

Deep Roots of the Anthropocene

Archaeological Mapping of Global Land Use

10,000 BP to 1850 CE

Erle Ellis

Geography & Environmental Systems
University of Maryland, Baltimore County

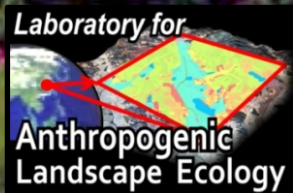
ecotope.org | ece@umbc.edu | [@erleellis](https://twitter.com/erleellis)

LUMIP Workshop
Aspen Global Change Institute
Snowmass, Colorado
September 16, 2019



GLOBAL COLLABORATION ENGINE

GLOBE



Geoglyphs >0.7 ka
Rondonia, Brazil

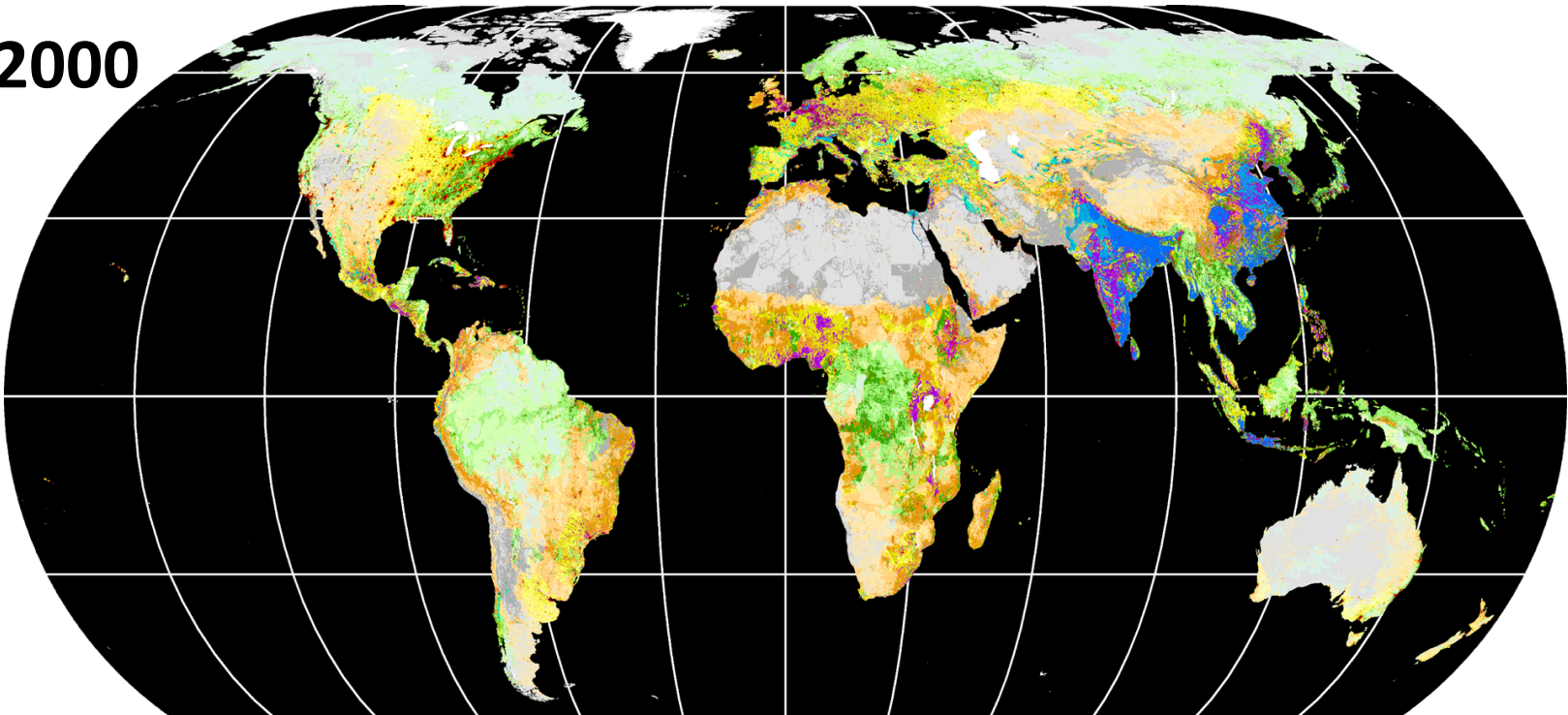
www.treehugger.com/natural-sciences/amazon-road-workers-find-ancient-earth-carvings.html

Ecosystems = $f(P, T)$
 P = Population density
 T = Land use

The Anthropogenic Biosphere

Anthromes (Anthropogenic Biomes)

2000



Used

Seminatural

Wild

Dense
Settlements



Urban Dense
settlements

Villages



Rice | Rainfed
Irrigated Pastoral

Croplands



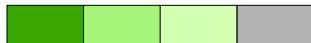
Residential Populated |
Irrigated Rainfed Remote

Rangelands



Residential | Remote
Populated

Seminatural



Woodlands
Residential | Remote
Populated

Treeless
& Barren

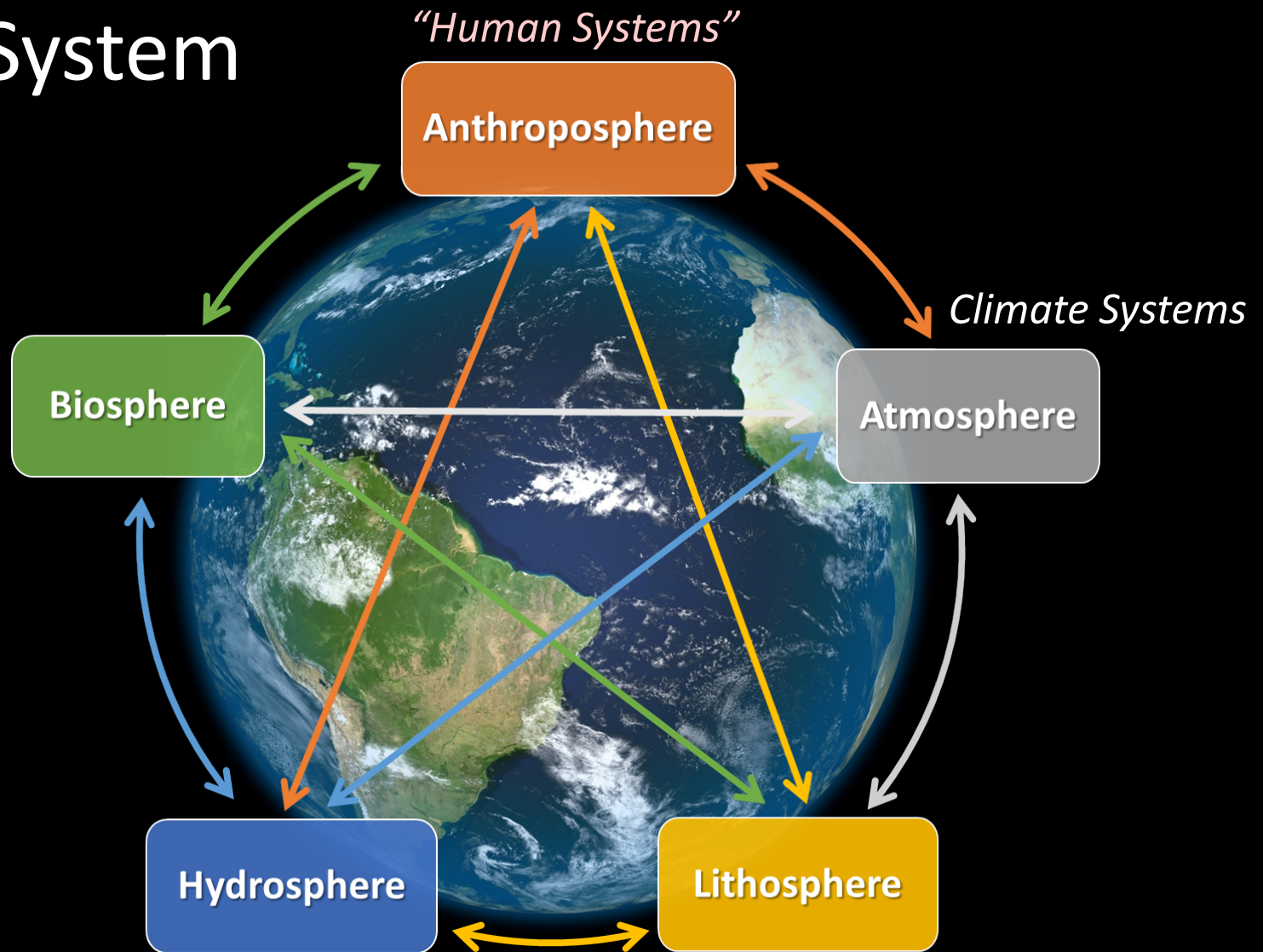
Wildlands



Woodlands
& Barren

Anthropocene

Earth System



Anthropocene : Recent

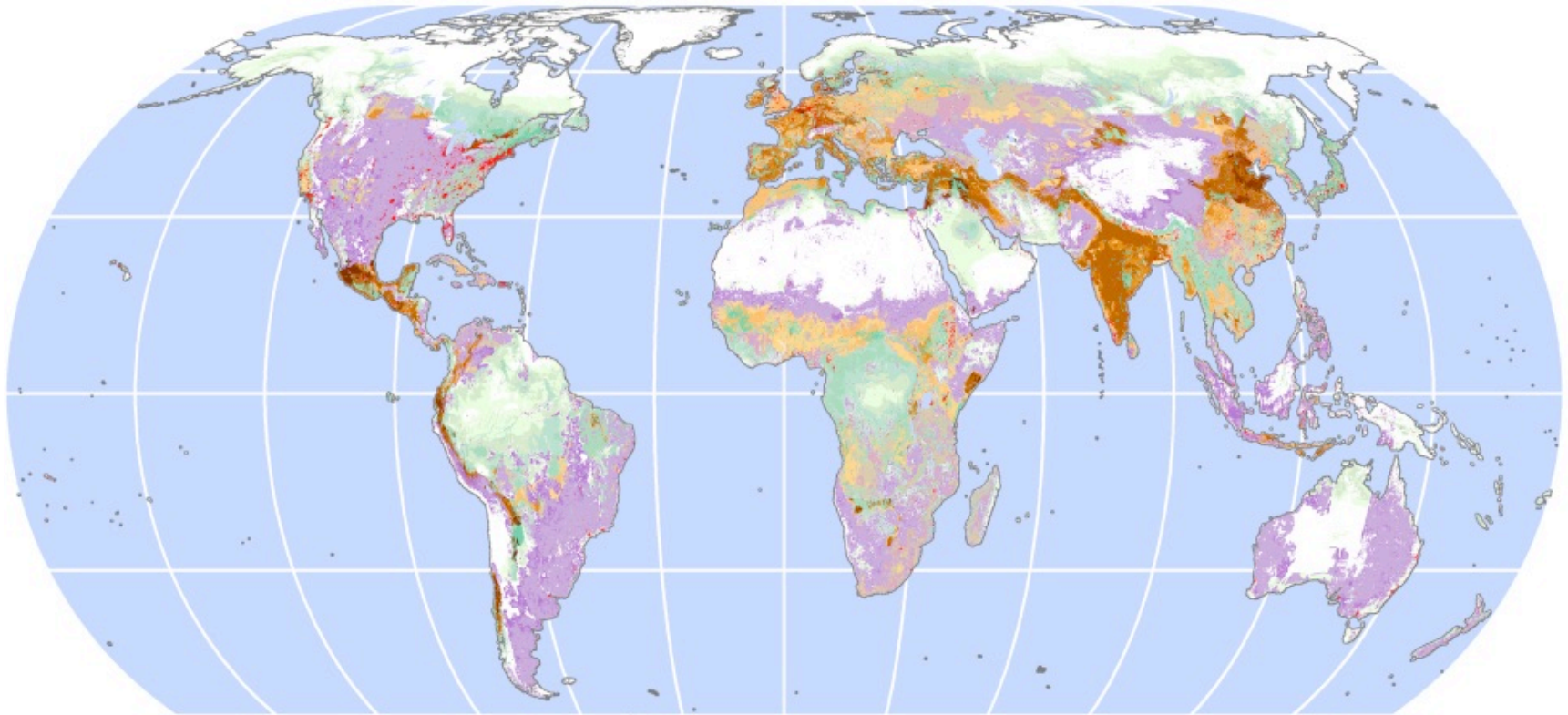
Fires and Deforestation on
the Amazon Frontier,
Rondonia, Brazil
May 28, 2009

Anthropocene : Archaeology

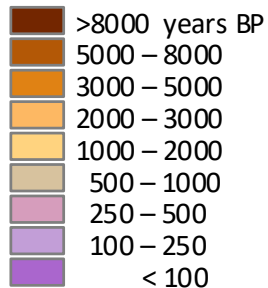


Geoglyphs >0.7 ka
Rondonia, Brazil

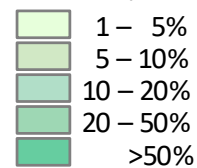
Used Planet | The Ancient Anthropogenic Biosphere



**Period of first
Significant Use**



Recovery
(% from peak use)

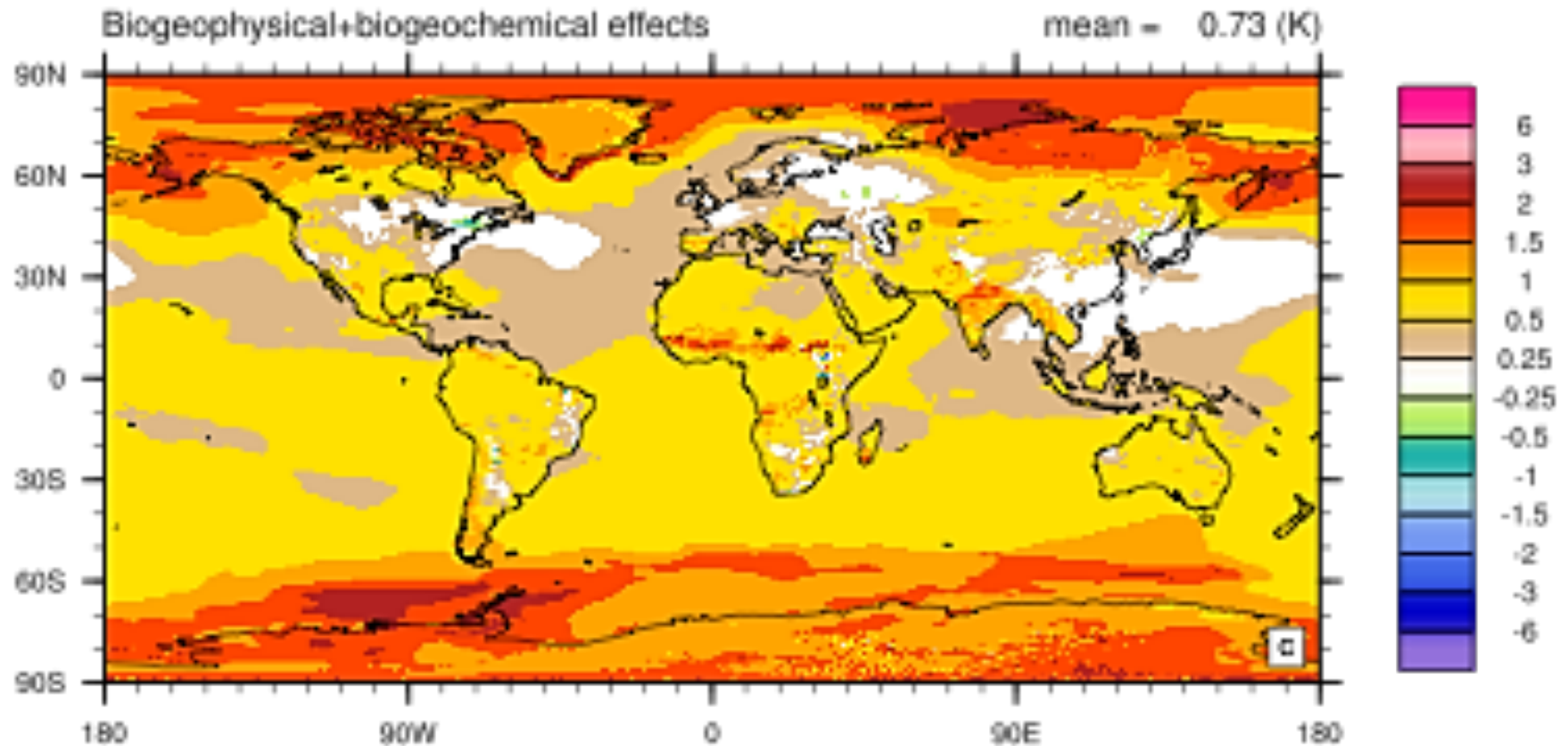


**Dense
Settlements**
AD 2000



The Ruddiman Hypothesis: Early farmers deforested the Earth

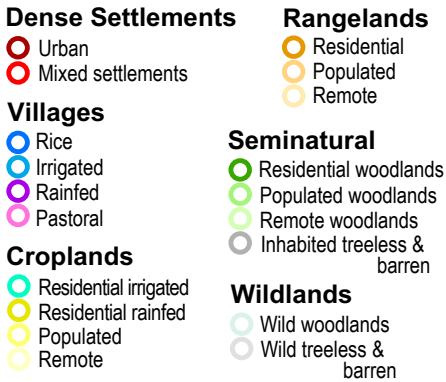
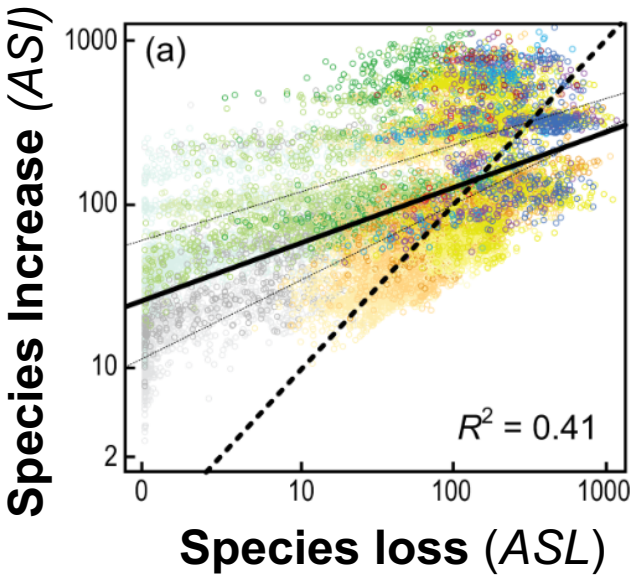
Early Land Use: Global Climate Change



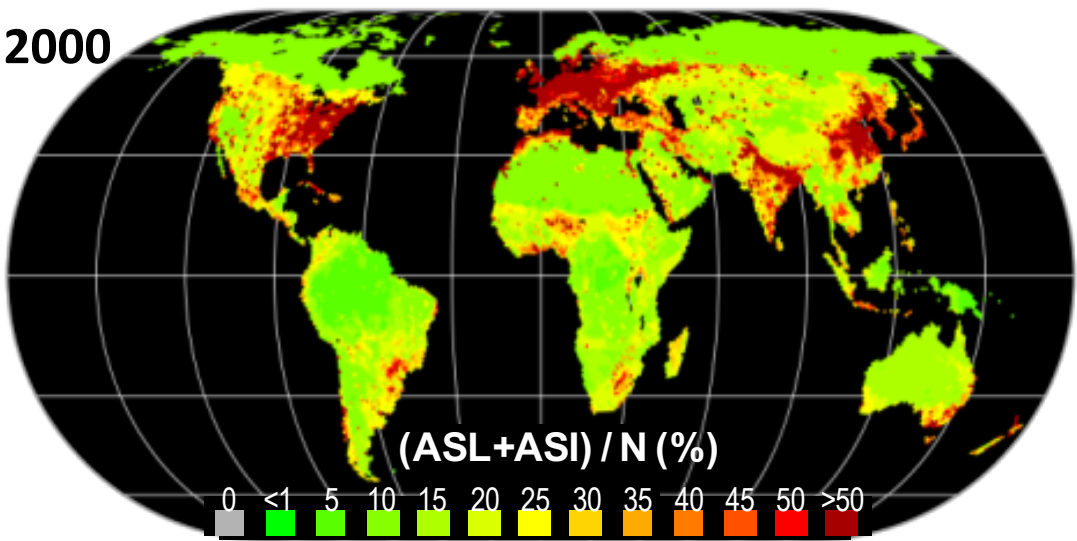
He *et al* 2013 *GRL*

Anthropogenic Changes in *Plant Assemblages*

- Species Richness *Increases*
- *Species loss and gain are related*

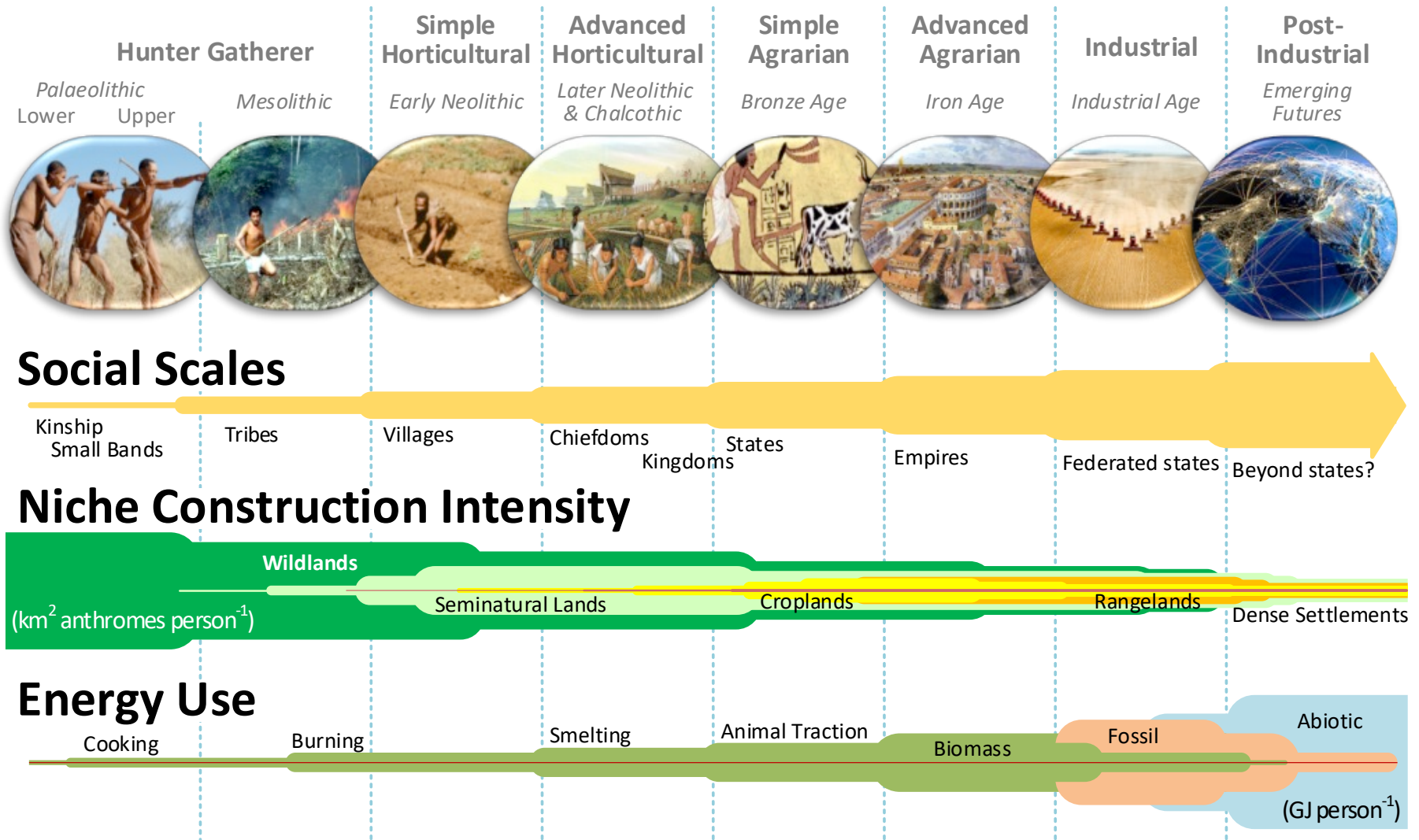


ASI + ASL: Vascular Plants

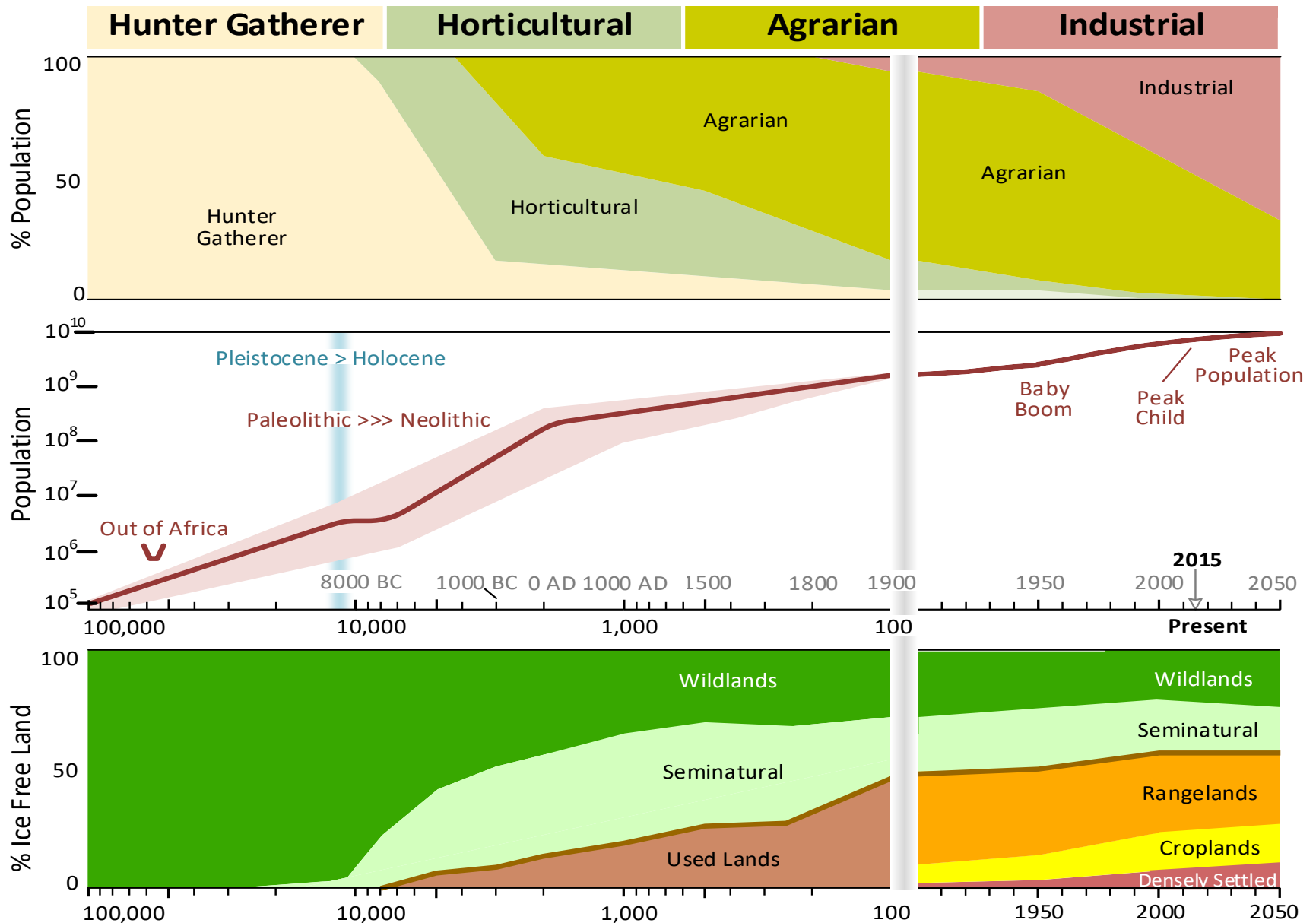


Anthropogenic Environmental Change

Evolution of Sociocultural Niche Construction



Long-Term Global Changes in Societal Scale and Biosphere Transformation



The Anthropocene is *Diachronous*

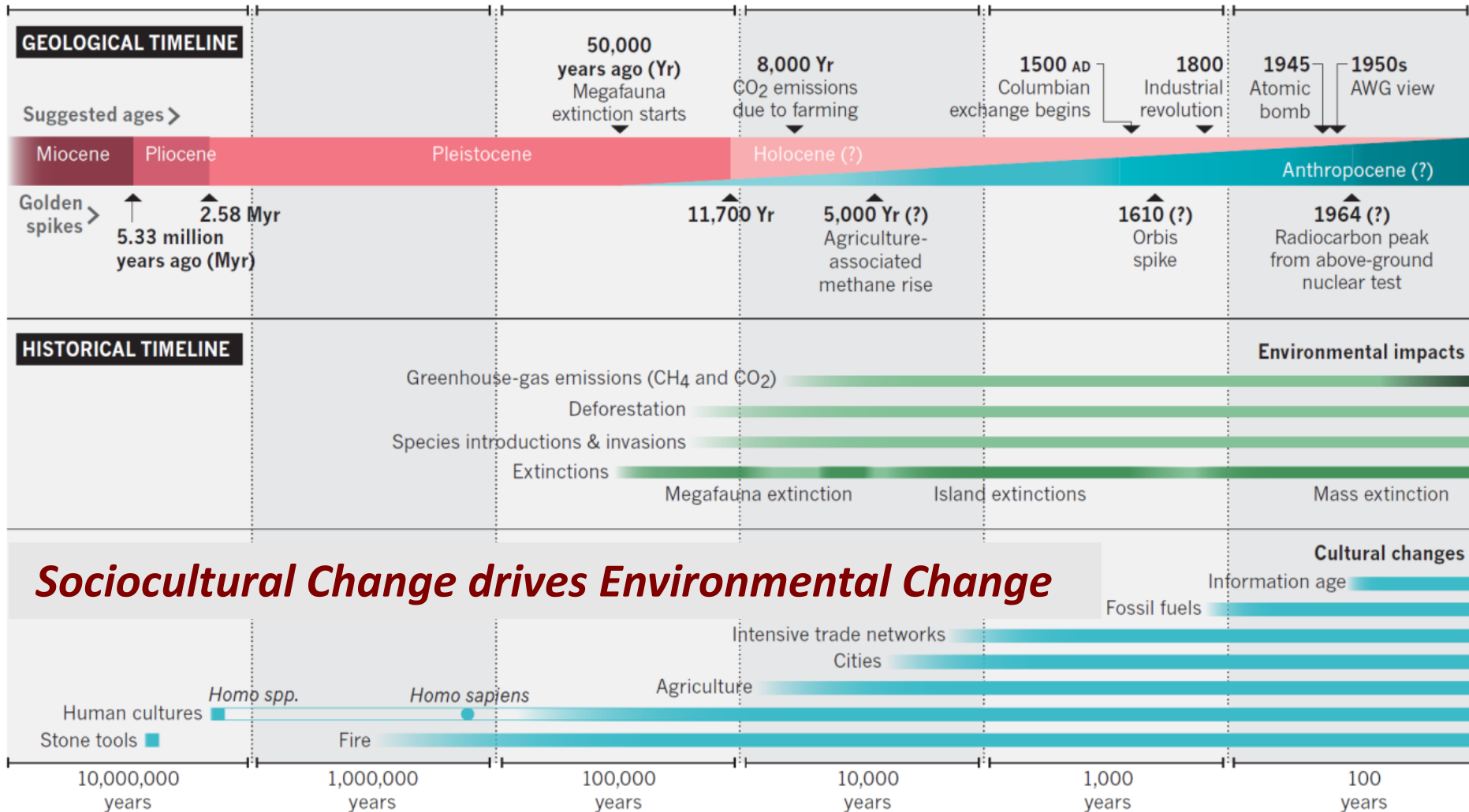
THE DEEP ROOTS OF THE ANTHROPOCENE

Human societies began altering Earth long ago. Human social and cultural capacities to alter its environmental processes have accumulated, scaled up and reinforced each other in complex and historically contingent ways. Defining an Anthropocene epoch should involve examining these transformative social-environmental changes, rather than solely focusing on globally instantaneous environmental transitions. 'Golden spikes' mark stratigraphic boundaries of geological time periods; '?' highlight recent boundary proposals.

nature

Ellis *et al.* 2016

Nature **540**:192-193



15,000 years ago

10,000

5,000

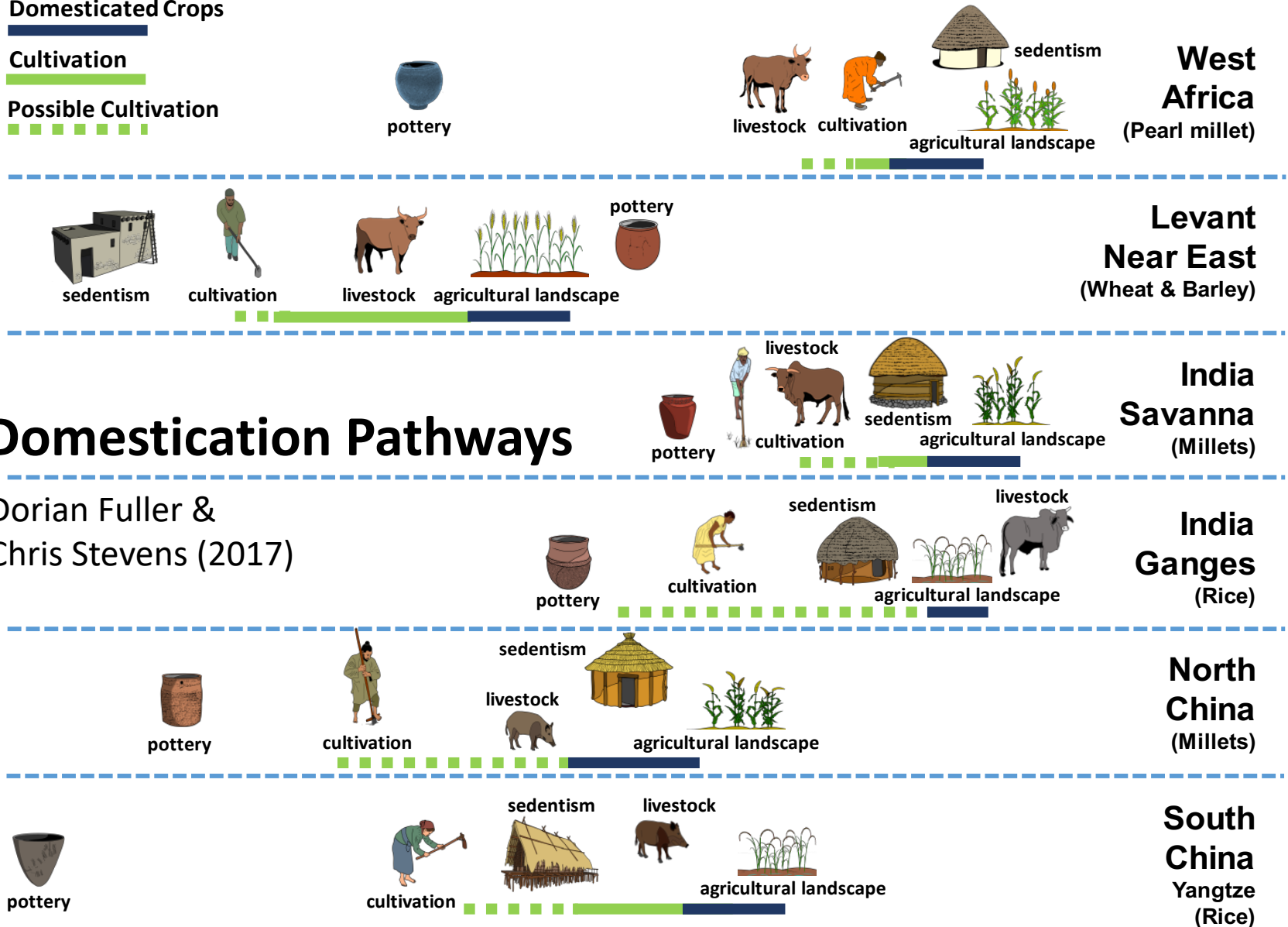
0

Present Day

Domesticated Crops

Cultivation

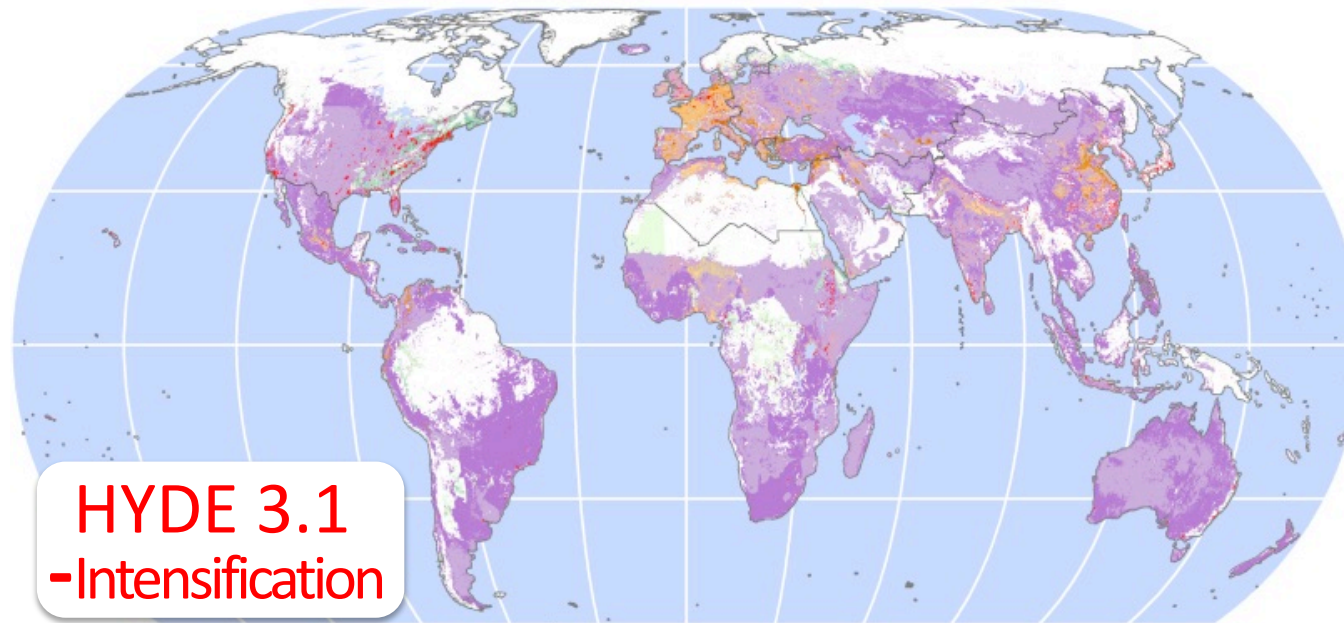
Possible Cultivation



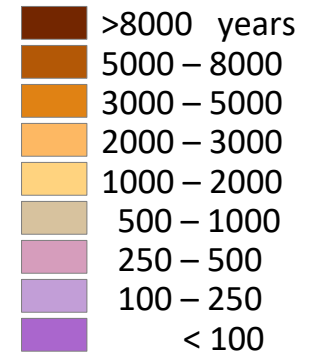
Domestication Pathways

Dorian Fuller &
Chris Stevens (2017)

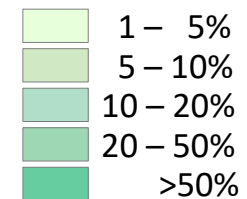
A Tale of Two Planets: Two different models of global land use history



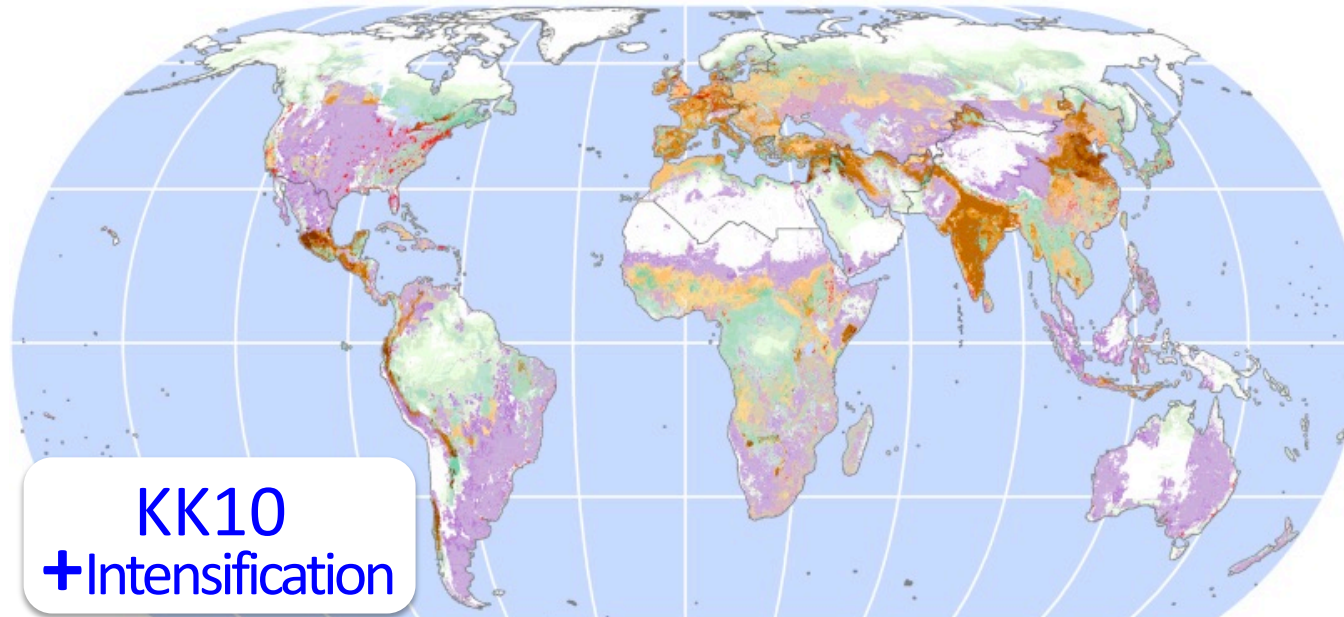
Period of first Significant Use



Recovery (% from peak use)



Dense Settlements



Ellis *et al.* 2013 *PNAS*
Used Planet: A Global History
doi:10.1073/pnas.1217241110

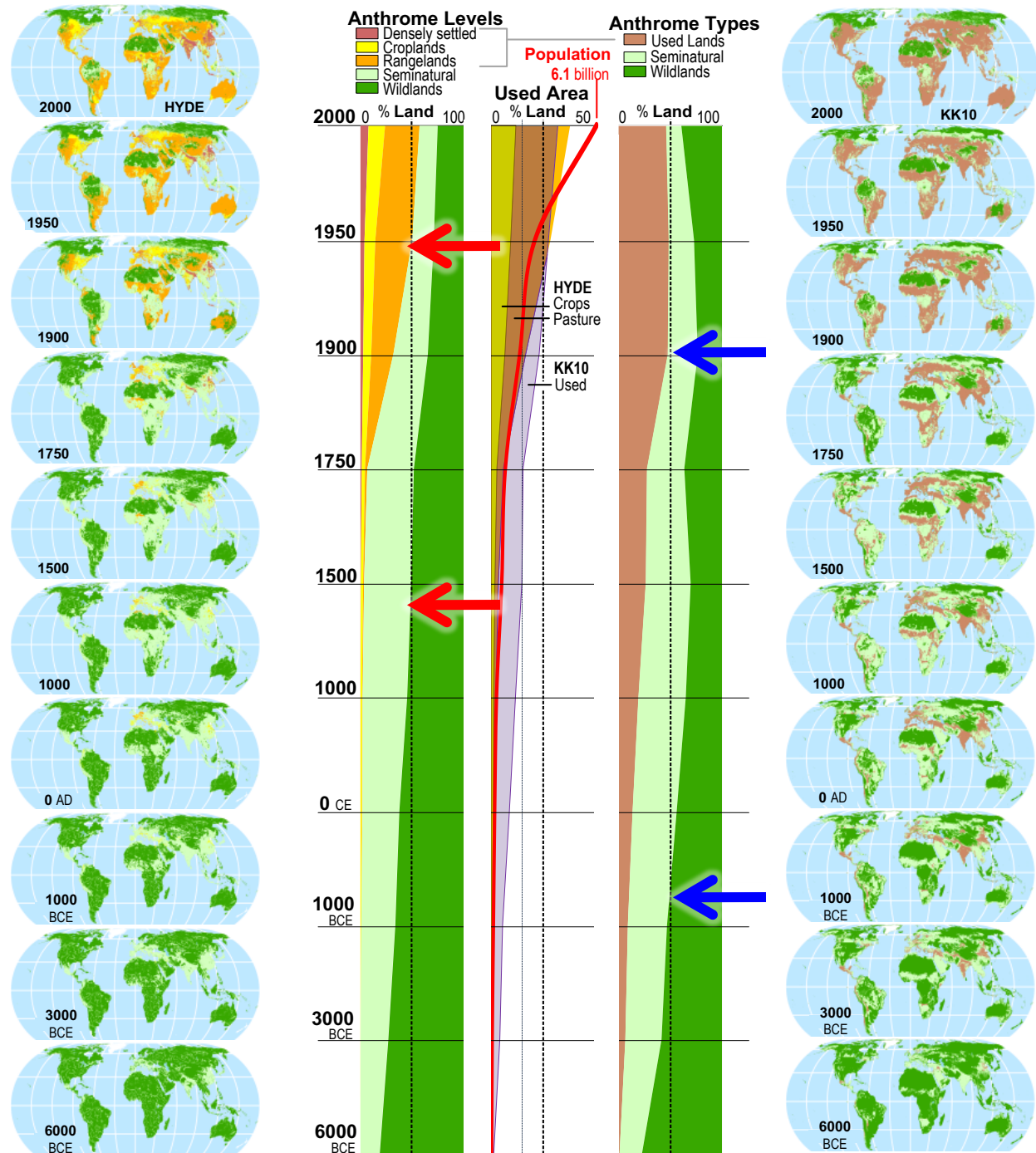
Anthropocene Transition

Land use =
 $f(\text{population})$

HYDE *constant*

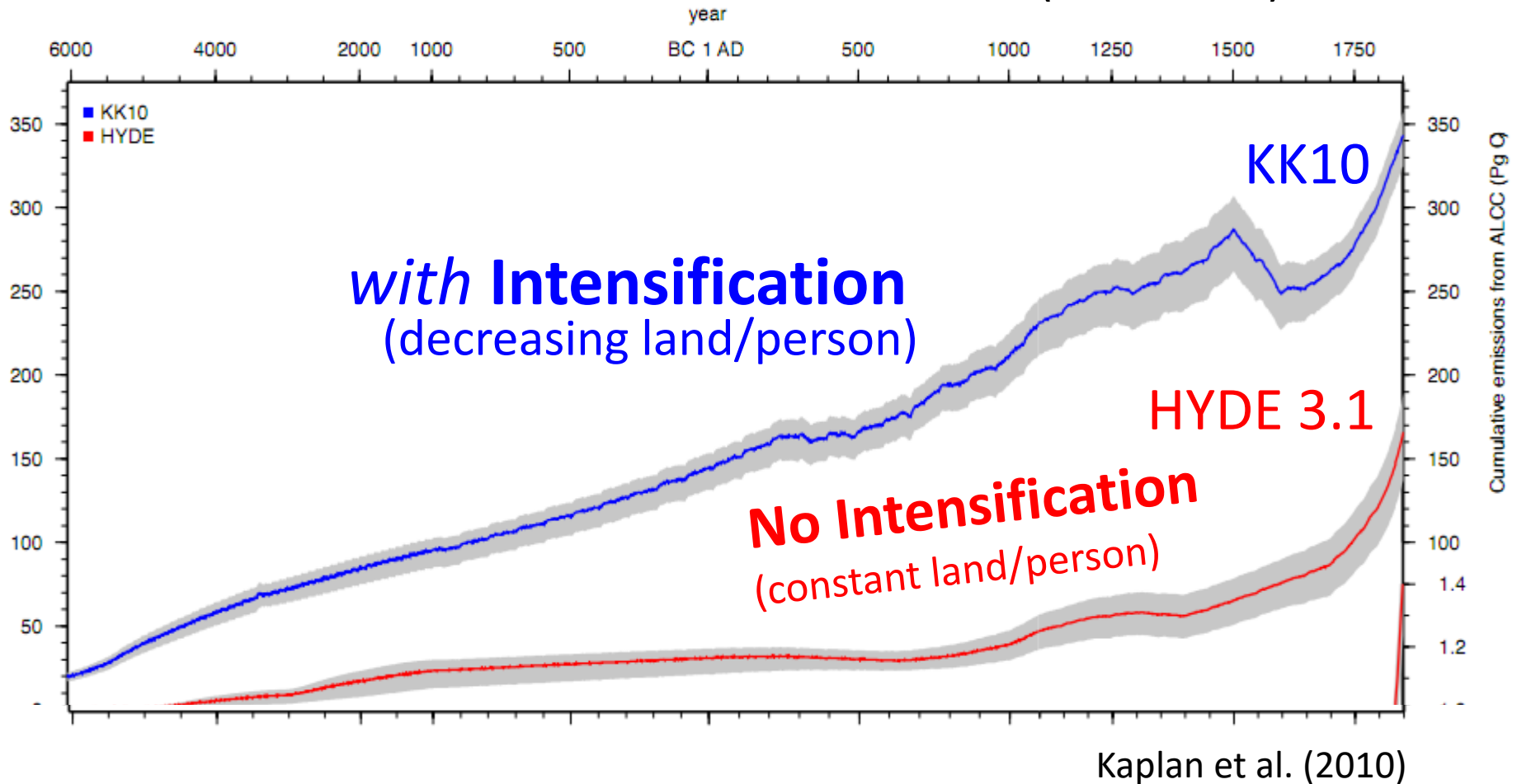
KK10 *empirical*

Ellis (2011)



Carbon Release from Agricultural Land Use

(6000 BP -)



Published online 25 March 2011 | Nature | doi:10.1038/news.2011.184

naturenews

The 8,000-year-old climate puzzle

Models bolster case for early human effect on greenhouse-gas levels.

19 SEPTEMBER 2003 VOL 301 SCIENCE www.sciencemag.org

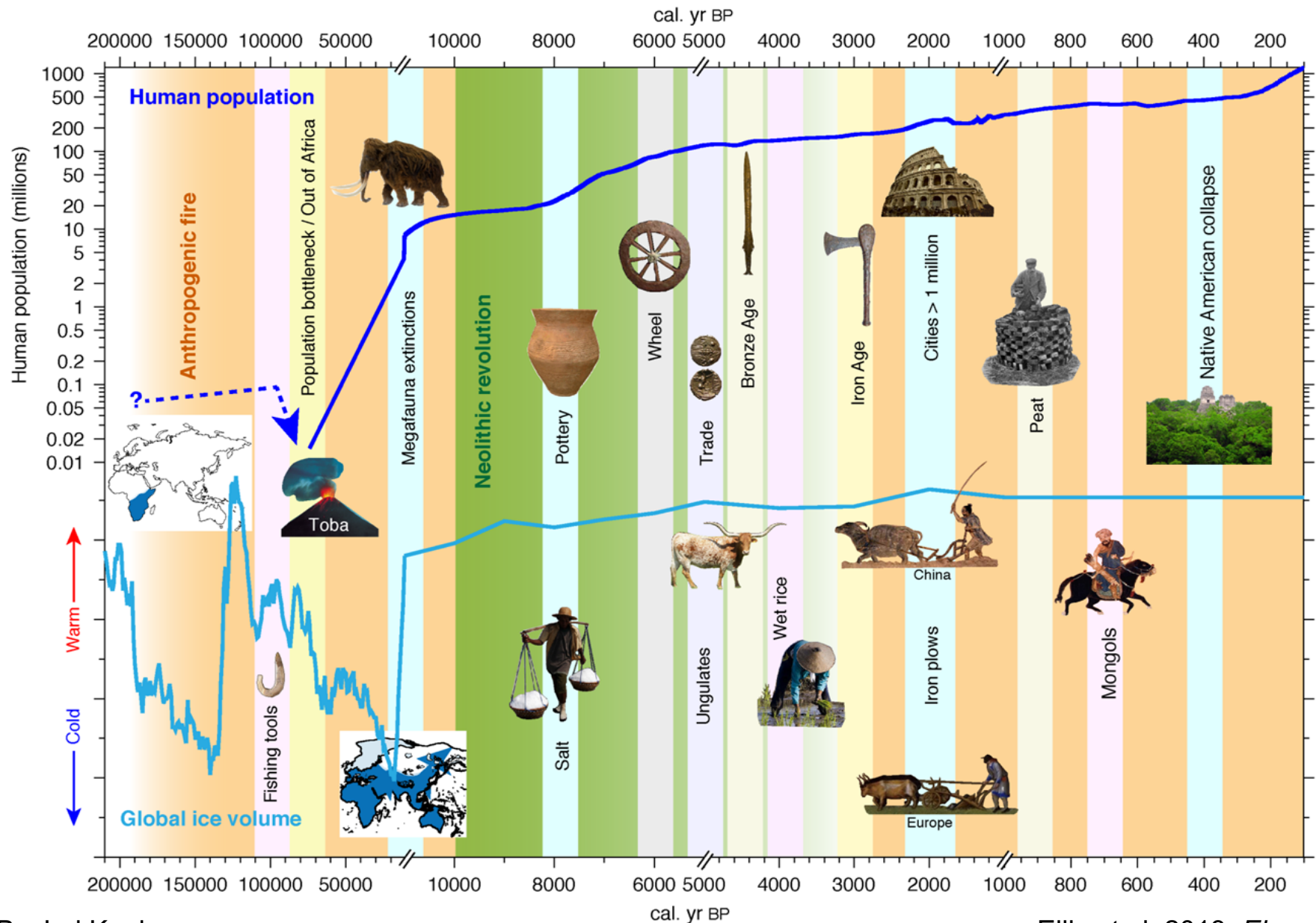
Amazonia 1492: Pristine Forest or Cultural Parkland?

Michael J. Heckenberger,^{1*} Afukaka Kuikuro,⁴
Urissapá Tabata Kuikuro,⁴ J. Christian Russell,²
Morgan Schmidt,³ Carlos Fausto,⁵ Bruna Franchetto⁵

Mann, C 2008 *Science*
321:1148

Squared off. The Fazenda
Atlântica geoglyph in Acre
is 250 meters on a side.

Can the **Anthropocene** be Dated Empirically?

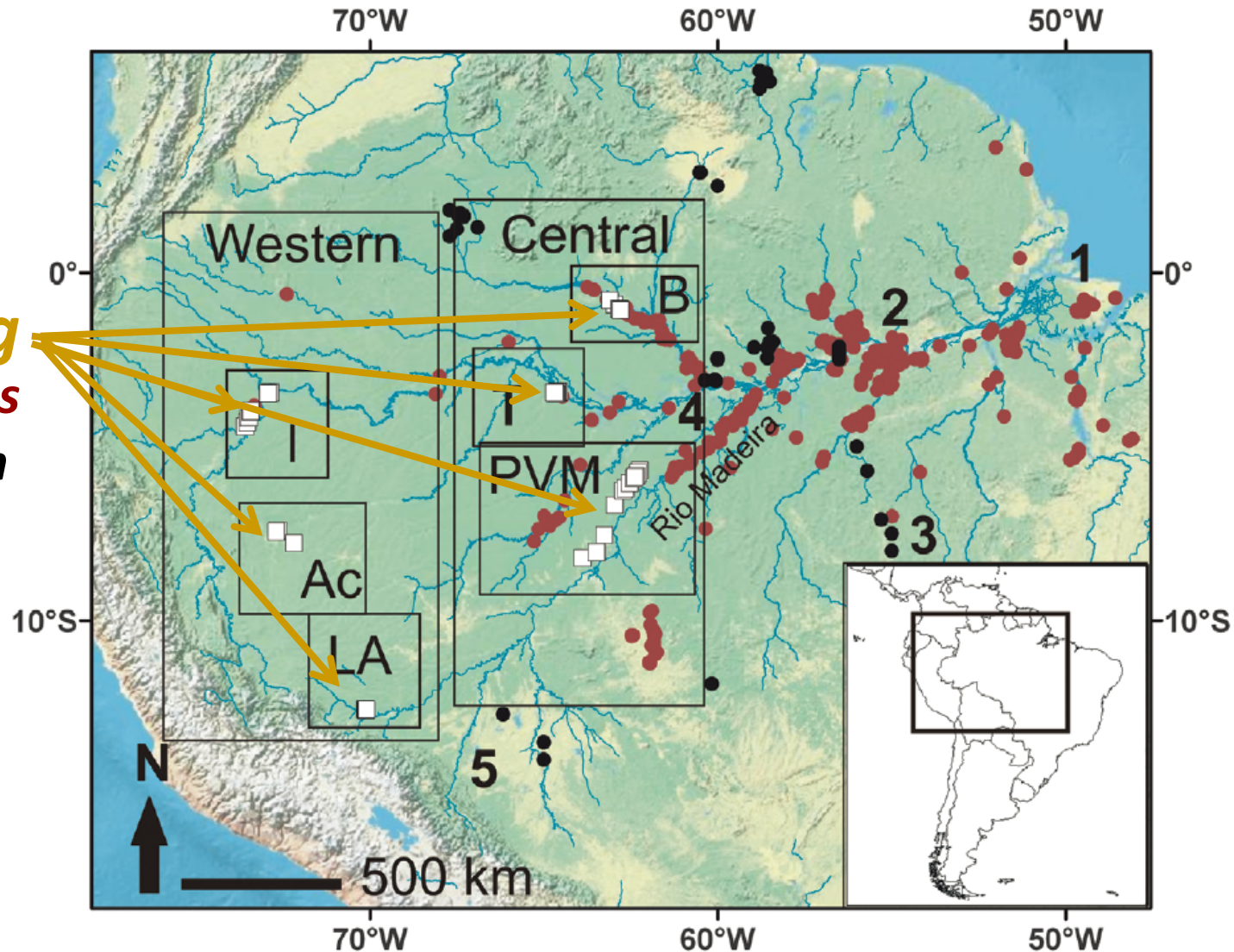


Sparse Pre-Columbian Human Habitation in Western Amazonia

C. H. McMichael,^{1*} D. R. Piperno,² M. B. Bush,¹ M. R. Silman,³ A. R. Zimmerman,⁴
M. F. Raczka,¹ L. C. Lobato⁵

www.sciencemag.org SCIENCE VOL 336 15 JUNE 2012

**Overcoming
Geographic Bias
in Site Selection**



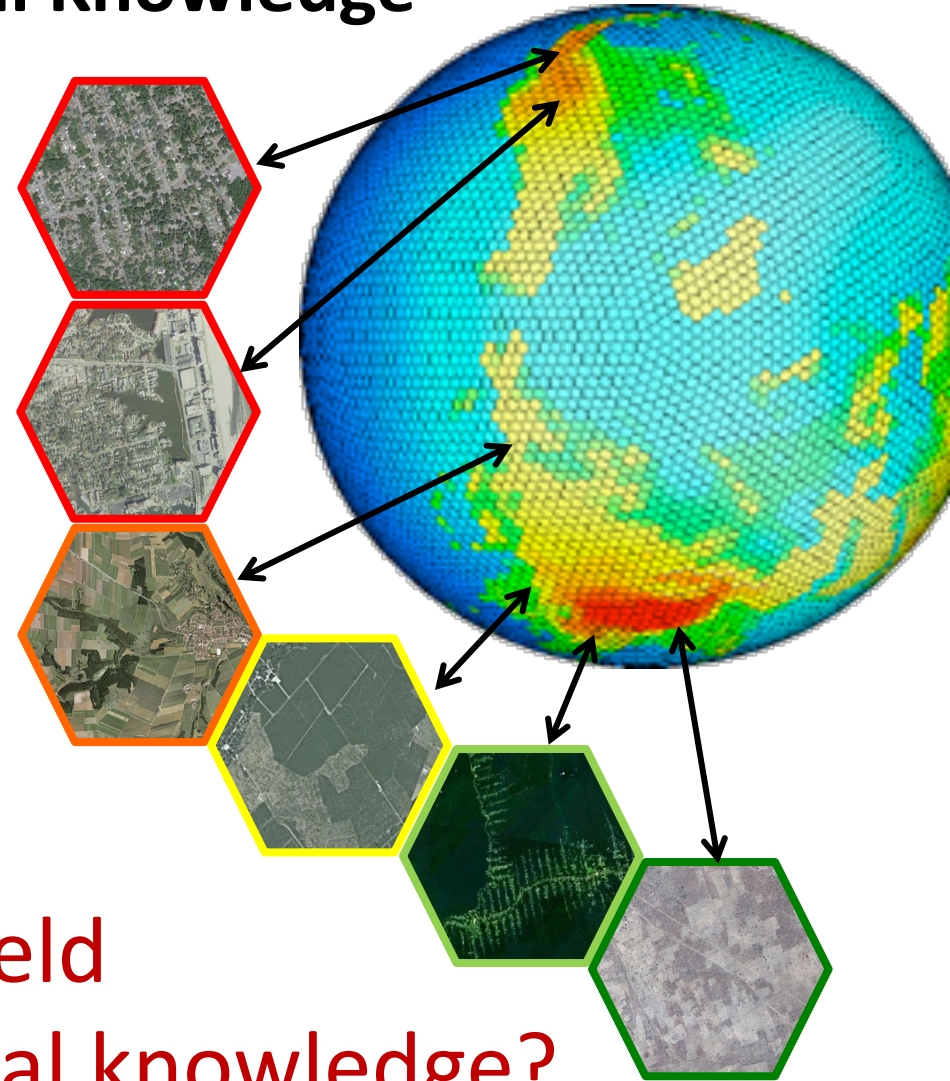
From Local Studies to Global Knowledge

**What is the Global Context
of Local Sites?**

Are there Sampling Biases?
How to correct them?

The Challenge:

**Can biased sampling yield
statistically robust global knowledge?**



Online Tools for Global Synthesis of Local Knowledge

Cyber-Enabled Discovery & Innovation
NSF #1125210: 2011 – 2016 (\$1.9M)

globe.umbc.edu



Go To... Send us Feedback

Representativeness Analysis for a GLOBE Collection

← View Collection

Switch Collection

Deforestation

Cases found by searching for "deforestation" on March 21, 2014

Analysis Parameters

Land Variable

Market Access Index ? [Change](#) | [Show distribution](#)

Filters (1)

Filters limit the land area used in analysis.

Add a filter predefined by the GLOBE team:

[Ice-Free Land ?](#) | [Tropical ?](#) | [Non-Wildlands ?](#)

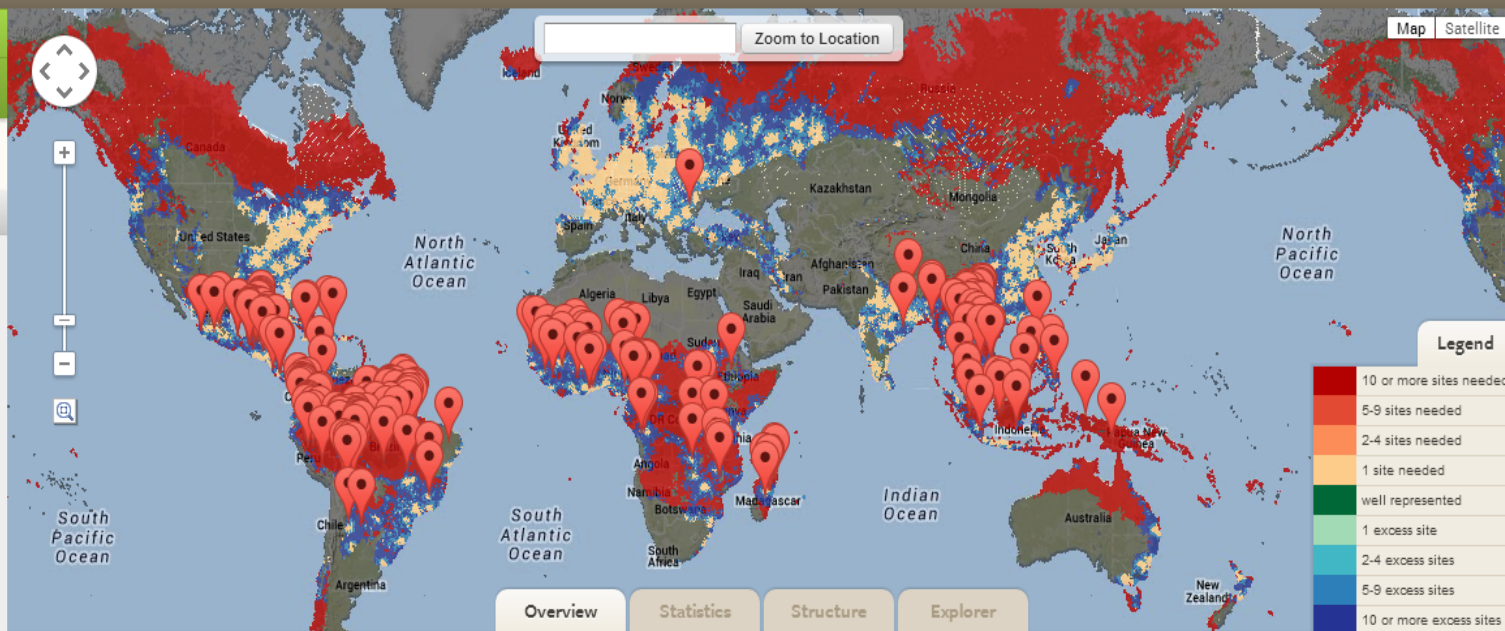
or Add a new filter

Olson Biomes ?

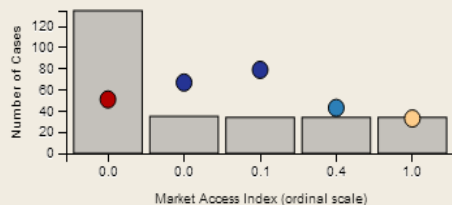
6 categories

Options

Cases In Collection



Overlaid Histogram



Overview

Statistics

Structure

Explorer

Summary

X² Test

X ² (ess)	142.502
p value (ess)	0
X ² (actual)	142.502
p value (actual)	0

Allocation Analysis

Explanation

The representativeness analysis compares observed data at your collection's sites against the distribution of those data for the global extent you have selected. Gaps between the two distributions indicate areas where your collection may be biased.

A X² analysis is a statistical test that compares a discrete distribution of expected values against a distribution of observed values to determine whether the hypothesis that the observed values could have been drawn at random from the population can be rejected or not. The X² test computes the probability of incorrectly rejecting the hypothesis of an unbiased collection as

A Global Assessment of Archaeological Land Use Knowledge

"Massively Collaborative" Global Assessment of Regional Land Use for 10 Time Slices



10 Time Slices, 10,000 BP to 1850

146 Global Analytical Units

255 Contributing Archaeologists

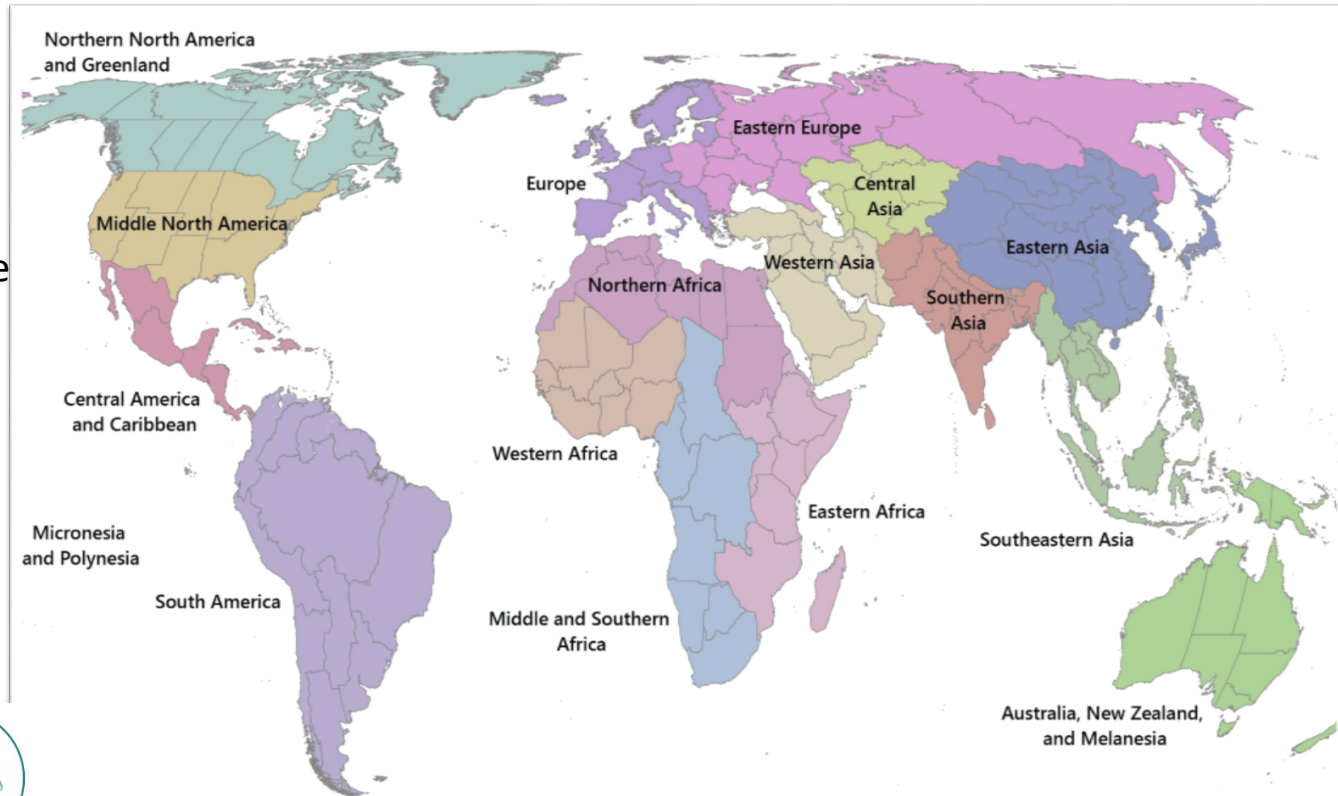
Contributions solicited May to June 2018

120 Authors

Lucas Stephens,
Dorian Fuller,
Torben Rick,
Nicole Boivin,
Nick Gauthier
Andrea Kay
Ben Marwick.... many more
Erle Ellis



MAX-PLANCK-GESELLSCHAFT

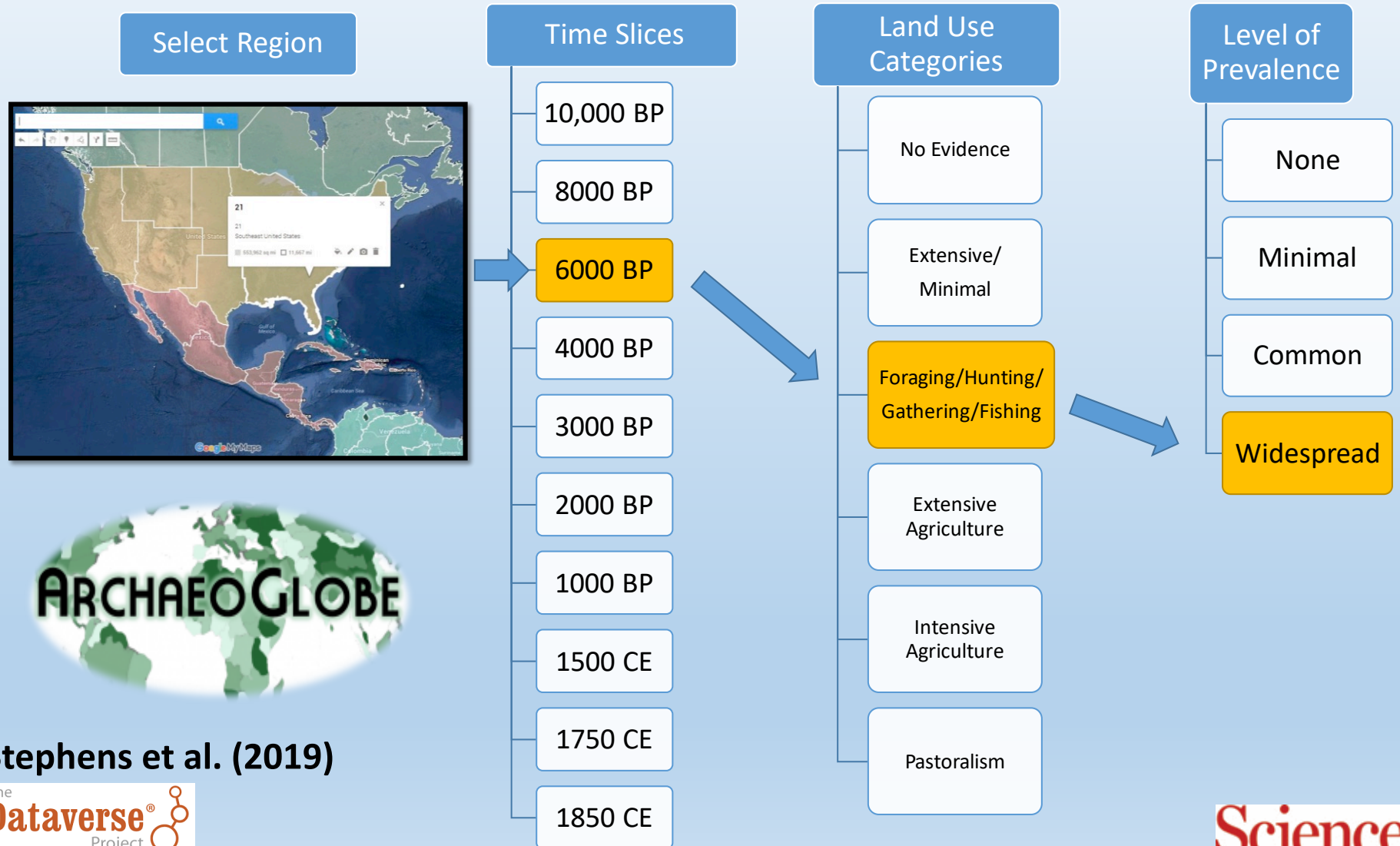


<http://globe.umbc.edu/archaeology>



A Global Assessment of Archaeological Land Use Knowledge

An Online Regional Land Use Survey for 10 Time Slices



Stephens et al. (2019)

The
Dataverse[®]
Project

<http://globe.umbc.edu/archaeoglobe/>

Science
AAAS



<http://globe.umbc.edu/archaeoglobe/>

[ArchaeoGLOBE Dataverse](#) (University of Maryland, Baltimore County)

A massively collaborative assessment of global land use from 10,000bp to 1850

[Harvard Dataverse](#) > **ArchaeoGLOBE Dataverse**

[Contact](#) [Share](#)

The ArchaeoGlobe Project assessed archaeological knowledge on human land use across the globe over the past 10,000 years through the expert knowledge contributions of more than 200 archaeologists provided through a questionnaire between May 18 and June 30, 2018. Regional land use across 146 regions was assessed at 10 distinct time points (10,000 bp, 8,000 bp, 6,000 bp, 4,000 bp, 3,000 bp, 2,000 bp, 1,000 bp, 1500 CE, 1750 CE, 1850 CE). Data were obtained for four land use categories: Foraging/hunting/gathering/fishing, Extensive agriculture Intensive agriculture, and Pastoralism.

Search this dataverse...

Find

[Advanced Search](#)

☒ **Dataverses (0)**

☒ **Datasets (3)**

☐ **Files (54)**

Publication Year

2019 (2)

2018 (1)

Subject

Earth and Environmental Sciences (3)

Social Sciences (3)

Author Name

[ArchaeoGLOBE Project \(3\)](#)

1 to 3 of 3 Results

Sort ▾

ArchaeoGLOBE Repository

Feb 13, 2019



ArchaeoGLOBE Project, 2019, "ArchaeoGLOBE Repository", <https://doi.org/10.7910/DVN/6ZXAGT>, Harvard Dataverse, V1

Repository containing entire R code used for all the analysis and visualizations contained in the paper "Archaeological assessment reveals Earth's early transformation through land use."

ArchaeoGLOBE Public Data

Feb 7, 2019

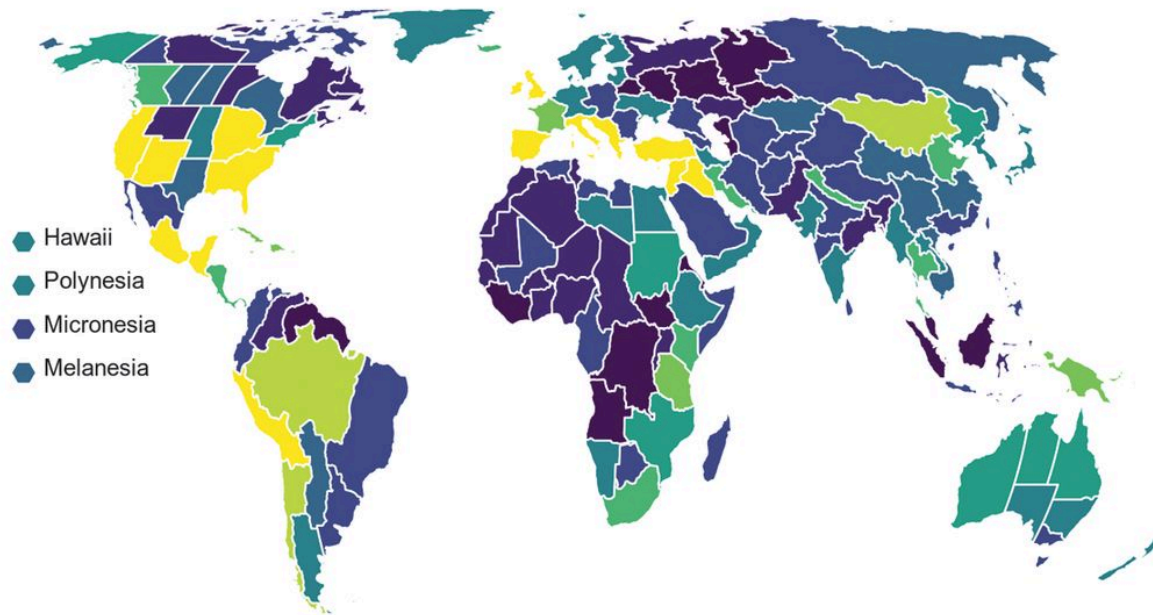


ArchaeoGLOBE Project, 2019, "ArchaeoGLOBE Public Data", <https://doi.org/10.7910/DVN/CNCANQ>, Harvard Dataverse, V2, UNF:6:L0BzYkQiUnGoi8qNAf/3uA== [fileUNF]

This dataset contains responses to the ArchaeoGLOBE land use questionnaire collected between May 18 and July 31, summary tables including consensus assessments, and supplementary figures. All personal and identifying information has been removed.

Fig. 1 Archaeological knowledge contributions.

A



Contributors 2 4 6 8 10+

B

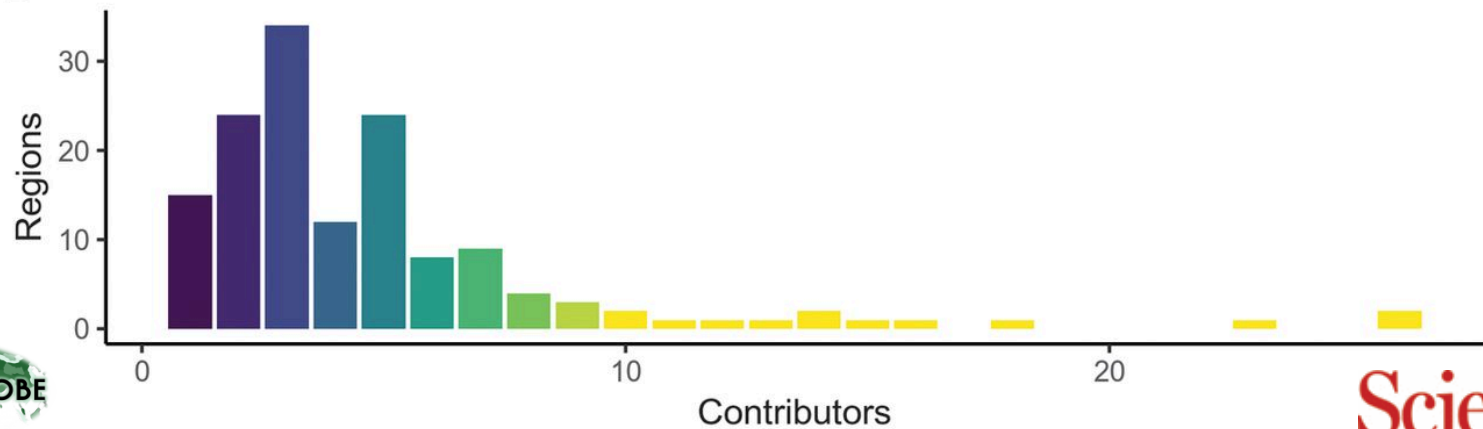
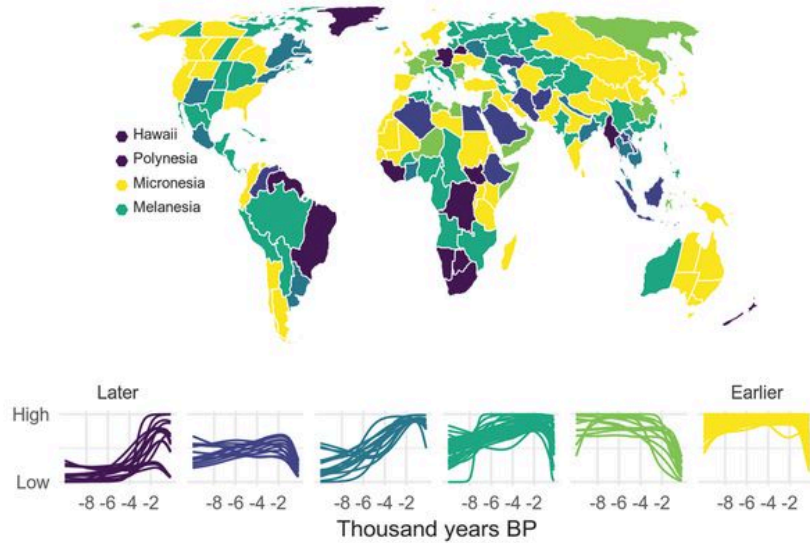


Fig. 2 Archaeological expertise, data quality & published excavations.

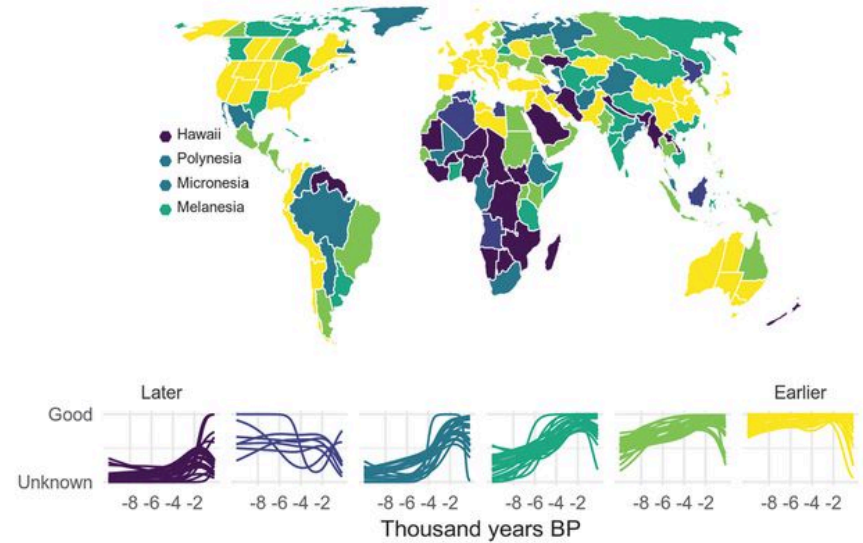
A

Expertise

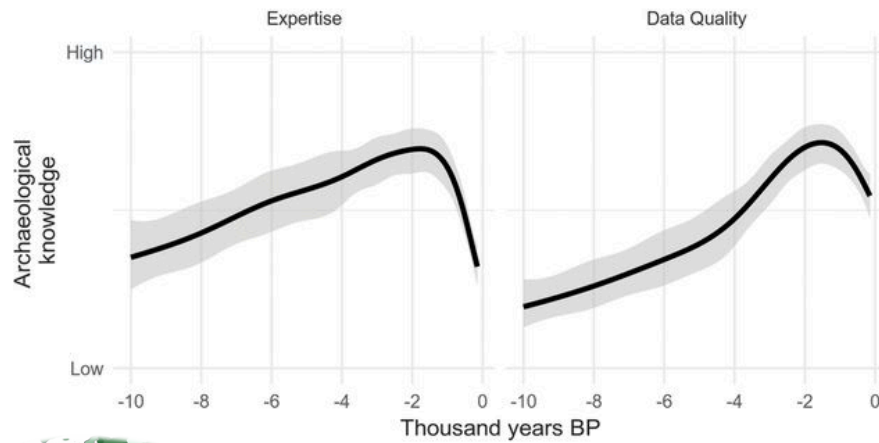


B

Data Quality



C



D

Published Excavations

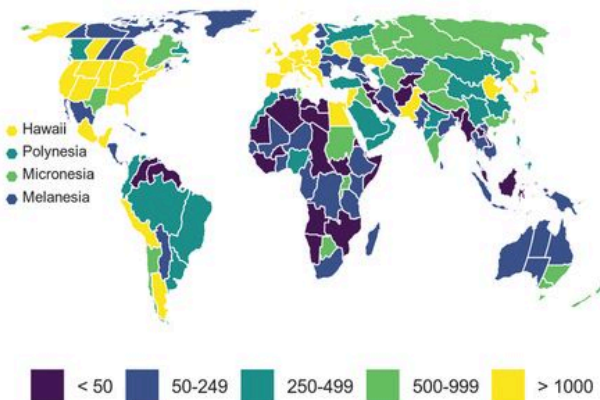
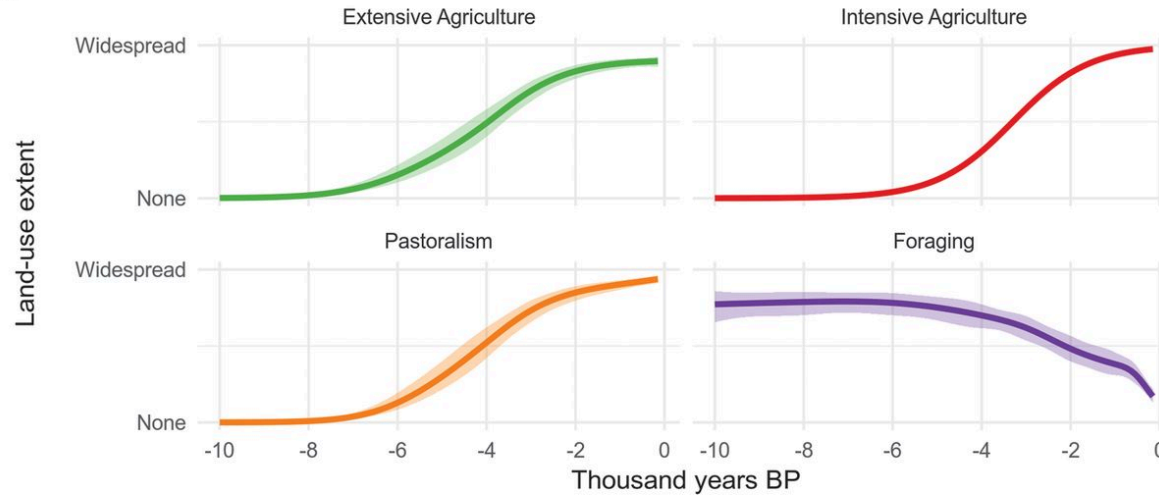


Fig. 3 Summary of global land-use trends.

A



B

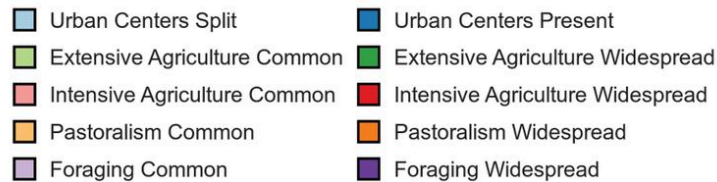
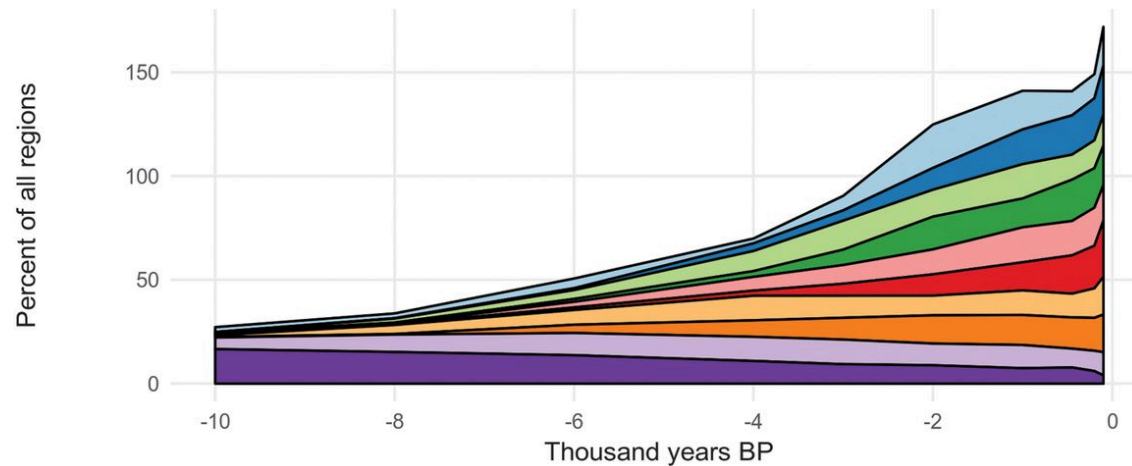
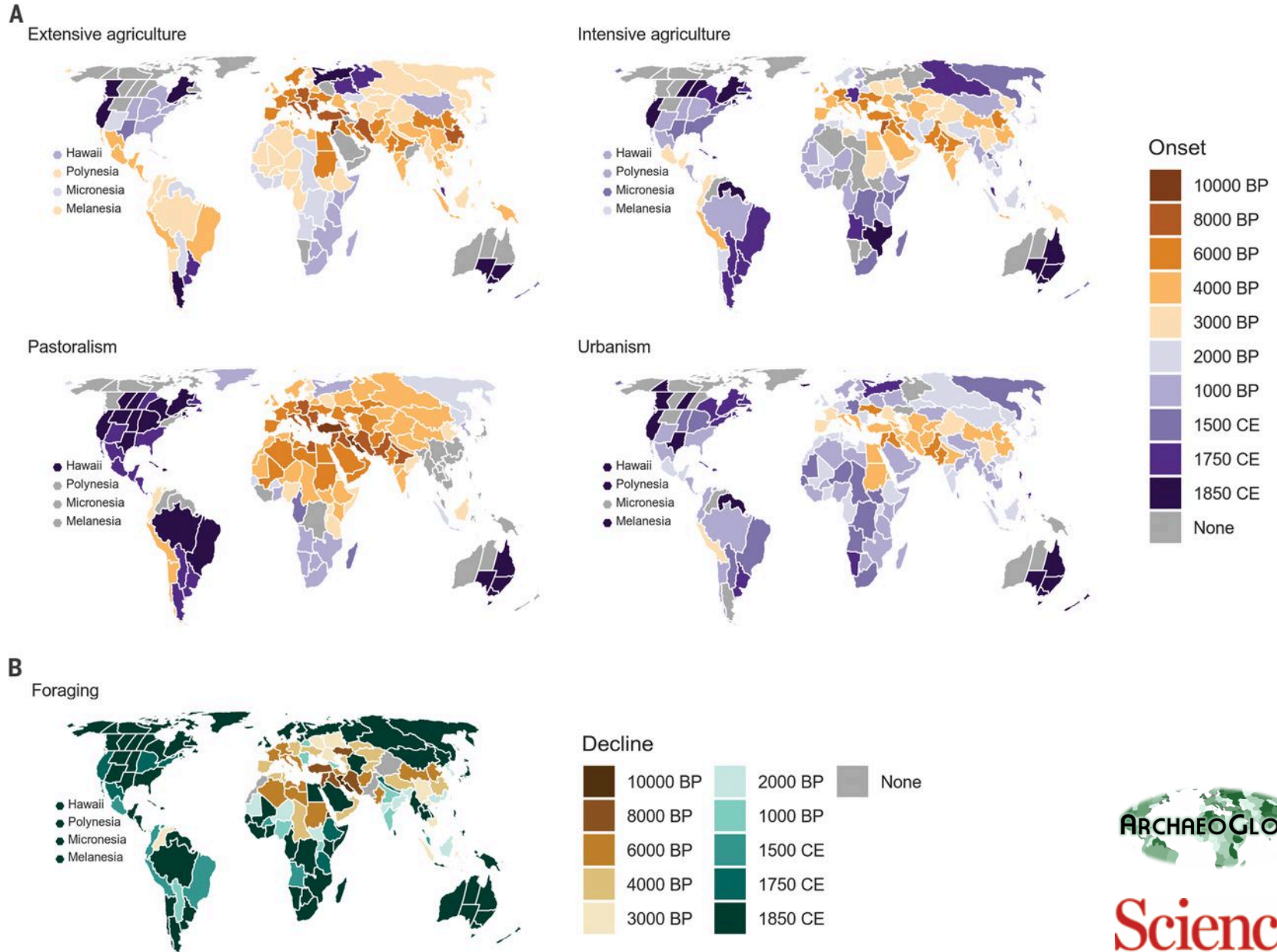


Fig. 4 Regional onsets of land-use categories and decline of foraging.

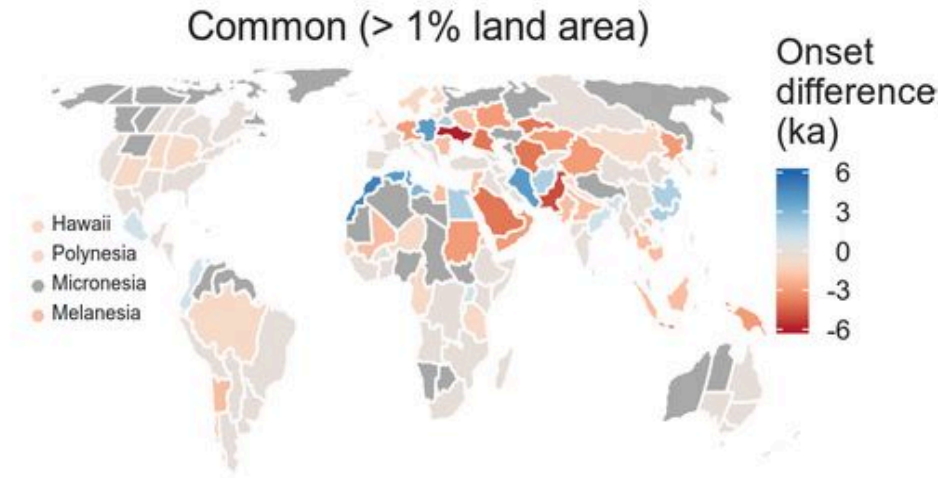


ARCHAEOGLOBE

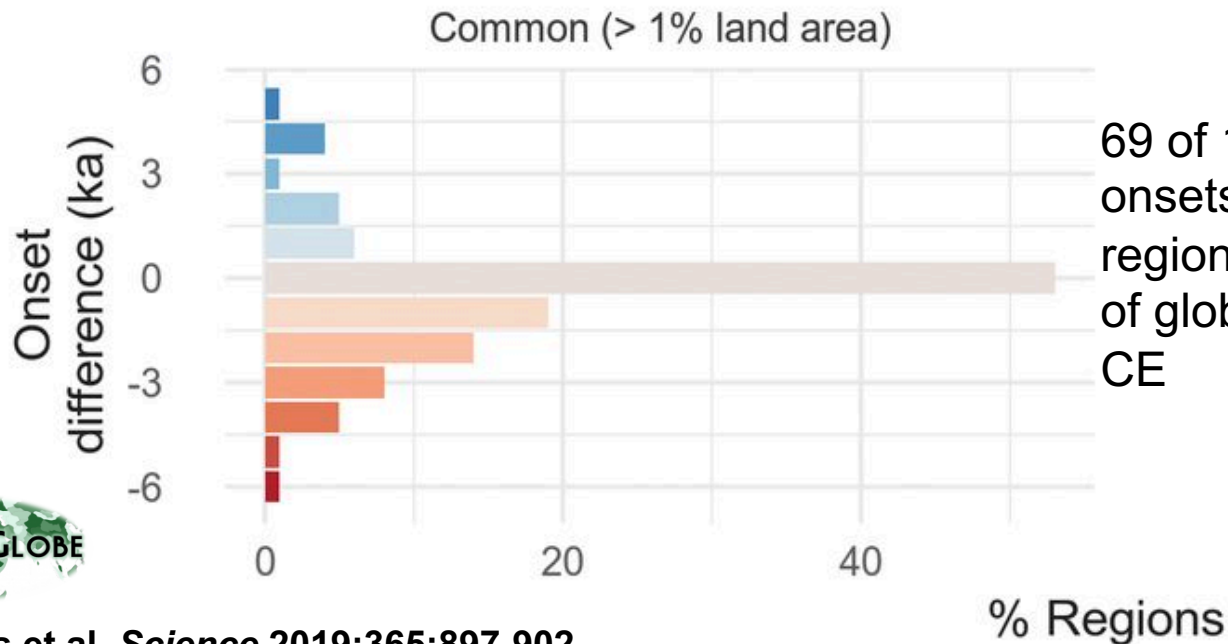
Science
AAAS

Fig. 5 Comparisons of agricultural onset in ArchaeoGLOBE vs HYDE.

B



C



69 of 130 ArchaeoGLOBE onsets were earlier, in regions encompassing 54% of global crop area at 2000 CE



Archaeological assessment reveals Earth's early transformation through land use

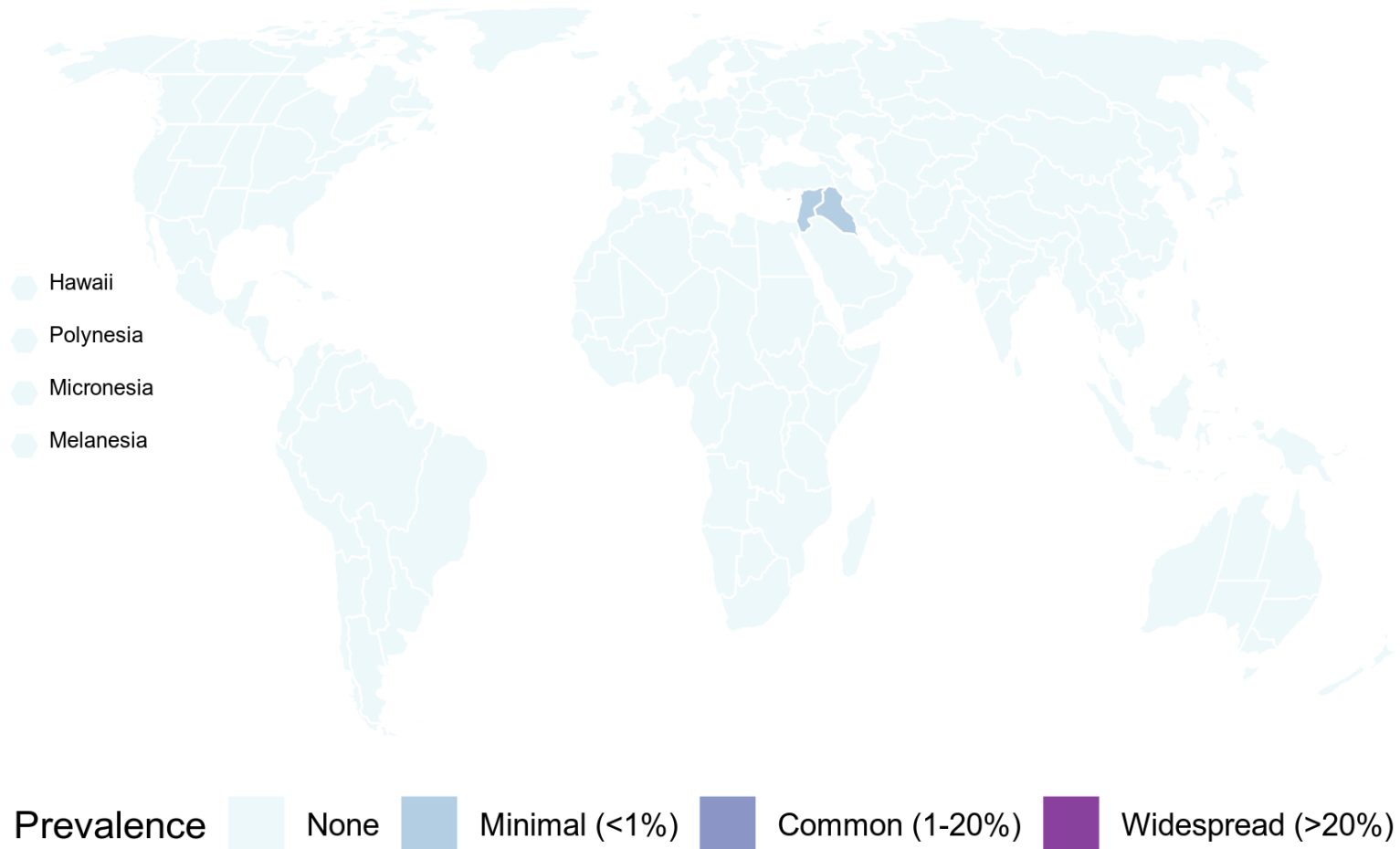
ArchaeoGLOBE Project*†

Stephens et al. 2019
Science 365:897-902

Science
AAAS

Intensive Agriculture 10000 years ago

Animation by Nicolas Gauthier



Archaeological assessment reveals Earth's early transformation through land use

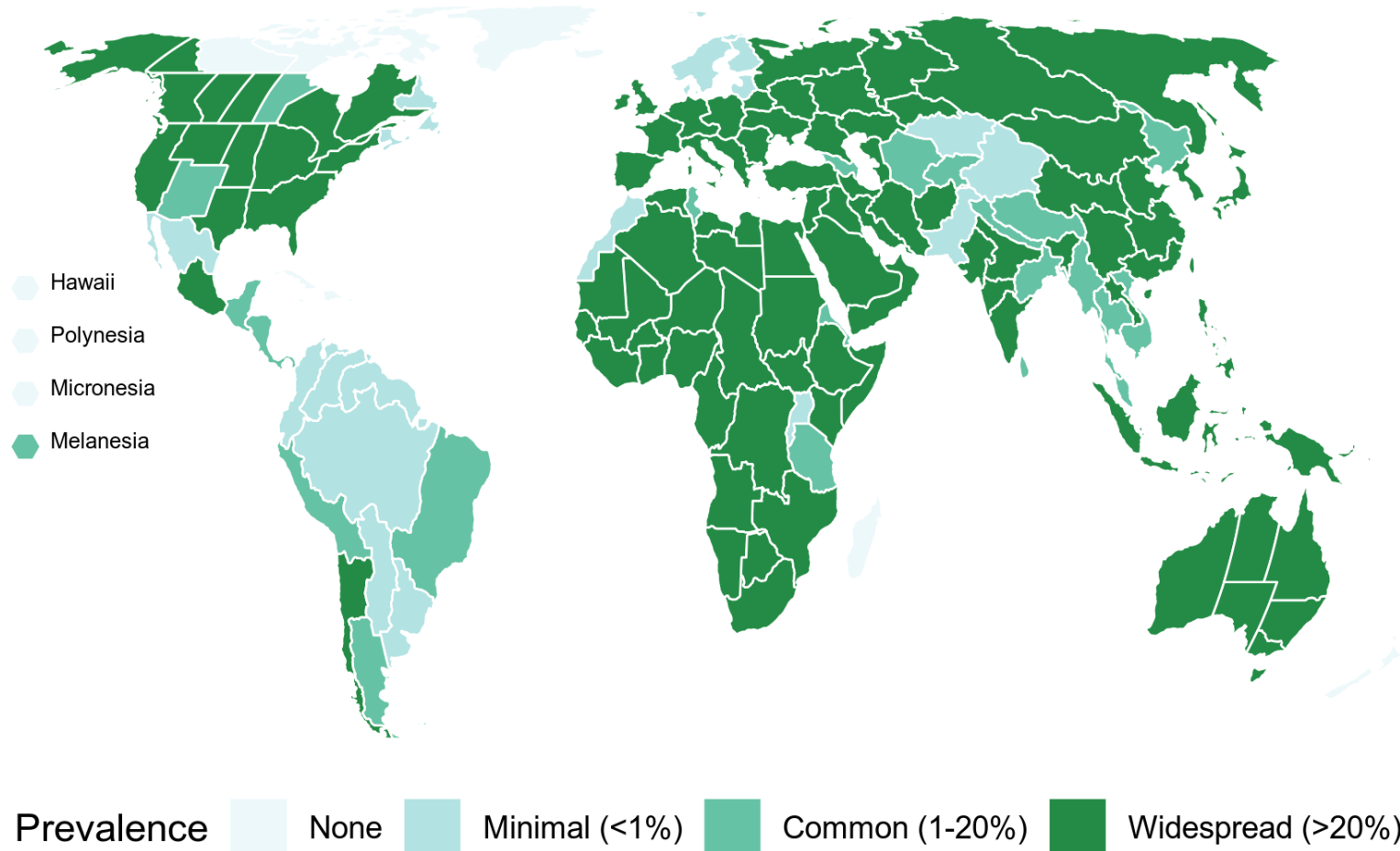
ArchaeoGLOBE Project*

Stephens et al. 2019
Science 365:897-902

Science
AAAS

Foraging/Hunting/Gathering 10000 years ago

Animation by Nicolas Gauthier







Global Assessment of Archaeological Land Use Knowledge

**Archaeologists confirm early global onset
of intensely transformative land use.**

What's Next?

A Global Assessment of Fire Management Regimes?

**Seek Funding to build a Collaborative
Global Land Use Mapping Cyberinfrastructure?**

A Global Archaeology of the Anthropocene

Collaborative Cyberinfrastructure for Anthropocene Dating

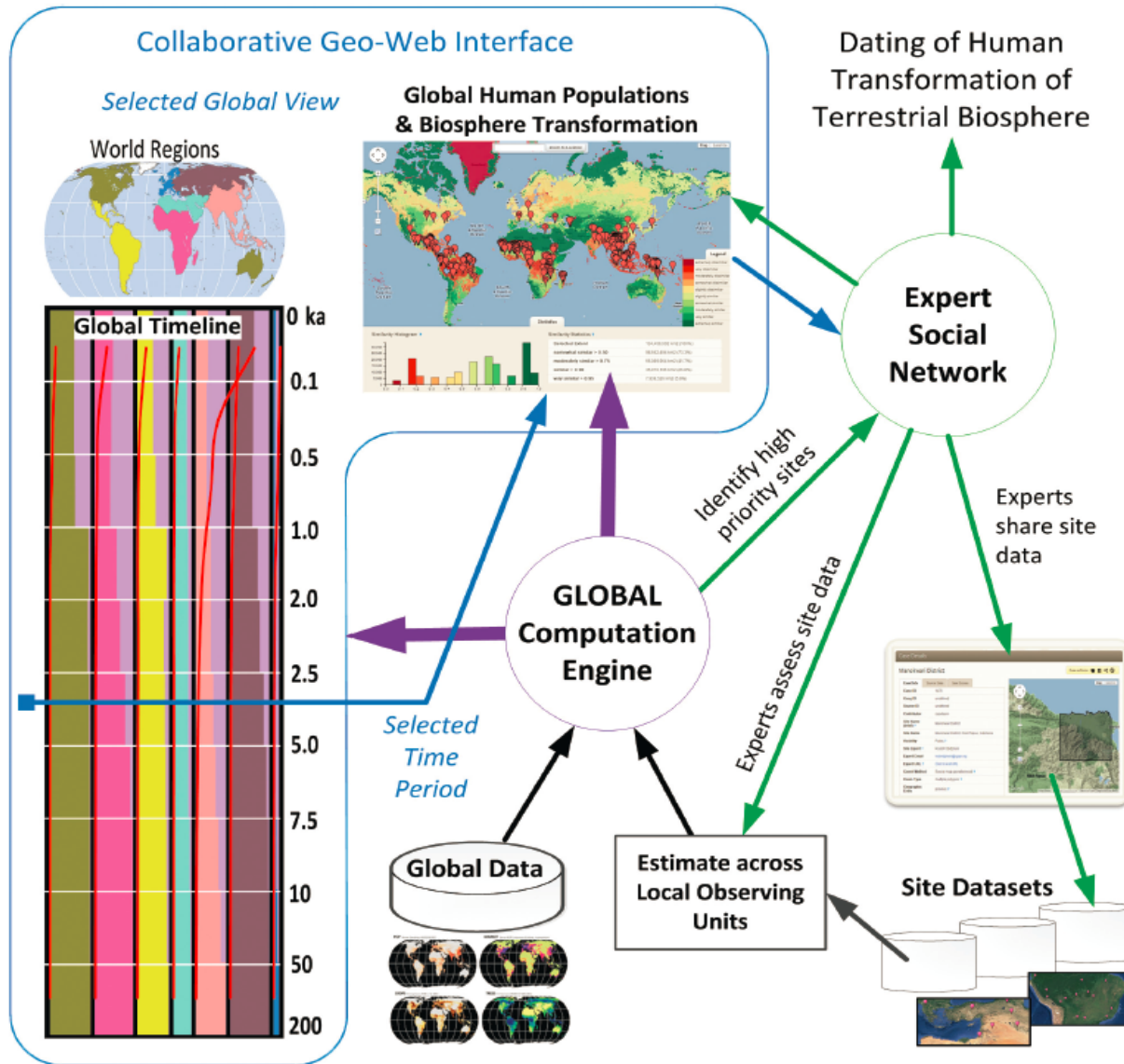


Figure 2

Conceptual design of online Anthropocene collaborative geo-cyberinfrastructure for dating human transformation of the terrestrial biosphere.

Site data are utilized to estimate human populations and ecosystem transformation across local observing units (eg. hexagonal global map tiles) and these are integrated globally to assess human transformation of the terrestrial biosphere using a global geo-temporal computation engine facilitating collaborations across social networks of experts.

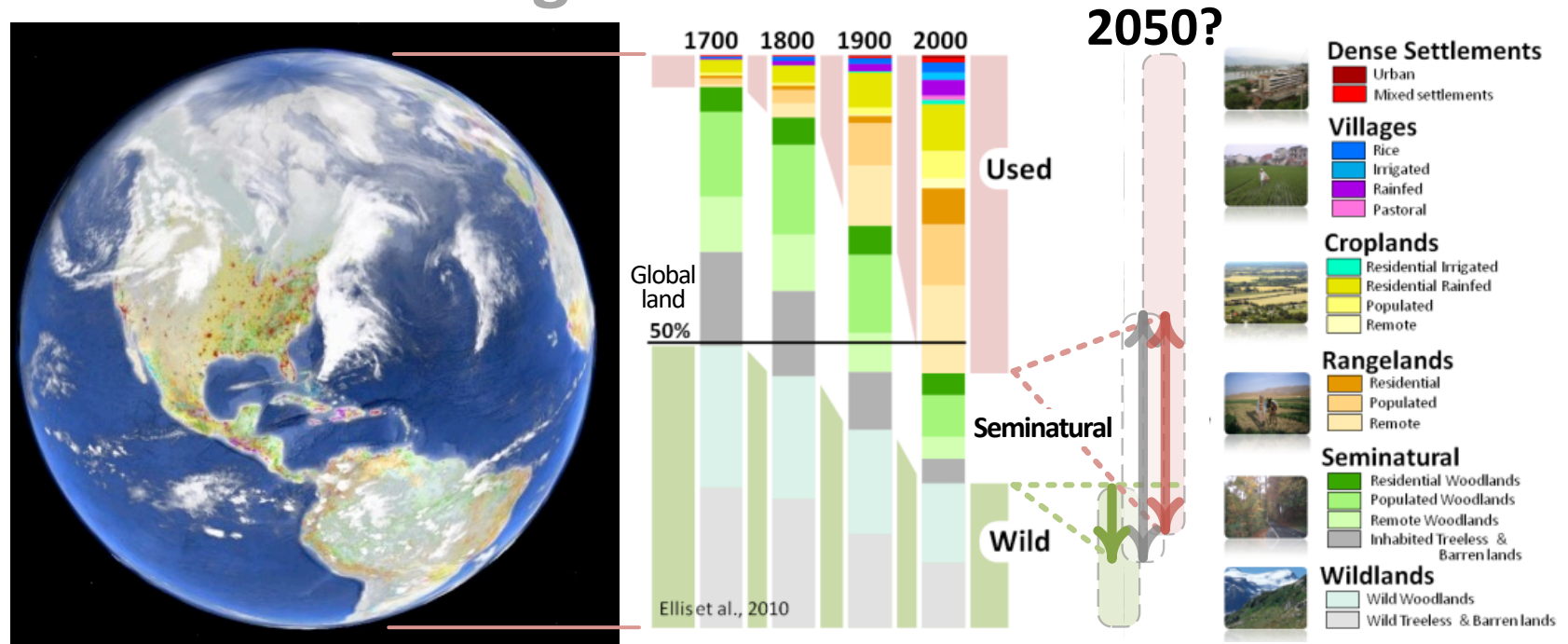
doi: 10.12952/journal.elementa.000018.f002

Ellis, Fuller,
Kaplan & Lutters.
2013. *Elementa*

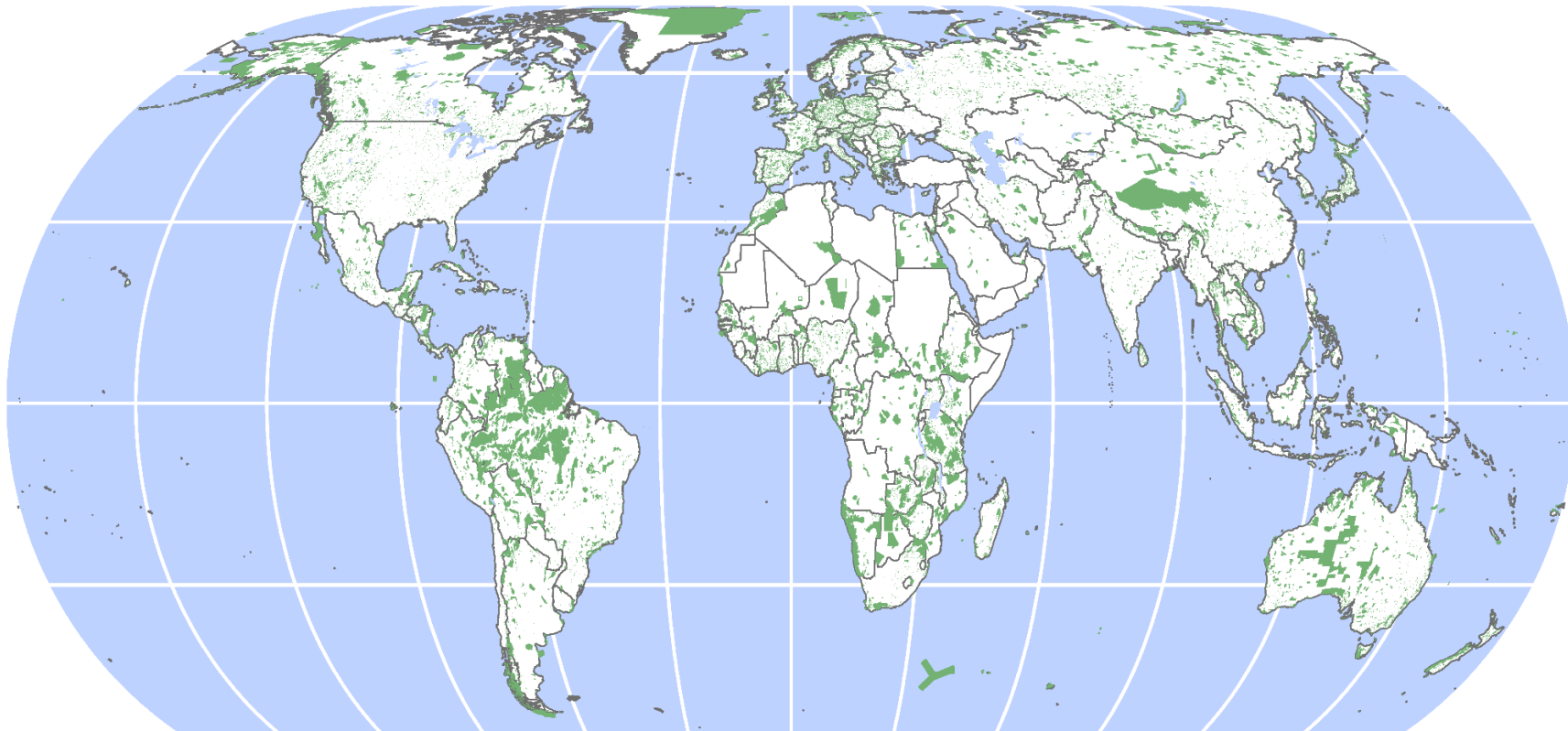
Earth Stewardship

What kind of biosphere do “we” want in 2050?

Anthrome Change Scenarios



Protected Lands | 2017



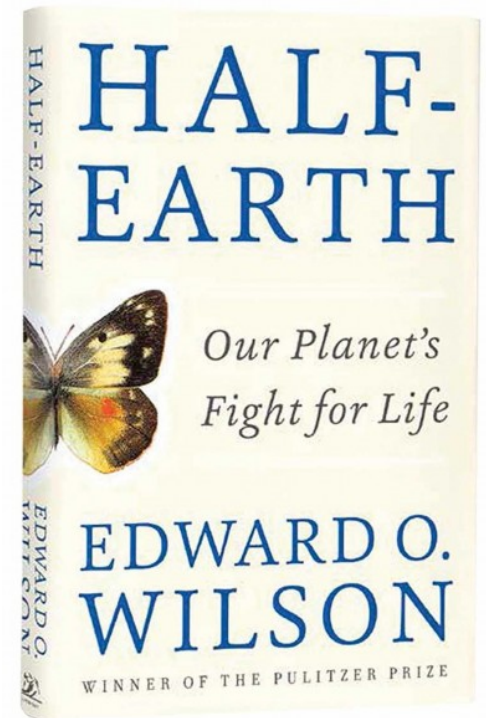
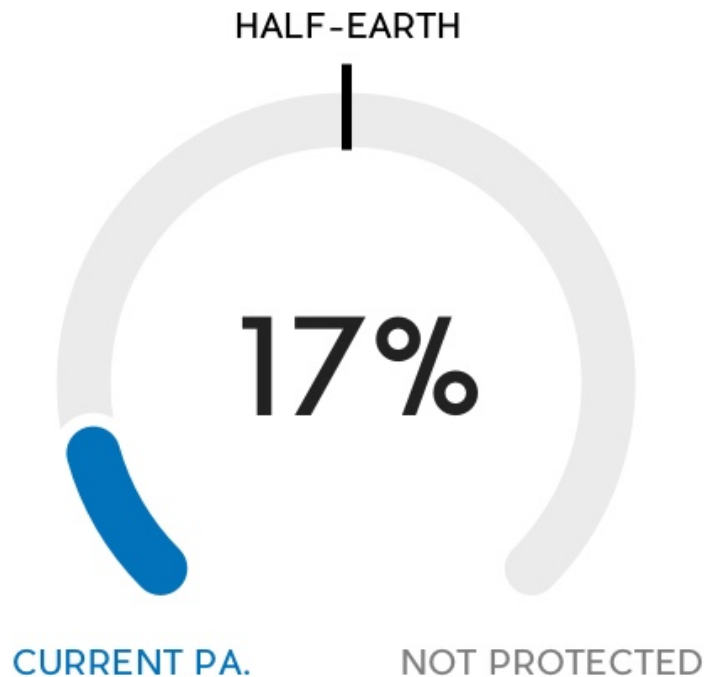
protected
planet

WDPA dataset June 2017

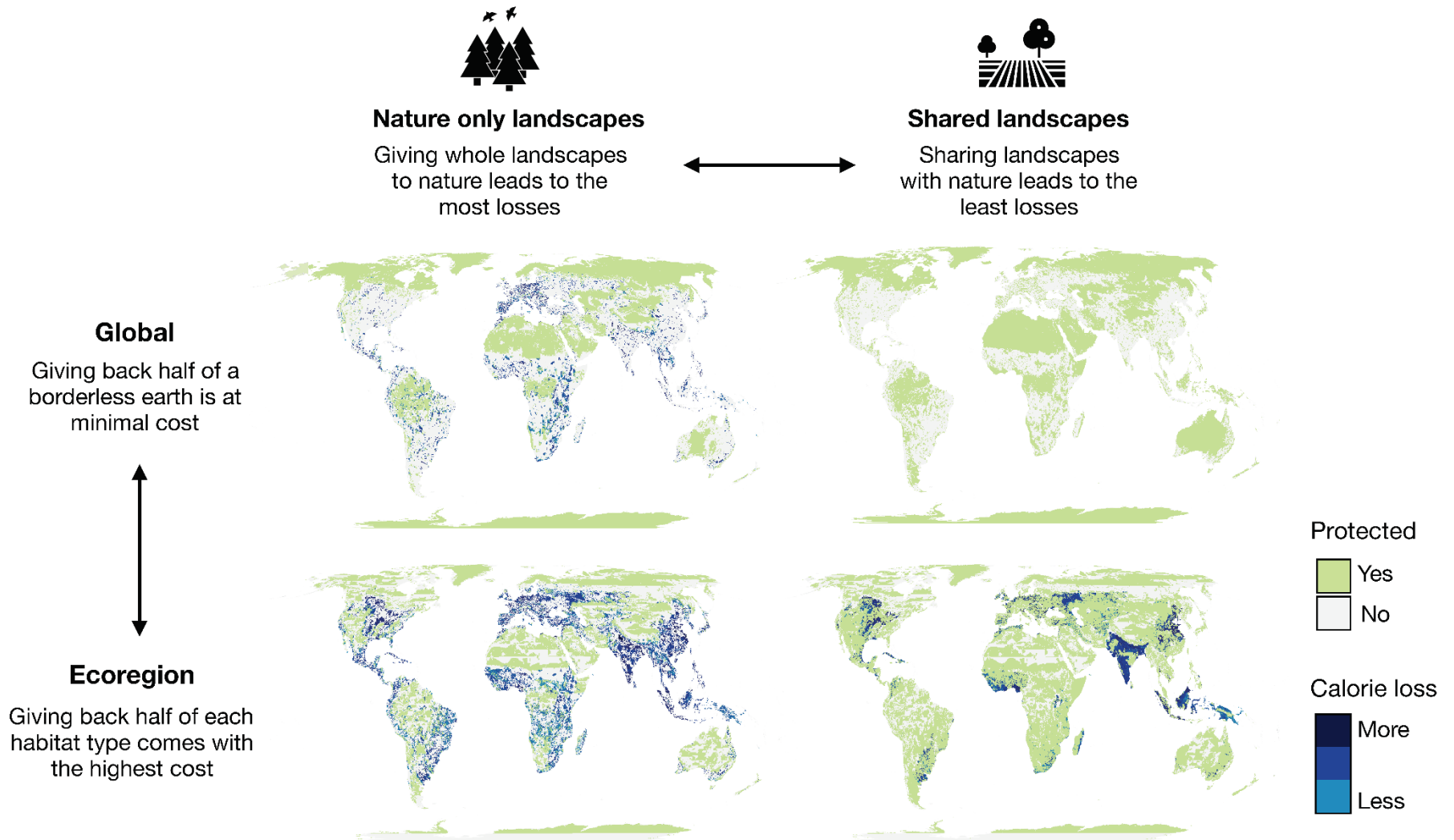
protectedplanet.net



half the earth for the rest of life

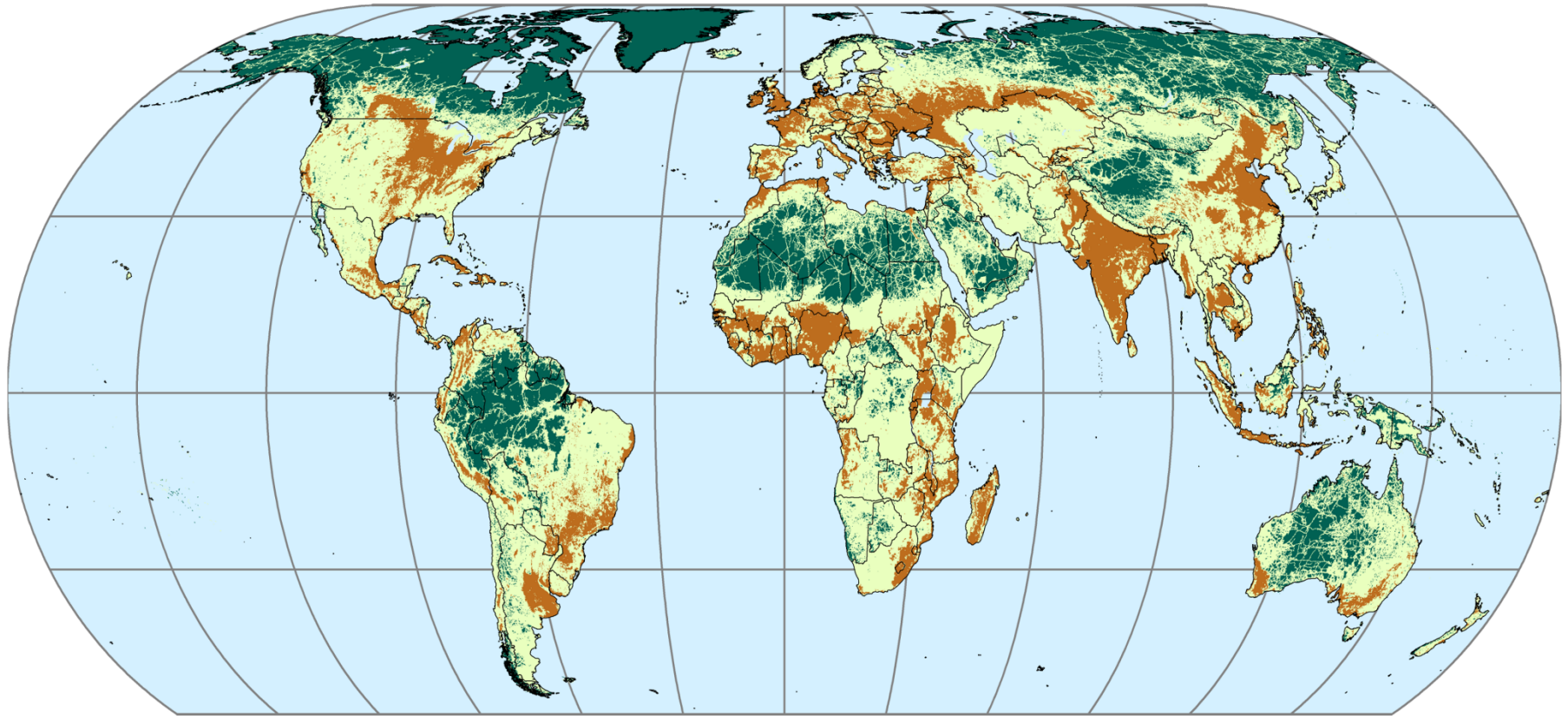


Sharing Earth's Land: Nature Only vs. Shared Landscapes



Three Global Conditions

for biodiversity conservation & sustainable use



17.7%

55.7%

26.5%

Cities and Farms

Shared Lands

Large Wild Areas

Locke *et al.* 2019. Three global conditions for biodiversity conservation and sustainable use: an implementation framework. *National Science Review* (accepted).

A spatial overview of the global importance of Indigenous lands for conservation

Garnett et al. 2018. *Nature Sustainability* 1:369-374.

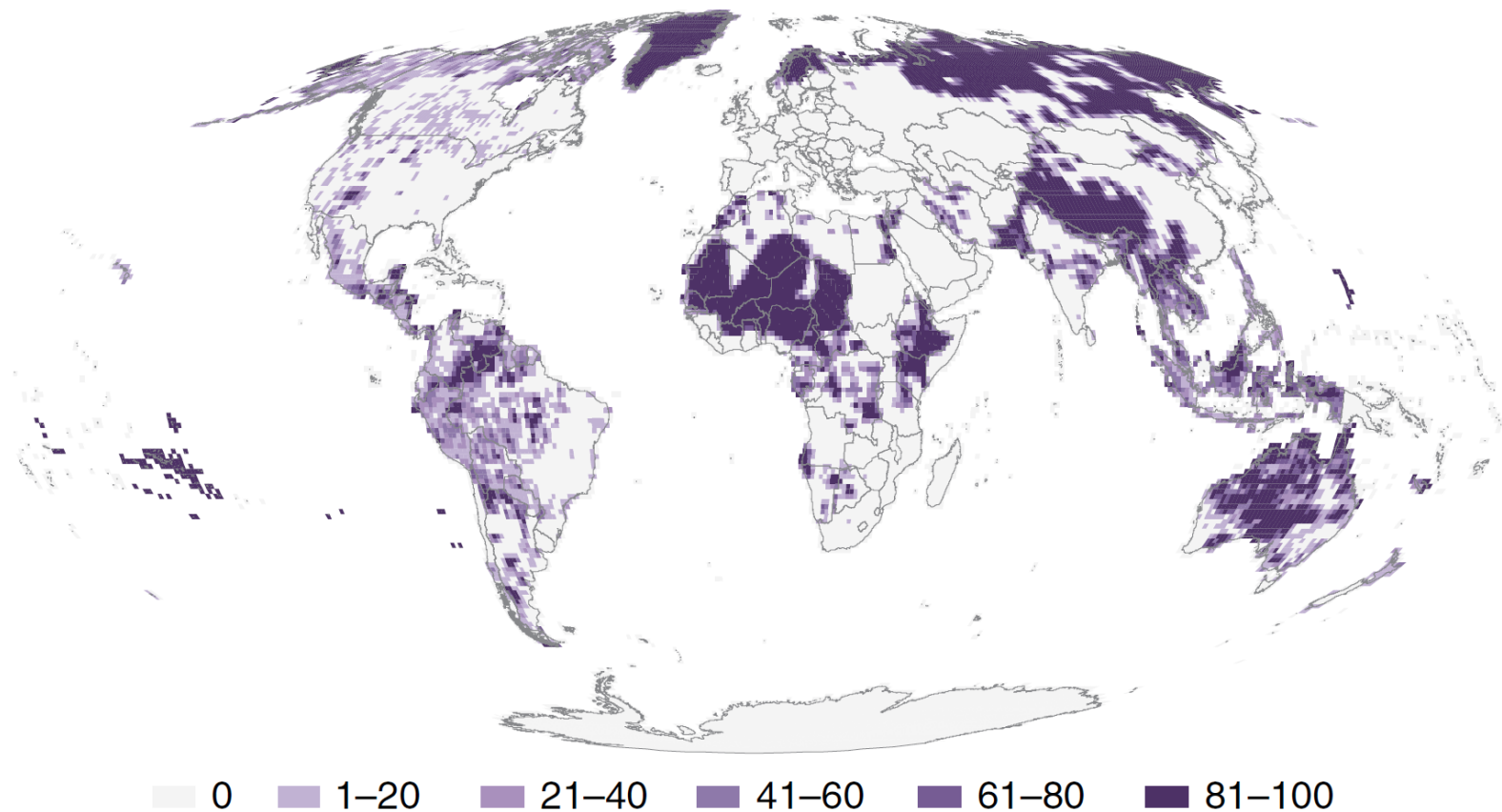


Fig. 1 | Global map of lands managed and/or controlled by Indigenous Peoples (percentage of each degree square mapped as Indigenous in at least one of 127 source documents; Supplementary Information section 2).

Global Safety Net

Computationally Optimized Conservation Reserve Design



RESOLVE



Pleistocene >>> Holocene

Land Use Intensification by Hunter-Gatherers

Adaptive technologies to sustain growing populations on limited land

Pre-Agricultural

Dietary Broadening



Proto-Agricultural

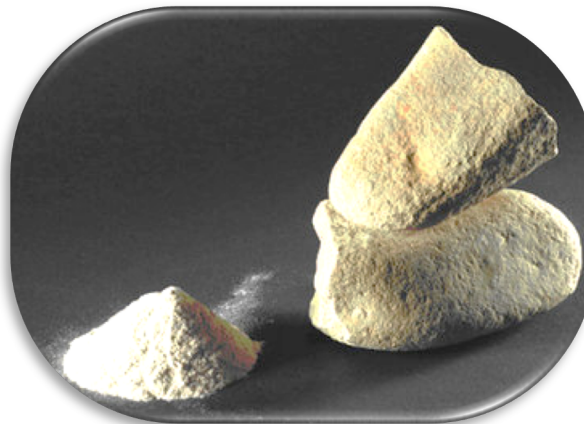
Burning for Hunting/Foraging



Propagating Favored Species



Food Processing







Domestication

Land Use Intensification

Increasing population density drives intensification of land use

Ester Boserup (1965)



Foraging		Long Fallow		Short Fallow		Annual cropping		Multicropping
ha/person		2 - 6		1 - 2		0.3 – 0.6		0.05 - 0.3
Cropping cycle (crops:years)		1:20 - 1:7		1:7 - 1:3		1:2 - 1:1		2:1 - 5:1
Population density (persons/km ²)		<15		5 – 65		65 - 250		>250



Anthropocene

Earth System

In the Anthropocene,
ecological change is social change,
and social change is cultural change.

Social Change > Ecological Change

