

ANTH/ARCG/EVST 473 Climate Change, Societal Collapse and Resilience
Tu Th 9.00-12.30 Summer 2024 H. Weiss



Ursilor Cave, NW Romania. Speleothems, calcium carbonate dissolved in cave roof drip with measurable isotopes of carbon and oxygen, provide temperature and precipitation records for at least the past 200,000 years with up to annual and sub-annual resolution. Note drip monitor, center. [photo: H. Weiss, Aug 17 2019].

Yale Summer Session 2023. Online via Zoom.

Course Description

Why do civilizations collapse? Societal collapse is documented --- frequently --- in the prehistoric and early historic records of the Old and New Worlds, including Mesopotamia, China, Europe, Mesoamerica, North America, and the Andes. And debates rage presently among anthropologists, archaeologists, historians, and paleoclimatologists about

1. the nature of these societal collapse events and processes: slow/gradual v. fast/abrupt; adaptive v. maladaptive.
2. societal collapse causality:
 - a. types of causality: direct/indirect/cascading/counterfactual; historical;
 - b. internal, cultural, anthropogenic v. external, physical, natural causality
 - c. “determinism” v. “chaotic reductionism”;
3. resilience, and “resilience theory”
4. environmental degradation prior to and at societal collapse;
5. causal role of abrupt onset megadroughts, discovered recently in Holocene (i.e., post-glacial, modern) paleoclimate records, and coincident/synchronous with several regional societal collapses. What were these abrupt megadroughts? How are their abruptness, magnitude and duration known to us? How did prehistoric and historic societies adapt to these climate changes?

Several exemplary archaeological and historical records of the Old and New Worlds will be examined for societies' vulnerabilities, resiliencies, and adaptations in the face of contending claims of:

- (1) abrupt climate change (real? how abrupt? magnitude? duration? equifinality?),
- (2) anthropogenic environmental degradation/resource depletion (real? ideological / imagined? labile data? quantifiable magnitude? effects?).

The societal collapse events and processes to be analyzed are:

- (1) Early Bronze Age (Mediterranean, Egypt, Mesopotamia synchronous collapse, 2200 BC)
- (2) Late Bronze Age (Mediterranean and Levant synchronous collapse, 1200 BC)
- (3) Assyrian Empire collapse (synchronous Near East and Egypt, 612 BC)
- (4) Mesoamerica (Maya collapse, 8th century CE)
- (5) North American (Anasazi/Ancestral Pueblo collapse, 1200 CE)
- (6) Late Victorian Holocausts (India, late 19th century CE)
- (7) The Anthropocene (global, present)

To judge from the headline-grabbing and competing claims of social scientists and paleoclimatologists, we are not likely to resolve all arguments. We will however, illuminate weaknesses, strengths, "data frontiers," and "dark corners." Advancing the frontiers of knowledge about the past also elevates discussion and analysis of the present. We might ask, "How are we adapting to an abrupt anthropogenic climate change?" as productively as we ask "Is the present the past?" Hence the last course meeting is devoted to the Anthropocene, the human dominated world of the present, its origins and its questionable sustainability.

Syllabus. The syllabus lists all readings for each course meeting and is illustrated with quotations, photographs and diagrams. The quotations, photographs and diagrams will be explained and discussed in our course meetings.

Prerequisites. There are no prerequisites for this course. Prior knowledge of archaeology, ancient history, anthropology, paleoclimatology is neither necessary nor assumed. This course presumes students' zero background knowledge of the issues, data, archaeology, history and science. We begin at the beginning!

Grade. 50% **final essay** due Meeting 10, 50% **final exam** at Meeting 10; attendance mandatory.

Final exam is 10 one-paragraph short answer questions at **last class meeting**..

Final essay is 2 page single-space essay answering 3 questions due **last class meeting**.

1. What, then, is societal collapse? A brief synthesis of past collapse observations and generalizations.
2. What causes collapse, and how can we distinguish --and rank-- societal collapse causes?
3. How do earlier Holocene climate changes differ from present-day climate change?

Required texts:

Davis, Mike. 2003. *Late Victorian Holocausts*. Verso.

Diamond, Jared. 2005. *Collapse. How Societies Choose or Fail*. Viking.

McAnany, Patricia and Norman Yoffee. 2012. *Questioning Collapse*. Cambridge.

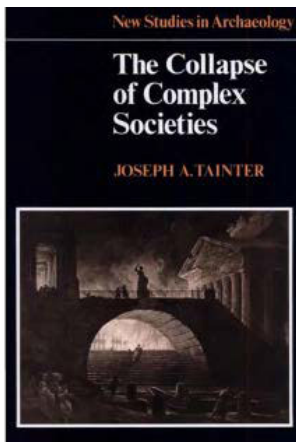
Tainter, Joseph. 1988. *The Collapse of Complex Societies*. Cambridge.

Weiss, Harvey. 2017. *Megadrought and Collapse*. Oxford.

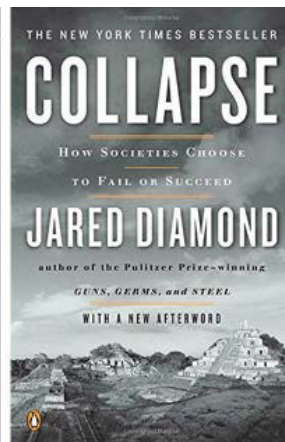
The textbooks have been selected from a plethora of recent publications, the past two decades' acceleration of societal collapse research (see end of syllabus Appendix) due to:

- (1) current biogeosphere and economic crises (e.g., "are 'we' facing collapse?"),
- (2) new paleoclimate tools (e.g., high-resolution sediment, tree ring, and speleothem analyses),
- (3) challenges to older ("1960s mushy multi-causality") social science paradigms.

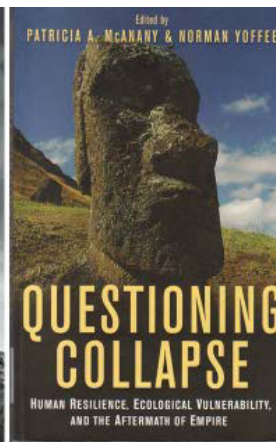
The article readings outside of the textbooks are available as pdf files under files/pdf.



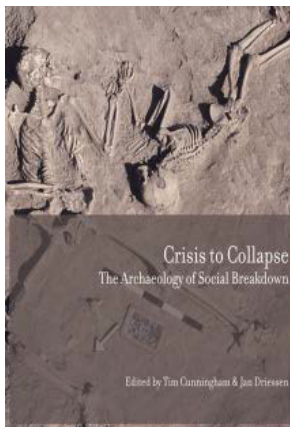
1988.
The law of diminishing returns explains "everything".



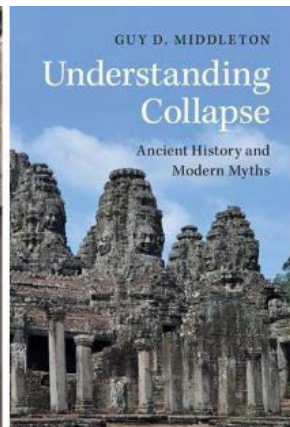
2005.
They did it to themselves....



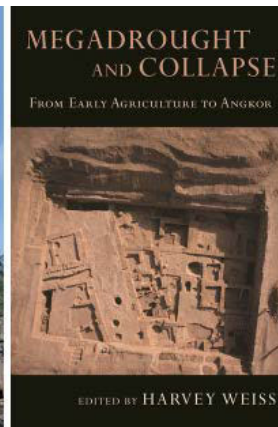
2009.
Climate change never happened and collapse never happened.



2017.
Back to the 20th century!
Societies collapse for ... social reasons.



2017.
Back to the 19th century!
It's all a myth.

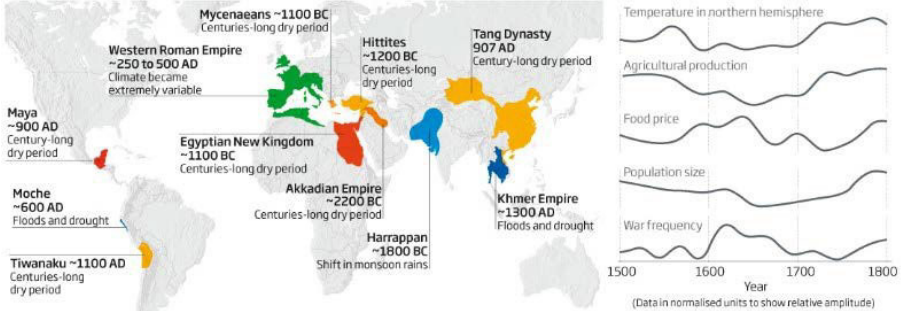


2017.
Truth, at last!

More than coincidence?

©NewScientist

The decline and fall of many civilisations coincided with periods of climate change, and there are also correlations between climate change, population size and the frequency of wars, as data from Europe shows (right)



The major societal collapse issues that are debated and researched intensely by Tainter, Diamond, McAnany and Yoffee, Weiss, Kennett, etc., including intentionality, determinism, climate change, agricultural vulnerabilities, declining marginal returns. Also, the paleoclimate proxies will be introduced along with the data types for megadrought, and the conceptualizations of “mushy multi-causality,” and other contemporary societal collapse trajectories.

Pre-instrumental Holocene climate known from high-resolution proxy records:

Climate Proxy	Sources	Dating
Marine cores:	foraminifera, alkenones, dust, IRD	^{14}C , tephra
Lake cores:	pollen, diatoms, ostracods, geochem	^{14}C , varves, tephra
Glacial cores:	$\delta^{18}\text{O}$, deuterium, CO_2 , CH_4 , SO_4 , dust	annual, ^{14}C , tephra
Speleothems:	$\delta^{18}\text{O}$, $\delta^{13}\text{C}$	$^{234}\text{U}/^{230}\text{Th}$
Tree rings:	ring width, density, $\delta^{18}\text{O}$	annual

See Bradley, R. 2014. Paleoclimatology. Springer. 3rd ed.

<https://www.sciencedirect.com/book/9780123869135/paleoclimatology>



Gruta Carlos Pacheco, Mexico;
Juan Pablo Bernal climbing (K. Christensen,
3 June 2011).

Schimpf et al 2011 QSR

What are speleothems? What information do they contain?

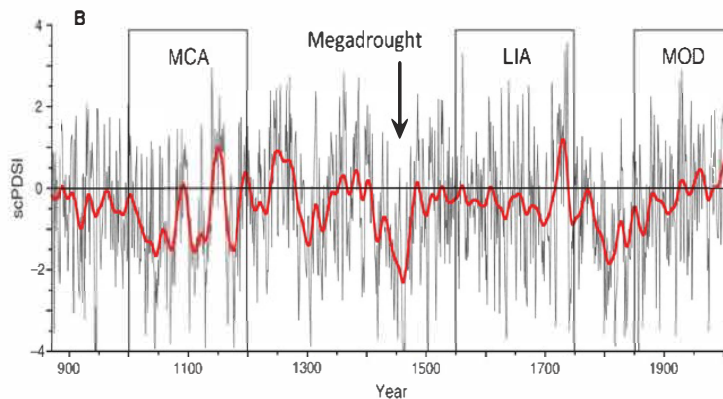


Fig. 3. Comparison of mean scPDSI fields in the OWDA during periods associated with the MCA, LIA, and modern period (MOD). (A) The mean fields were calculated over the time intervals indicated, and the areas in those fields with significant mean anomalies of wetness or dryness ($p < 0.01$, two-tailed, corrected for lag - 1 autocorrelation) are indicated in the middle set of maps. The area of maximum dryness during the MCA period is indicated by the yellow rectangle in the lower MCA map. (B) Average of OWDA reconstructions from within this rectangle. It confirms the drier conditions during the MCA period and also shows the occurrence of an extraordinary megadrought in the mid-15th century. CL, confidence level.

Cook et al 2015 Science

Meeting 2 Collapse analyzed, erroneously.

Assignment: Tainter 1988 *The Collapse of Complex Societies*. chapters 1, 2, 3, 4.

Questions: What, specifically, is erroneous in Tainter's collapse cases? We will discuss this!

How many of Tainter's collapses are actually one collapse event/process?

Is there a "law of diminishing returns"? What forces counter the "law"?

Meeting 3 A mushy multi-causality view, "they did it to themselves"

Assignment: Diamond 2005 *Collapse*. chapters 2, 4, 5, 8.

Questions: What are the data and perspectives, now old, that frame these issues?

Anthropogenic v. natural forcing?

Why does everyone dislike Jared Diamond?

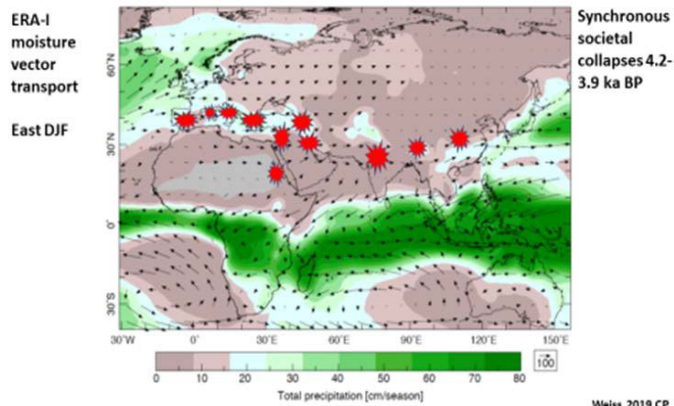
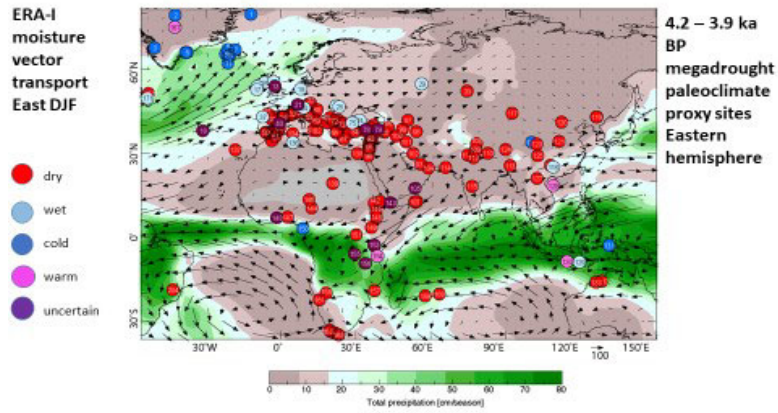
An idealist view of collapse becomes a "politically correct" view ("it never happened!")

Assignment: McAnany and Yoffee, eds. 2010 *Questioning Collapse*. chapters 1, 5, 6, 7.

Questions: How are the authors able to dismiss the paleoclimate megadrought data?

Is it true, that if you are alive, your ancestors' societies did not collapse?

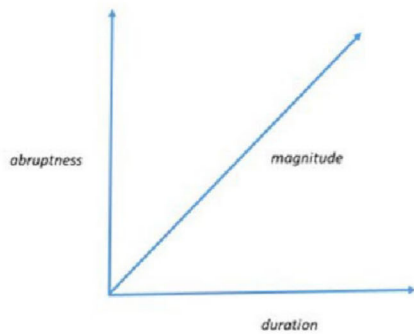
Meeting 4 Megadrought and Collapse at 4.2 ka BP/ 2200 BC – “everywhere”





Tell Leilan, NE Syria, Lower Town South, 2200 BC, excavated 1989, kite suspension photo.
 How do we know this is “Akkadian”? How do we know was abandoned at 2200 BC? [Weiss et al *Science* 1993]

Megadrought Vectors



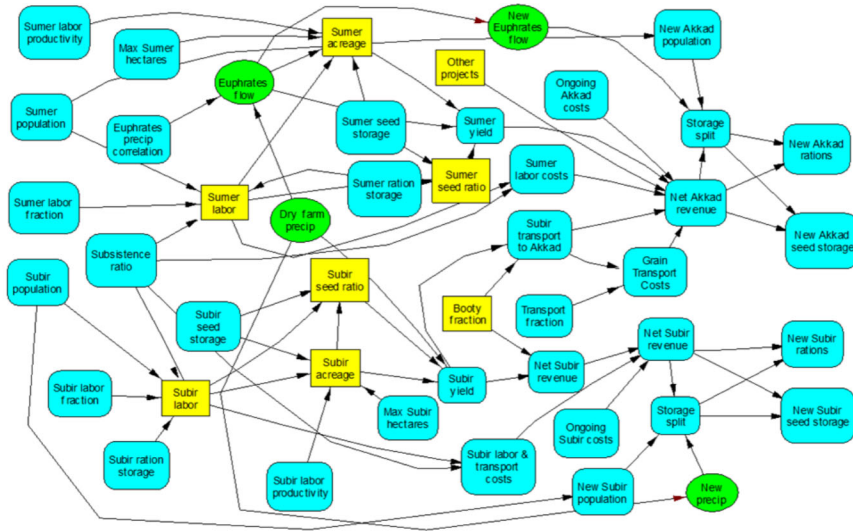
Adaptive societal responses

- a. Crop innovation available?
- b. Agro-technology innovation available?
- c. Politico-economic reorganization available?
- d. **Collapse and habitat tracking !**



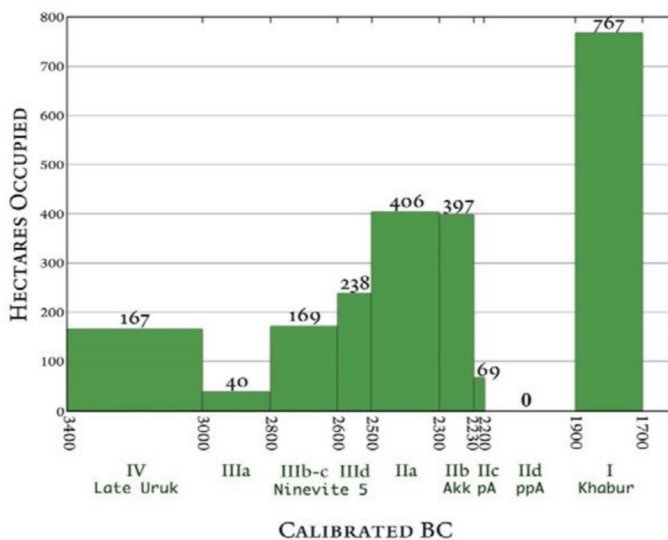
Dating, Quantification, Modeling !

Weiss and Bradley 2001 *Science*



**Influence diagram. Akkadian empire and imperialization. [Weiss 2000].
Can this be quantified and temporalized? What happens when you remove dry farming precipitation?**

LEILAN REGION SURVEY



Leilan Region Survey, 1650 kms², documents: 1. Akkadian collapse (2200 BC), 2. post-Akkadian remnant, post-post Akkadian desertion, 4. Amorite nomad/ Khabur ware period resettlement (1900 BC) at the return of pre-aridification event (2200-1900 BC) precipitation (Weiss2012).

Assignment:

The Mesopotamian collapse at 4.2 ka BP (=2200 BC):

Weiss et al. 1993 The genesis and collapse of north Mesopotamian civilization *Science*.

Weiss 2015 Altered Trajectories in *Oxford Handbook*;

Weiss 2017 chapter 1 in Weiss, ed. 2017, *Megadrought and Collapse*;

Questions:

What was the Akkadian empire? What explains the 2200 BC abandonment of rain-fed west Asia? What explains the ca. 1950 BC resettlement of rain-fed west Asia?

What is megadrought? Can megadrought be quantified?

Why were these societies *not* resilient? Or, were they?

What is Butzer's "concatenation" complaint?

We will examine this in detail in class.

Meeting 5 Habitat-tracking and Resilience:

Assignment:

In natural systems:

Eldredge 2000 Species, Speciation and the Environment:

<https://www.actionbioscience.org/evolution/eldredge.html#primer>

In social systems/archaeology:

Cowgill, G. 2012. Concepts of collapse or regeneration in human society.

R. K. Faulseit, 2016 Introduction *Beyond Collapse: Archaeological Perspectives on Resilience, Revitalization and Transformation in Complex Societies*.

Questions:

What is societal resilience?

Is it always a societal possibility?

When do societies habitat-track, if ever?

Meeting 6 The Indus Valley and the Egypt Old Kingdom collapse, why synchronous?

Assignment:

Harappan Indus collapse:

Giesche et al 2023 Recurring summer and winter droughts from 4.2 - 3.97 thousand years ago in north India. *Communications Earth and Environment* 4:10.

Old Kingdom Egypt collapse:

Garcia Moreno 2015 Egypt First Intermediate Period, in Meller ed 2015, 2200 BC.

Weiss 2022 Pyramid Building and Collapse *Proc Natl Acad Sci USA* 119:37.

Questions:

Where are the Indus Valley cities? How many were there? What was Indus agriculture? Why do Giesche et al 2017 believe collapse was not the 4.2 ka BP societal response in the Indus—or do they?

What is the source of the Nile, the basis of Egyptian agriculture?

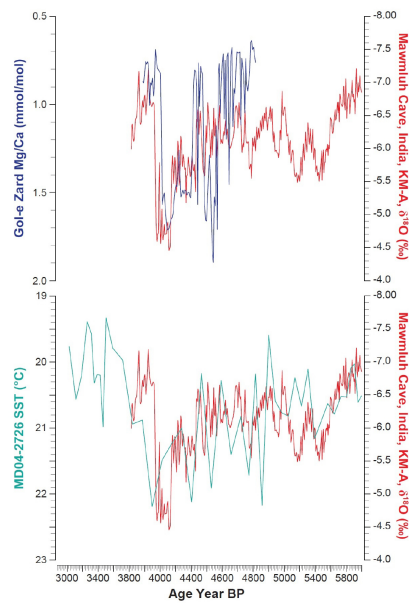
When did Old Kingdom pyramid building cease?

Note how Garcia Moreno avoids all non-historical, i.e., paleoclimate, data.

[“History is what is written“!]



Egypt at 2200 BCE. What are the colored sites? What physical process is represented?



Three paleoclimate proxy records: Indian Summer Monsoon, midlatitude westerlies (Iran), and Nile flow at Mediterranean. Note horizontal axis.

Multi-proxy stacks permit observation of synchronous changes in different paleoclimate proxy types and at different loci. We will examine and discuss these in class.

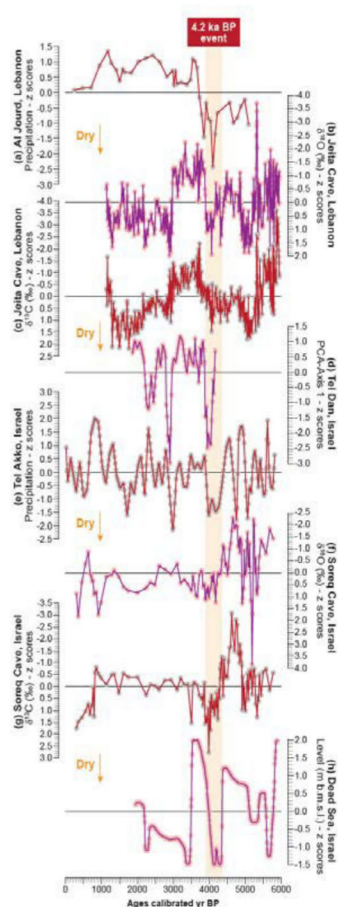
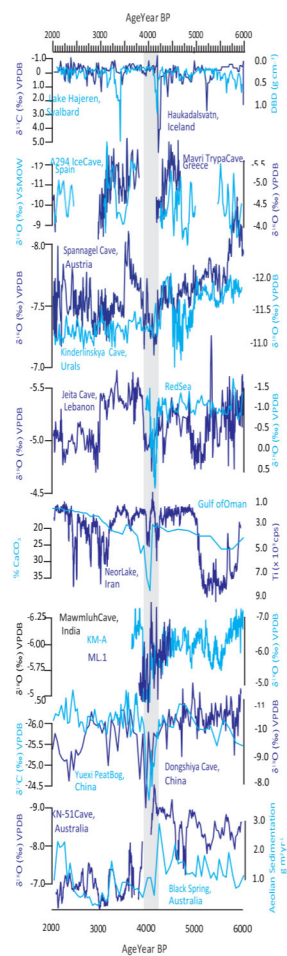


Figure 4. Paleoclimate series (z score transformed), with the type of climate proxy noted. The orange vertical band represents the 4.2 ka BP event. From top to bottom: Al Jourid (Lebanon; Cheddadi and Khater, 2016), Jeita Cave (Lebanon; Cheng et al., 2015), Tel Dan (Israel; Kaniewski et al., 2017), Tel Akko (Israel; Kaniewski et al., 2013), Soreq Cave (Israel; Bar-Matthews et al., 2003; Bar-Matthews and Ayalon, 2011), and the Dead Sea (Israel; Bookman Ken-Tor) et al., 2004; Migowski et al., 2006; Kagan et al., 2015).

www.clim-past.net/14/1529/2018/

Multi-proxy stack, 6 ka BP – 2 ka BP, Iceland to Australia.

Lake Hajeren, Svalbard: 1, van der Bilt et al, 2015; Lake Haukadalsvatn, Iceland: Giersdottir and Miller, 2015; A294 Ice Cave, Spain: 35, Sancho et al 2018; 63, Mavri Trypa, Greece: Finné et al 2017; Spannagel Cave, Austria: 22, Fohlmeister et al 2012; Kinderlinskaya Cave, Urals: 29, Baker et al, 2017; Jeita Cave, Lebanon: 90, Cheng et al, 2015; Red Sea: 96, Arz et al 2006; Neor Lake, Iran: 99, Sharifi et al 2016; Gulf of Oman: 104, Cullen et al 2001; Mawmluh Cave KM-A: 113, Berkelhammer et al 2012; Mawmluh Cave ML.1: 113, Kathayat et al, 2018; Yuexi Peat Bog, China: 125, Hong et al 2018; Dongshiyi Cave, China: 121, Zhang et al, 2018; Australia: 132, KN-51 Cave, Deniston et al, 2015; Black Spring, Australia: 133, McGowan et al 2012. Weiss 2020 CP.

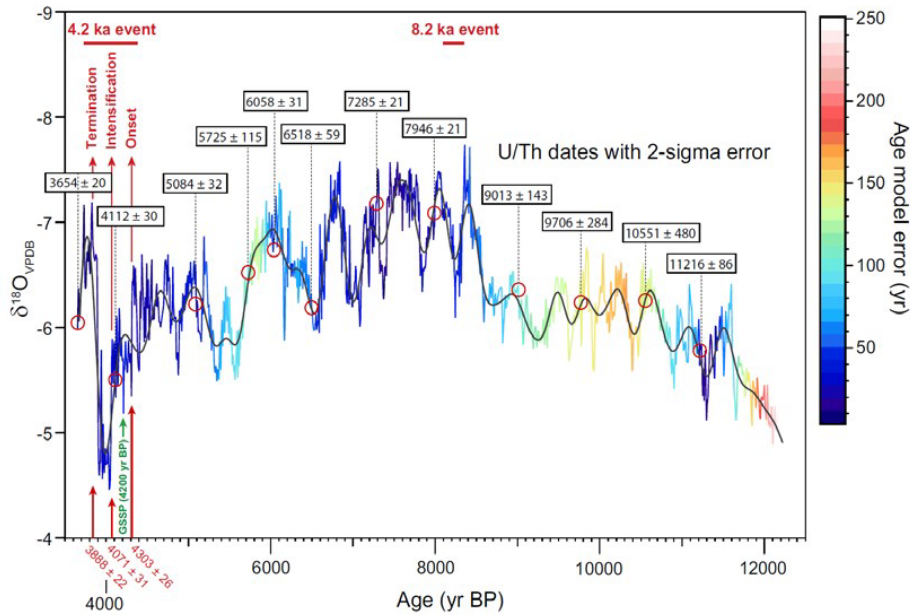
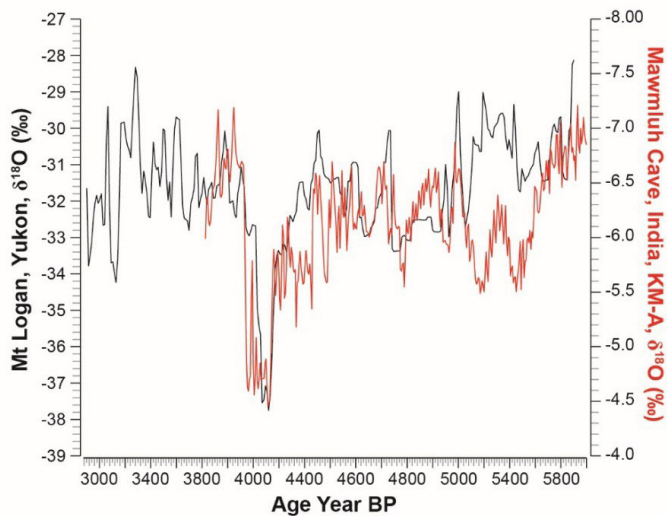


Figure 6. The Mawmluh Cave $\delta^{18}\text{O}$ record for speleothem KM-A, showing the position of the 4.2 ka event on the stable isotope trace (after Berkelhammer et al., 2012). The continuous black line through the isotope trace is a low pass filter removing any variability with a frequency higher than 10 years. Red circles mark all U-Th dates obtained, which are given with their 2σ analytical uncertainty in black boxes. Age uncertainty (95% confidence interval) was assessed using a Monte Carlo fitting procedure through the U-Th dates, and is also shown by variations in colour along the trace. The envelope of the event (onset and termination) is shown by the arrowed red lines, and the beginning of the most intensive phase of weakened monsoon is shown by a third arrowed red line: their dates (in red) are given with uncertainty that is also assessed using the Monte Carlo fitting procedure. See Berkelhammer et al. (2012) for details on the age model calculations. The position of the GSSP, with a modelled age of 4200 yr BP (4250 b2k) is indicated by the green arrow. Note that the 8.2 ka event also registers as a significant excursion in the stable isotope record from Mawmluh Cave.



Mawmluh-2 speleothem, in Hai Cheng laboratory, Xi'an, China, 23.vi.18
(photo: H. Weiss)



Mt Logan, Yukon, Fisher et al 2008; Mawmluh KMA, India, Berkelhammer et al 2012.
4.2 ka BP event coincidence across 9000 kms. [Weiss 2019 CP]

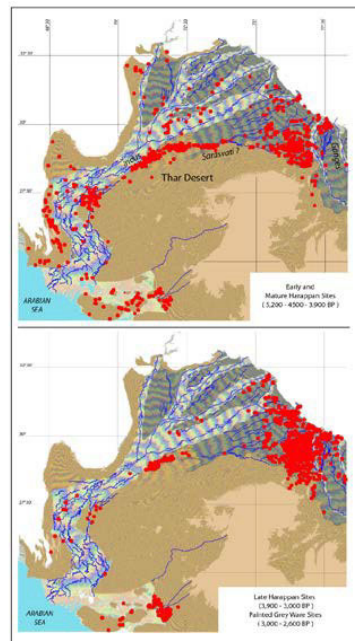
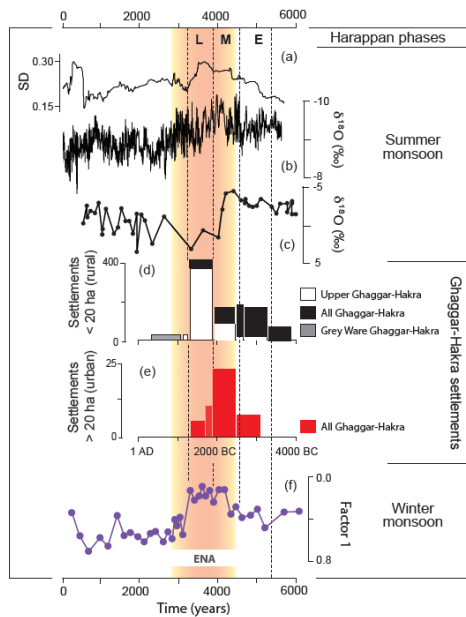
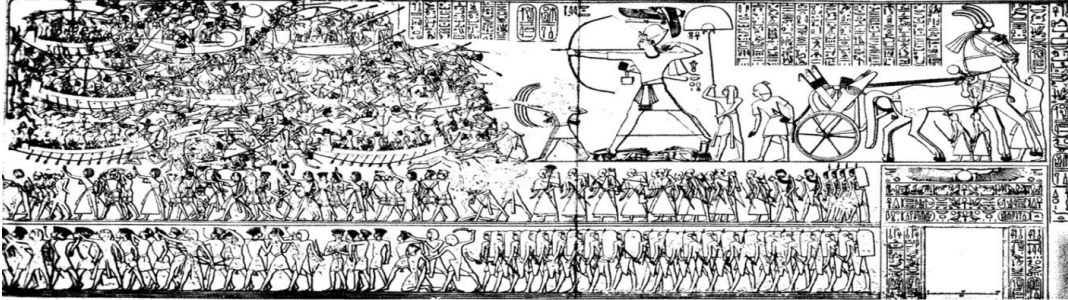


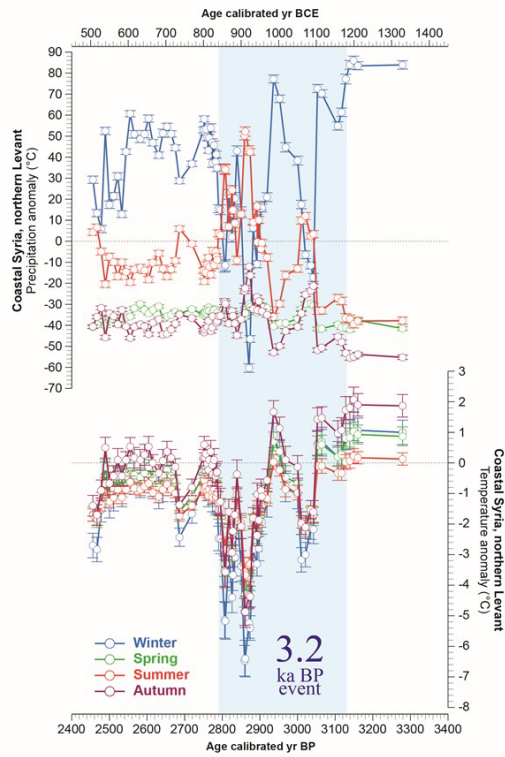
Fig. S3. Archaeological sites in the Indus domain for the Early and Mature Harappan periods (upper panel) and Late Harappan and Painted Gray Ware periods. The morphology of the region is highlighted by the color scheme: for altitudes, pattern of colors repeats every 10 m to 300 m in height; interfluvies in gray mask and incised valleys with no mask; active and fossilized river channels are in blue.

Giosan et al 2018 Figure 6 and S3.

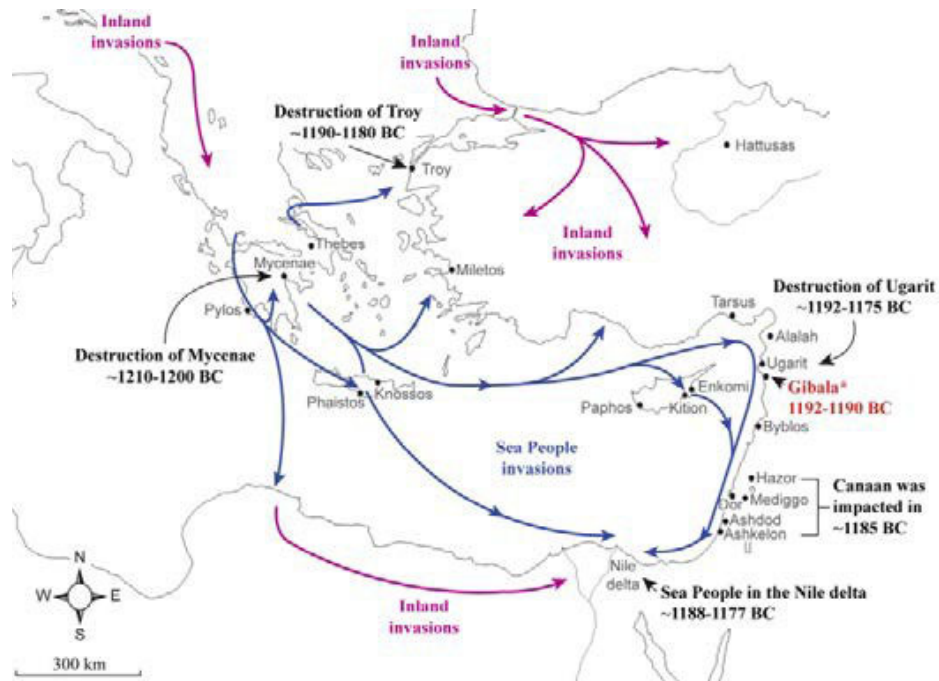
Meeting 7 Late Bronze Age Collapse, The Facts and the Fictions



Medinet Habu temple bas-relief, Rameses III, ca. 1190 BC., repelling "The Sea Peoples."



Lake sediment core, coastal Syria, vertical axes are precipitation and temperature. Kaniewski et al 2013.



Sea Peoples at 1177 BC moving across the eastern Mediterranean.

Assignment:

Cline 2014 *1177 BC: the year civilization collapsed*. pp. 73-170.

Kaniewski and van Campo 2017 in Weiss, ed 2017;

Finné et al 2017 *PLOS One*

Questions:

Transfer functions: can 3.2 ka BP climate changes be quantified as precipitation or temperature alterations?

Who were the “Sea Peoples”, and how are they depicted?

What drives the notion that these were “brittle” LBA states, and therefore “ready” to collapse? How are “destruction levels” identified archaeologically? “Abandonment levels”?

What are the “migration markers” for region-wide migrations and collapses?

Meeting 8 “The Mother of all catastrophes”: Assyrian Empire Collapse

Sinha, Kathayat, Weiss, et al., 2019 Role of Climate in the Rise and Fall of the Assyrian Empire, *SciAdv* 5, eaax6656(2019).



Deportees from the Assyrian siege of Lachish, Judea, 701 BC. Detail from a bas-relief ripped from walls of Sennacherib's "Palace Without Rival", Nineveh, 1845, and shipped to the British Museum, London (photo: British Museum).

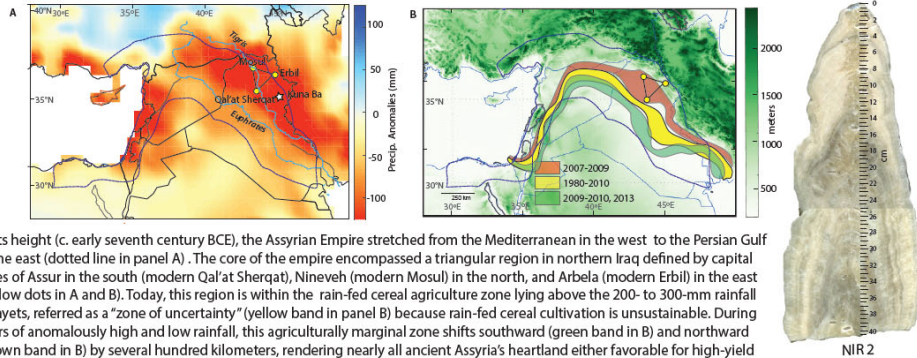


Assyrian Empire, maximum extent, mid 7th century, reign of Assurbanipal (668-627 BC)

Role of Climate in the Rise and Fall of the Neo-Assyrian Empire

Northern Iraq was the political and economic center of the Neo-Assyrian Empire (c. 912 to 609 BCE)—the largest and most powerful empire of its time. After more than two centuries of regional dominance, the Neo-Assyrian state plummeted from its zenith (c. 670 BCE) to complete political collapse (c. 615 to 609 BCE). Earlier explanations for the Assyrian collapse focused on the roles of internal politico-economic conflicts, territorial overextension, and military defeat. Here, we present a high-resolution and precisely dated speleothem record of climate change from the Kuna Ba cave in northern Iraq, which suggests that the empire's rise occurred during a two-centuries-long interval of anomalously wet climate in the context of the past 4000 years, while megadroughts during the early-to mid-seventh century BCE, as severe as recent droughts in the region but lasting for decades, triggered a decline in Assyria's agrarian productivity and thus contributed to the abrupt and complete collapse from which it never recovered. The mystery of the collapse and the region's subsequent centuries' long devastation and abandonment have puzzled archaeologists for more than one hundred years and led to its label as "an historical scandal."

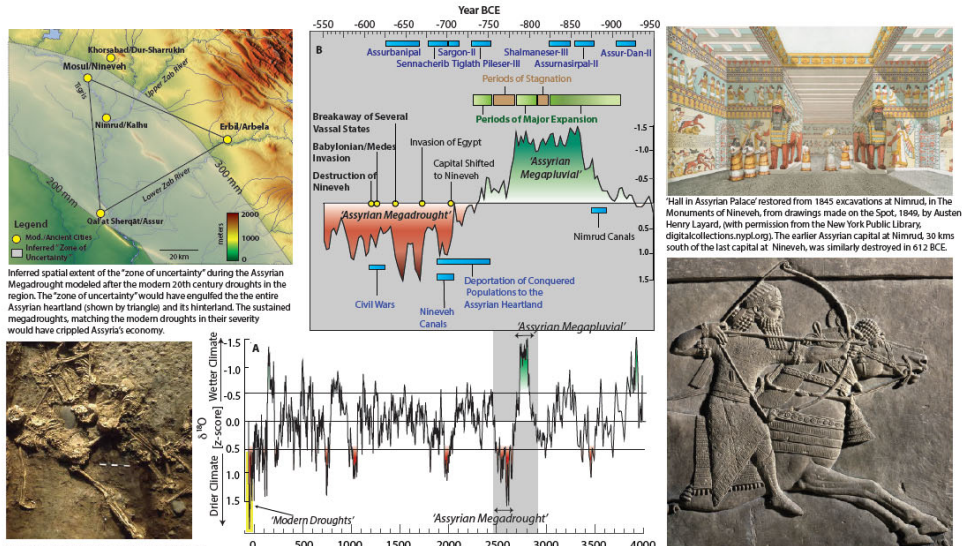
Modern Climatic and Geographic Context



At its height (c. early seventh century BCE), the Assyrian Empire stretched from the Mediterranean in the west to the Persian Gulf in the east (dotted line in panel A). The core of the empire encompassed a triangular region in northern Iraq defined by capital cities of Assur in the south (modern Qal'at Sherqat), Nineveh (modern Mosul) in the north, and Arbela (modern Erbil) in the east (yellow dots in A and B). Today, this region is within the rain-fed cereal agriculture zone lying above the 200- to 300-mm rainfall isohyets, referred to as a "zone of uncertainty" (yellow band in panel B) because rain-fed cereal cultivation is unsustainable. During years of anomalously high and low rainfall, this agriculturally marginal zone shifts southward (green band in B) and northward (brown band in B) by several hundred kilometers, rendering nearly all ancient Assyria's heartland either favorable for high-yield cereal cultivation or vulnerable to crop failures. The severe drought episodes of 2007–2008, the most severe in the past 50 years, were marked by up to 60% reduction in rainfall (shaded red in panel A) that led to cereal crop failures across northern Syria and Iraq. In this paper, we used speleothems from Kuna Ba cave (star in panel A) to reconstruct the region's precipitation history over the last 4000 years, including the modern and ancient droughts.

NIR 2
Scanned image showing the polished cut-half of one of the speleothem samples used in this study. Speleothems were collected from Kuna Ba cave located in the Kurdistan portion of northern Iraq. Photo: Ashish Sinha

Results and Implications



Inferred spatial extent of the "zone of uncertainty" during the Assyrian Megadrought modeled after the modern 20th century droughts in the region. The "zone of uncertainty" would have engulfed the entire Assyrian heartland (shown by triangle and its hinterland). The sustained megadroughts, matching the modern droughts in their severity would have crippled Assyria's economy.

Skeletons of individuals who were slaughtered and left unburied on the roadway of the Halzi Gate at the combined Babylonian and Median armies' siege of Nineveh, the capital of the Assyrian Empire, in 612 BCE (excavation by Prof. D. Stronach, U. Calif. Berkeley, Expedition to Nineveh, 1996; photograph by D. Stronach).

"Hall in Assyrian Palace" restored from 1845 excavations at Nimrud. In the Monuments of Nineveh, from drawings made on the Spot, 1846, by Austen Henry Layard, with permission from the New York Public Library digitalcollections.nypl.org. The earlier Assyrian capital at Nimrud, 30 kms south of the last capital at Nineveh, was similarly destroyed in 612 BCE.

Ashurbanipal, last major ruler of the Assyrian Empire, depicted in the royal lion hunt bas-reliefs (c. 645 BCE) that were ripped from the walls of the North Palace at Nineveh during the excavations of 1852–1855 and shipped to the British Museum. The bas-reliefs are widely regarded as "the supreme masterpieces of Assyrian art." (photograph courtesy of British Museum).

The Kuna Ba cave oxygen isotope record (panel A) delineates a number of multidecadal periods of inferred drought over the last four thousand years. The interval between ~2800 and 2690 yr B.P. (~850 and 740 BCE) dubbed as the 'Assyrian Megapluvial' emerged as one of the wettest periods representing ~15 to 30% increase in the cool season precipitation amount (relative to 1980–2007 CE). This exceptionally wet period is synchronous with the significant phases of the Assyrian imperial expansion. The interval between ~2625 and 2500 yr B.P. (~675–550 BCE) is a ~125-year period of peak aridity, termed here the *Assyrian Megadrought*, which is synchronous with the period of the Assyrian imperial collapse (c. 660–600 BCE). The inset (B) shows the oxygen isotope record between 960 and 550 BCE and major historical Assyrian events. Our record suggests that climate change was an underlying causal factor, whose effects on the Assyrian imperial economy began centuries before the Empire's collapse. High agrarian outputs encouraged high-density urbanization and imperial expansion during the Assyrian megapluvial that were not sustainable when climate shifted to the 7th century BCE megadrought. These megadroughts (as severe as modern droughts in the region) likely crippled the Assyrian economy and precipitated its collapse. Our data also suggest that the recent multiyear droughts superimposed over a century-long drying trend are among the worst episodes of drought in the region during the past four millennia.

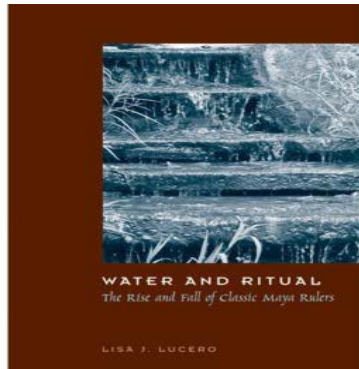
Meeting 9 Maya Collapse & Ancestral Pueblo Collapse



From Temple IV, Tikal, Guatemala. Photo: L.J. Lucero.



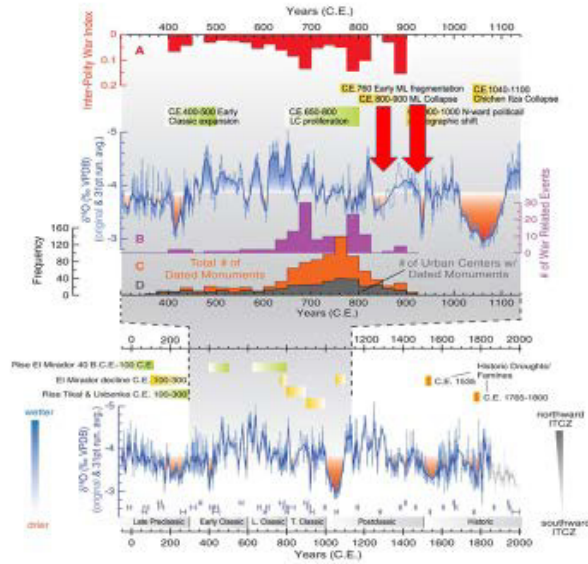
Catherwood, F., 1844 *Views of Ancient Monuments in Central America, Chiapas and Yucatan*. London.



Lucero, Lisa J., 2006. *Water and Ritual: The Rise and Fall of Classic Maya Rulers*. U Arizona Press.



Yok-1 speleothem $\delta^{18}\text{O}$ climate record/Maya collapse



Kennett et al 2012 *Science*

“One factor can contribute to the production or prevention of another in a great variety of ways.”
N. Cartwright 1999

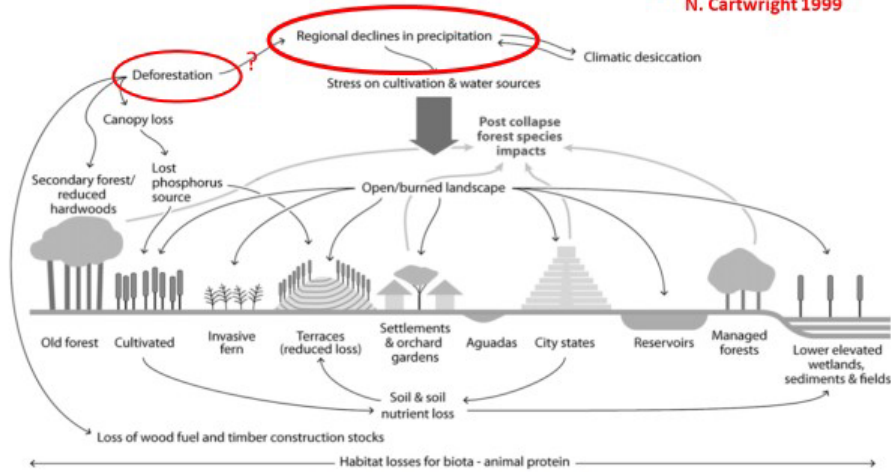


Fig. 2. Human-environment dynamics in the CMLs.

Turner and Sabloff 2012

Assignment:

Turner and Sabloff 2012 *Proc Natl Acad Sci*
Kennett and Hodell 2017 in Weiss, ed. 2017;
Evans et al 2018 *Science*

Questions:

- What were the foundations of Mayan agriculture?
- How many Maya in the pre-collapse 9th century? Post-collapse?
- What was post-collapse Maya subsistence?
- Does deforestation cause drought?

“...how severe do internal stresses in a civilization have to become before relatively minor climate shifts can trigger widespread cultural collapse?” Jeremy Sabloff 1995 *Nature*

“Rohling emphasized they are not saying that climate ended the ancient Mayan civilization. ‘We are documenting that there was a reduction in rainfall, and that reservoirs of water were evaporating,’ he said. This may in turn have led to societal unrest or diseases or both, ‘which are more likely to explain the actual collapse of society.’” Rohling on Medina-Elizade and Rohling 2012 *Science*

“The collapse is especially intriguing because it seemingly occurred at “a time in which developed a sophisticated understanding of their environment, built and sustained intensive production and water systems and withstood at least two long-term episodes of aridity,,” B.L. Turner 2012 *Smithsonian*

“We’re not saying deforestation explains the entire drought, but it does explain a substantial portion of the overall drying that is thought to have occurred,” Benjamin Cook on Cook et al *GeophyResLtrs* 2012

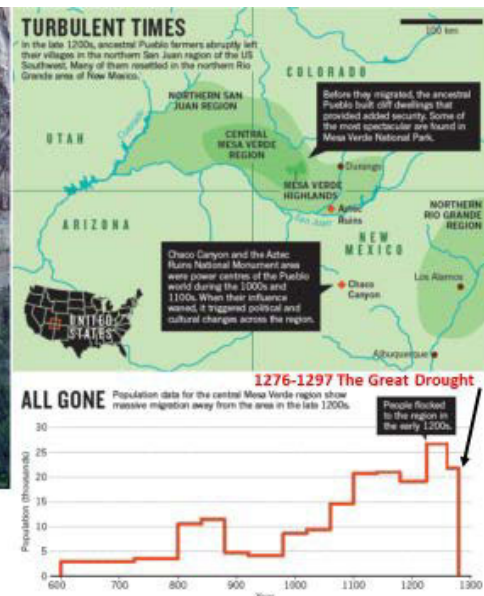
“The ±1s range determined from the PDFs indicates that the precipitation reduction could vary from 20 to 70% throughout the modeled droughts (Fig. 3). This variability represents the transition into and out of drought phases and demonstrates that the severity of the droughts could be intense (up to a70% reduction in precipitation) while maintaining the isotope balance and without desiccating the lake.” Evans et al 2018 *Science*

Ancestral Pueblo collapse: why is everyone in denial?



Mesa Verde, Colorado, constructed ca. 1190 AD, abandoned ca. 1280, excavated 1910.

Schwindt et al 2016 *AmAntiq*



Assignment:

- Axtell et al 2002 Population and Anasazi Collapse *ProcNatlAcadSci*;
- Kohler et al 2008. Mesa Verde Migrations *American Scientist* 96: 146-153

Questions:

What was “The Great Drought,” and how do we know?

How many Ancestral Pueblo fled, and how quickly? Did some remain, and how? Where did the Ancestral Pueblo go, and why?

“Exploitation phases characterized by demographic expansion and aggregation ended with climatically driven downturns in agricultural favorability, undermining important bases for social consensus.” Bocinsky et al 2016

“During the A.D. 1225-1260 period ... the study area as a whole reached [its] most unfavorable balance between population size and the size of the area in which maize could be grown.”

Schwandt et al 2016 Social consequences climate change Mesa Verde *AmAntiq*

“The Great Drought certainly had a major impact on the people in the Mesa Verde area and probably contributed to a continuing process of depopulation late in the 13th century. However, because it started well after the beginning of the regional population decline and even longer after the start in the decline in the size of the maize growing niche, the drought cannot be argued to have initiated that process which is what we are attempting to assess here.”

Kintigh and Ingram 2018 Was the drought really responsible? *JArchSci*

Meeting 10 El Nino and Collapse in the late 19th century,



Famine in India, 1876. photo: W.W. Hopper.



William Digby. *The Famine Campaign Southern India, 1876-1878.* London: Longmans, Green.

Assignment: Davis 2001 *Late Victorian Holocausts.* NY: Verso.

Questions:

Why was India “the jewel in the Crown”? Can this be quantified?

What propelled the expansion and endurance of 18th - 20th century British imperialism?

What is ENSO? El Niño? Teleconnection?

How did the Indians and the Chinese traditionally survive drought episodes and avoid famine?

**Meeting 10 The Anthropocene and the final exam (last hour of meeting 10).
Final exam is 10 one-paragraph short answer questions, and 50% of term grade)**

"Only to the white man was nature a 'wilderness.'"

---Luther Standing Bear, Chief of the Oglala Sioux, 1933.

"Human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future."

---Revelle and Suess 1957

Assignment

Weart 2007 Roger Revelle's Discovery <https://history.aip.org/climate/Revelle.htm>

Crutzen 2002 Geology of Mankind *Nature*

Zalasiewicz et al 2015 When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal *Quaternary Intl*

Questions:

Can you define "Anthropocene"?

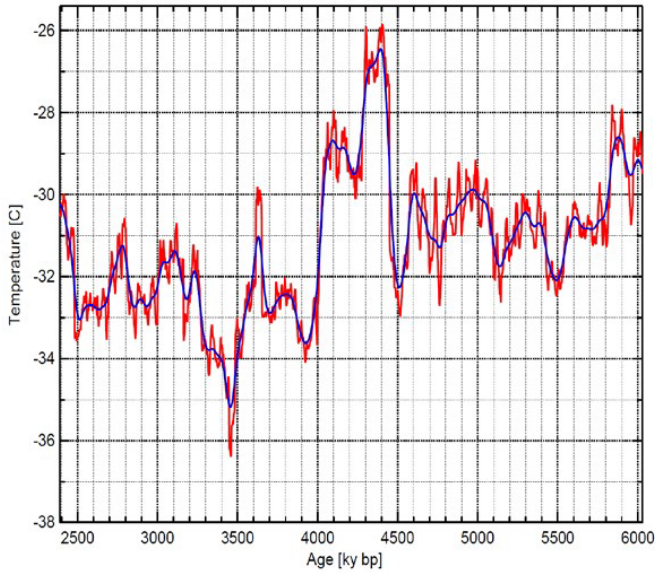
What did Revelle and Suess 1957 discover?

What did Crutzen 2002 add to that discovery?

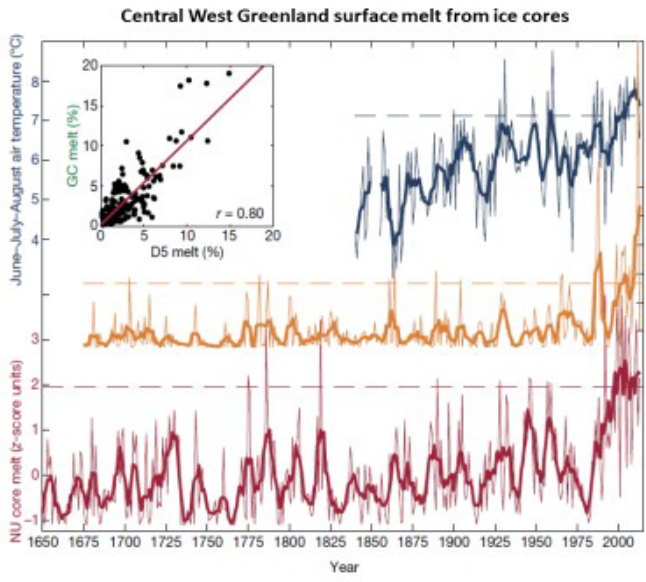
Why is there an argument about Anthropocene onset dating??

What drove The Great Acceleration?

Compare magnitude/abruptness of NGRP 4.2 ka BP temperature spike with GrIS 2k air temperature spike (below).



NorthGRIP air temperature [centigrade], 6000-2400 ka BP.
Gkinis et al 2014 EPSL 45.



"We find that the initiation of increases in GrIS melting closely follow the onset of industrial-era Arctic warming in the mid-1800s, but that the magnitude of GrIS melting has only recently emerged beyond the range of natural variability. Owing to a nonlinear response of surface melting to increasing summer air temperatures, continued atmospheric warming will lead to rapid increases in GrIS runoff and sea-level contributions."

Trusel et al 2018 Nonlinear rise in Greenland runoff in response to post-industrial Arctic warming
NATURE 564: 105-108 [Dec 6 2018]

Appendix. A bibliography of recent societal collapse books, 30 years.

A. 1988-1989

Tainter, Joseph A. 1988. *The Collapse of Complex Societies*. NY: Cambridge UP.

Yoffee, Norman, George Cowgill, eds., 1989. *The Collapse of Ancient States and Civilizations*. Tucson: U Arizona.

B. recent 1997-2000

Bawden, Garth, Richard Reycraft, eds., 2000. *Confronting Natural Disaster: Engaging the Past to Understand the Future*. Albuquerque: Maxwell Museum of Anthropology / University of New Mexico Press.

Dalfes, Nuzhet, George Kukla, Harvey Weiss, eds., 1997. *Third Millennium BC Climate Change and Old World Collapse*. NATO, Advanced Seminar Series. Berlin: Springer.

Lentz, David, ed., 2000. *Imperfect Balance: landscape transformations in the pre-Columbian Americas*. NY: Columbia U Press.

McIntosh, Roderick J., Joseph A. Tainter, Susan K. McIntosh, eds., 2000. *The Way the Wind Blows: Climate Change, History, and Human Action*. NY: Columbia UP.

C. very recent 2005-2012

Butzer, Karl 2012 Collapse, environment and Society. *Proc. Natl. Acad. Sci.* 109.10: 3632. Supporting Information Butzer 10.1073/pnas.1114845109 Environmental Determinism and the Akkadian Collapse.

Diamond, Jared, 2005. *Collapse: how societies choose to fail or succeed*. Penguin.

Rosen, Arlene Miller, 2007. *Civilizing Climate: Social Responses to Climate Change in the Ancient Near East*. Albuquerque: Altamira Press.

Schwartz, Glenn, and John Nichols, eds., 2006. *After Collapse: The Regeneration of Complex Societies*. Tucson: Univ. Arizona Press.

Staubwasser, Michael and Harvey Weiss, eds., 2006. *Holocene Climate and Cultural Evolution in Late Prehistoric –Early Historic West Asia*. Quaternary Research, vol. 66, special issue.

Kuzucuoğlu, Catherine and Catherine Marro, eds., 2007. *Sociétés humaines et changement climatique à la fin du troisième millénaire: une crise a-t-elle eu lieu en haute Mésopotamie?* Varia Anatolica XIX. Paris.

McAnany, P.A. and N. Yoffee, eds., 2010 *Questioning Collapse*. Cambridge U Press.

D. Current (2016 - 2017)

Faulseit, Ronald K. ed. 2016. *Beyond Collapse: Archaeological Perspectives on Resilience, Revitalization, and Transformation in Complex Societies*. Southern Illinois University Press.

Cunningham, Tim and Jan Driessen, eds. 2017. *Crisis to Collapse: The Archaeology of Social Breakdown*. Actes de Colloque. Presses Universitaires de Louvain.

Middleton, Guy. 2017. *Understanding Collapse: Ancient History and Modern Myths*. NY: Cambridge UP.

Weiss, Harvey, ed. 2017. *Megadrought and Collapse: From Early Agriculture to Angkor*. NY: Oxford.

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You must document all of your source material. If you take any text from somebody else, you must make it clear the text is being quoted and where the text comes from. You must also cite any sources from which you obtain numbers, ideas, or other material. If you have any questions about what does or does not constitute plagiarism, ask! Plagiarism is a serious offense and will not be treated lightly. Fortunately, it is also easy to avoid and if you are the least bit careful about giving credit where credit is due you should not run into any problems.