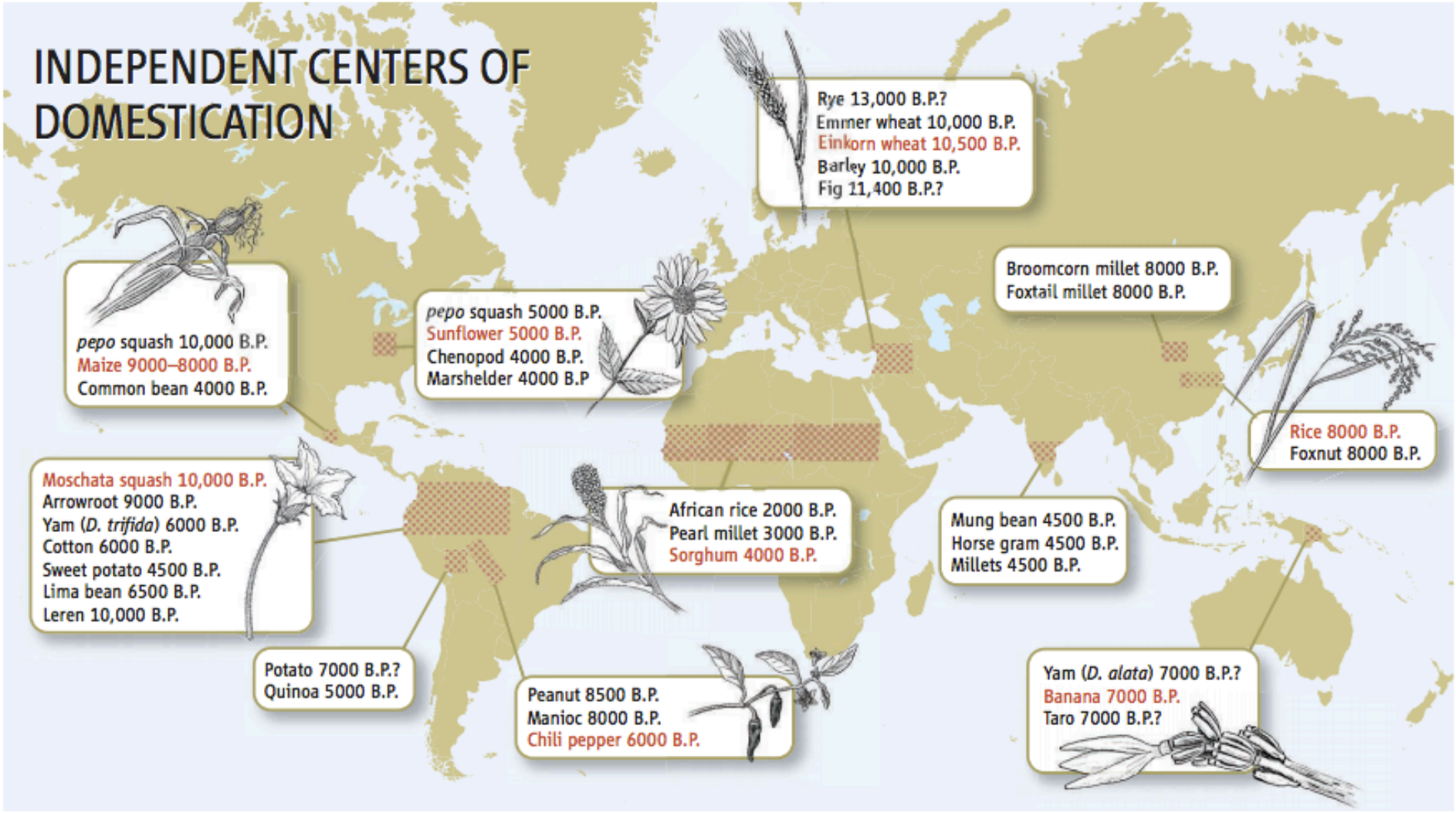
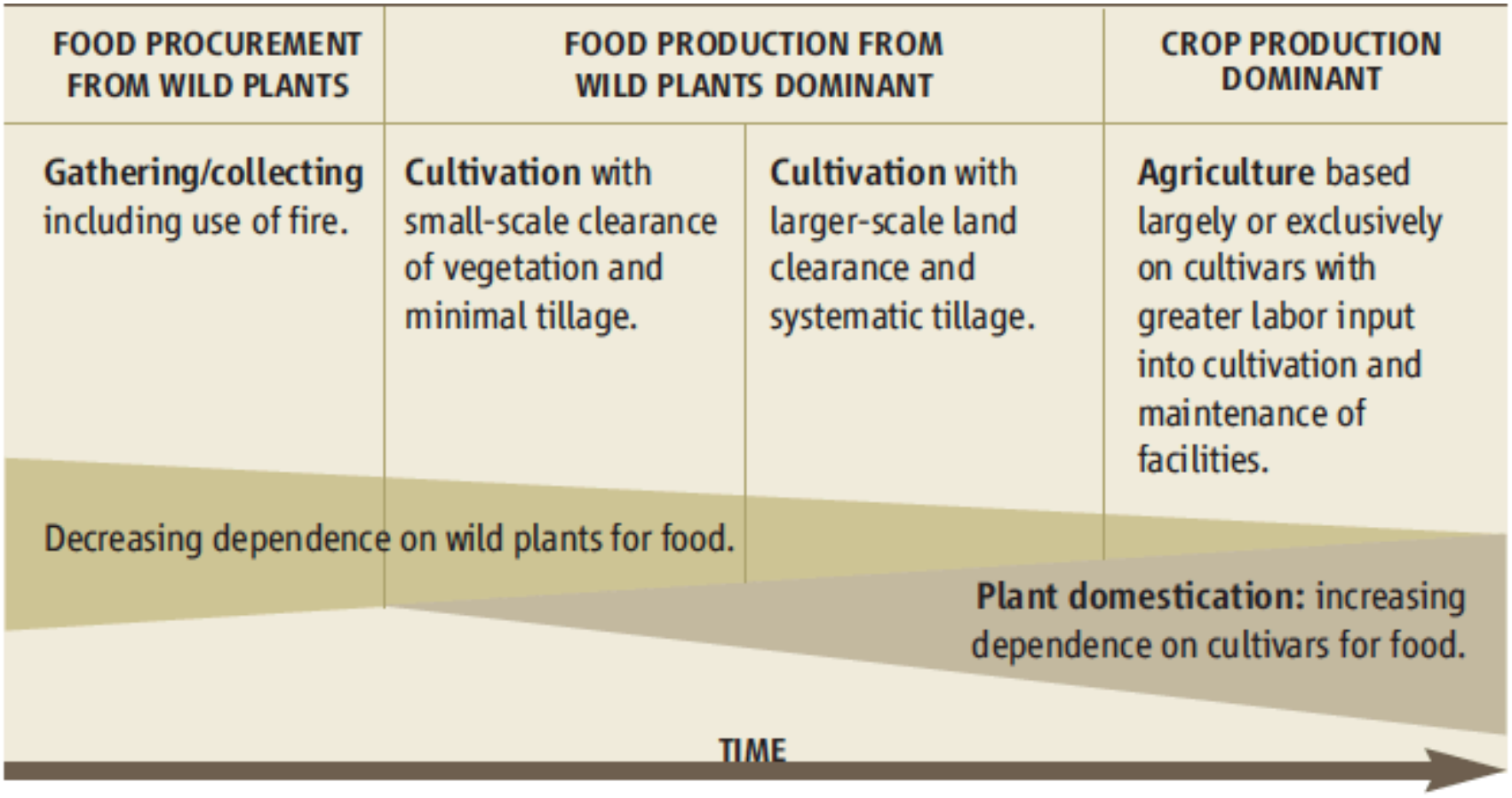
FOOD: Agriculture, domestication



Multiple birth. People in many different parts of the world independently began to cultivate and eventually domesticate plants.

Balter 2007

FOOD: Agriculture, domestication

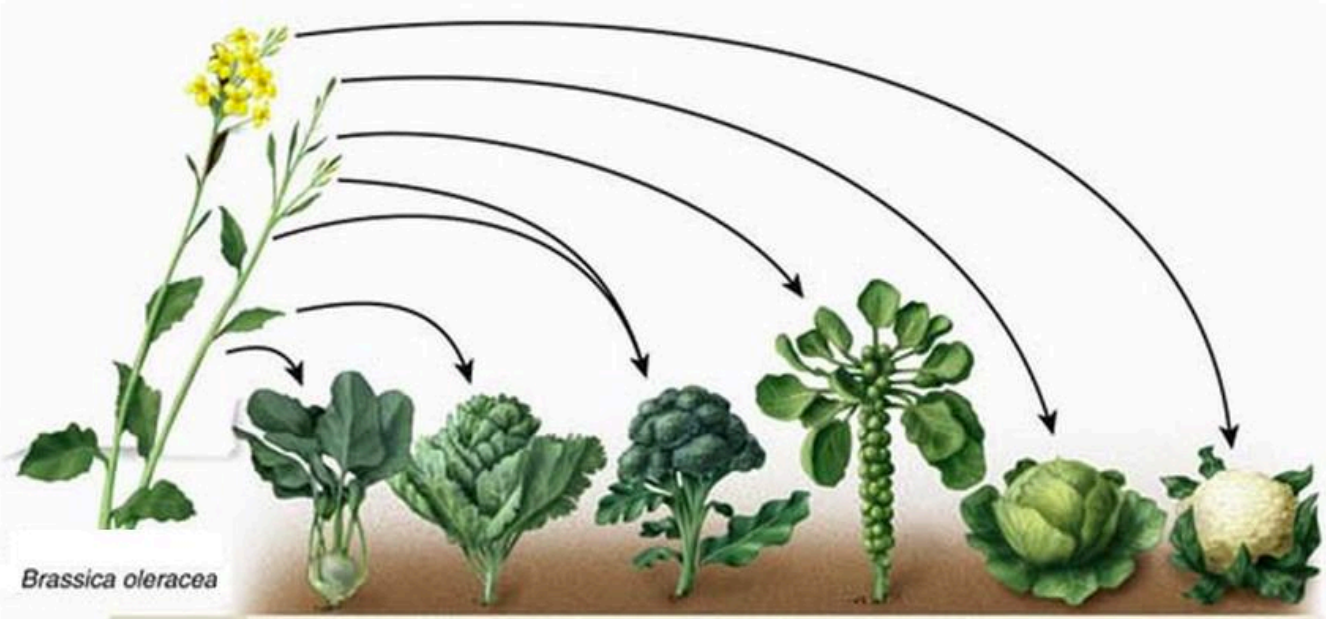


Balter 2007

FOOD: Agriculture, domestication

"Neolithic farmers were the first geneticists and domestic agriculture was the lever with which they moved the world."

– Driscoll et al., 2009



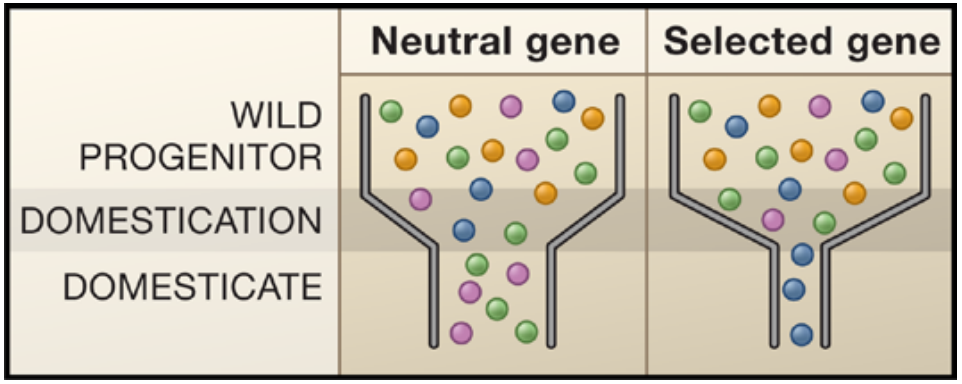
Strain	Kohlrabi	Kale	Broccoli	Brussels sprouts	Cabbage	Cauliflower
Modified trait	Stem	Leaves	Flower buds and stem	Lateral leaf buds	Terminal leaf bud	Flower buds

FOOD: Agriculture, domestication

"Domestication Syndrome"

- Larger fruits or grains
- More robust plants overall
- Robust growth of central stem in comparison to the side stems
- Loss of natural seed dispersal (seeds remain attached for easy harvest)
- Loss of seed dormancy
- Decrease in bitter substances in edible structures
- Changes in photoperiod sensitivity
- Synchronized flowering

One consequence is a ***decrease in genetic diversity***
→ few progenitors
→ selection of favored types



Doebley et al., 2006

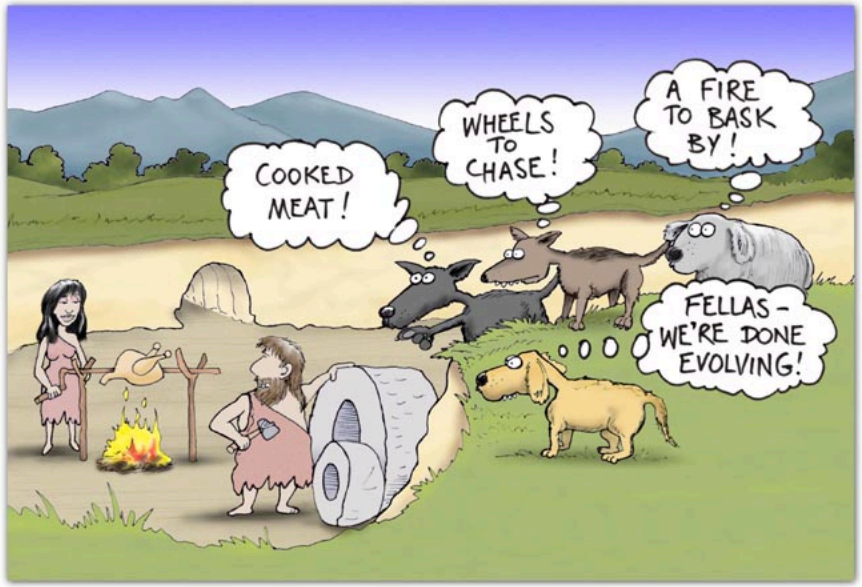
FOOD: Agriculture, domestication

ANIMALS: Taming vs. Domestication

Favorable	Unfavorable
Social structure	
Dominance hierarchy	Territoriality
Large gregarious groups	Family groups or solitary
Male social group affiliation	Males in separate groups
Persistent groups	Open membership
Food preferences	
Generalist herbivorous feeder or omnivore	Dietary specialist or carnivore
Captive breeding	
Polygamous/Promiscuous mating	Pair bonding prior to mating
Males dominant over females	Females dominant or males appease females
Males initiate	Females initiate
Movement or posture mating cues	Color or morphological mating cues
Precocial young	Altrical young
Easy divestiture of young	Difficult divestiture of young
High meat yield per food/time	Low meat yield
Intra- or inter-species aggressiveness	
Non-aggressive	Naturally aggressive
Tameable/readily habituated	Difficult to tame
Readily controlled	Difficult to control
Solicits attention	Avoids attention/independent
Captive temperament	
Low sensitivity to environmental change	High sensitivity to environmental change
Limited agility	Highly agile/difficult to contain
Small home range	Large home range
Wide environmental tolerance	Narrow environmental tolerance
Non-shelter seeking	Shelter seeking
Implosive herd reaction to threat	Explosive herd reaction
Commensal initiative	
Exploits anthropic environments	Avoids anthropic environments

Driscoll et al., 2009

FOOD: Agriculture, domestication



Forget the experts: domestication of the dog only took about 8 seconds.

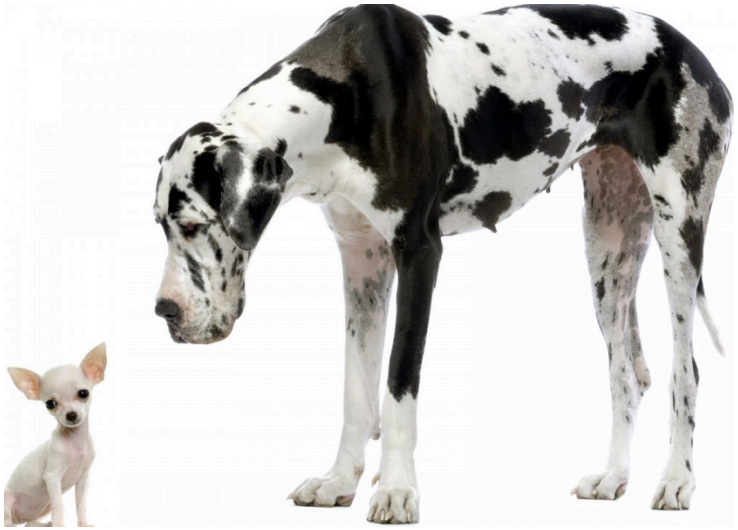
Scavengers

↓

Barking sentinels

↓

Socialized (decreased flight, increased sociality)



"Domestication genes"

Genes known (from human & mouse studies) to be involved in memory formation, behavioral sensitization, and a gene known in humans to be associated with gregariousness

FOOD: Agriculture, domestication

Russian Fox experiments

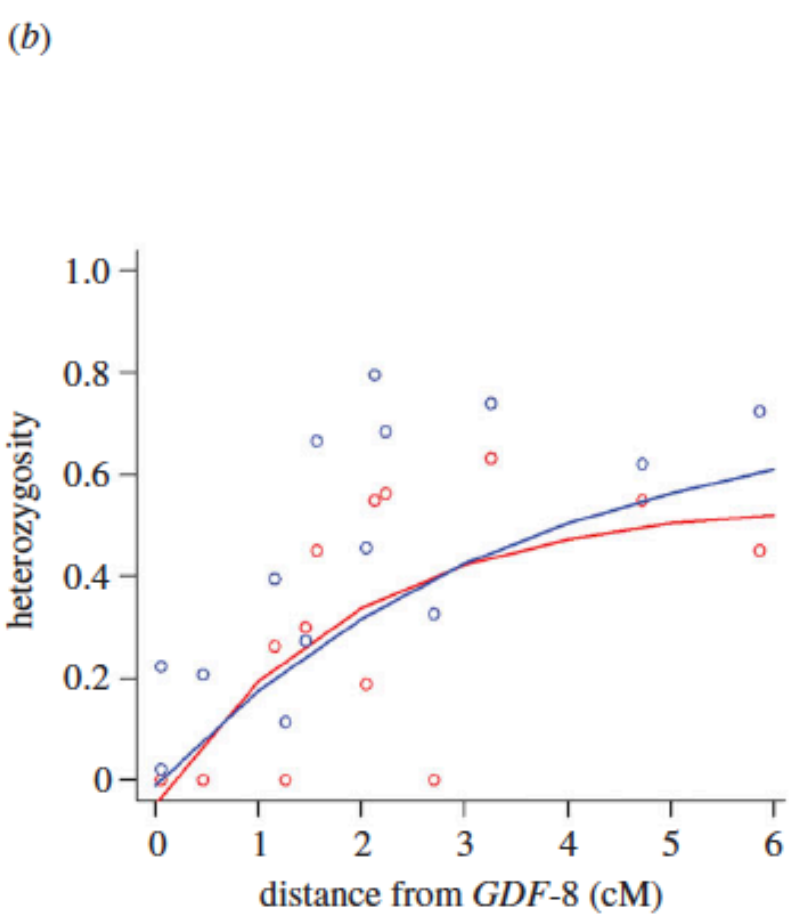
30-35 generation selective breeding experiment

"Tameness" was the only trait under selection

characteristic	animals per 100,000 with trait		increase in frequency
	domesticated population	nondomesticated population	(percent)
depigmentation (*Star*)	12,400	710	+1,646
brown mottling	450	86	+423
gray hairs	500	100	+400
floppy ears	230	170	+35
short tail	140	2	+6,900
tail rolled in circle	9,400	830	+1,033

Figure 8. Foxes in the domesticated population show an unusually high incidence of certain other changes, including *(clockwise from top left)* floppy ears, shortened legs and tails, tails curled upward like dogs', and underbites and overbites. The rates of some common aberrations are compared in the table. In addition to the *Star* depigmentation pattern, the increased incidence of doglike tail characteristics was most marked.

FOOD: Agriculture, domestication



Wiener & Wilkinson, 2011