Workshop on Historical Systemic Collapse

Friday & Saturday, April 26-27, 2019
Princeton University
Survey Responses

Workshop Participants

Marty Anderies	Arizona State University – Professor, School of Evolution and Social Change & School of Sustainability
Haydn Belfield	University of Cambridge – Academic Project Manager, Centre for the Study of Existential Risk (CSER)
Seth Baum	Global Catastrophic Risk Institute – Executive Director
Richard Bookstaber	University of California – Chief Risk Officer, Office of the CIO
Ingrid Burrington	USC – Fellow, Annenberg Innovation Lab Freelance Writer and Artist
Peter Callahan	Princeton University –PIIRS Global Systemic Risk research community
Miguel Centeno	Princeton University – Professor, Sociology & WWS; Director, PIIRS Global Systemic Risk research community
Eric H. Cline	George Washington University – Director, Capitol Archaeological Institute
Samuel Cohn, Jr.	University of Glasgow – Professor, Medieval History
Adam Elga	Princeton University – Professor, Philosophy
Sheldon Garon	Princeton University – Professor, History and East Asian Studies
Jack Goldstone	George Mason University – Professor, Public Policy
Christina Grozinger	Penn State University – Professor, Entomology Director, Center for Pollination Research
John Haldon	Princeton University – Professor, History
Jeff Hass	University of Richmond – Professor, Sociology and Anthropology
Sherwat Elwan Ibrahim	American University in Cairo – Professor, Management
Robert Jensen	University of Texas – Emeritus Professor, School of Journalism
Luke Kemp	University of Cambridge – Research Associate, Centre for the Study of Existential Risk (CSER)

Ann Kinzig	Arizona State University – Professor, School of Life Sciences
Tim Kohler	Washington State University, the Santa Fe Institute, and Crow Canyon Archaeological Center – Archaeologist
Paul Larcey	University of Cambridge – Centre for Smart Infrastructure and Construction
Tim Lenton	University of Exeter – Director, Global Systems Institute Chair, Climate Change and Earth System Science
Simon Levin	Princeton University – Professor, Ecology & Evolutionary Biology
Igor Linkov	US Army Engineer R&D Center – Lead, Risk and Decision Science Focus Area
Tim Maughan	Author and Journalist
Doug Mercado	Princeton University – Visiting Lecturer, Woodrow Wilson School
Zia Mian	Princeton University – Co-Director, Program on Science and Global Security
Arka Mukherjee	Founder & CEO, Global IDs Princeton University – PIIRS Global Systemic Risk Research Community
Deborah L. Nichols	Dartmouth College – Professor, Anthropology
Thayer Patterson	Princeton University – PIIRS Global Systemic Risk Research Community
Benoît Pelopidas	Sciences Po – Associate Professor, Security Studies
Gwythian Prins	London School of Economics – Emeritus Research Professor Ecole Spéciale Militaire de Saint-Cyr – Senior Academic Visiting Fellow
Steve Pyne	Arizona State University – Emeritus Professor, School of Life Sciences
Juan Rocha	Stockholm Resilience Centre – Postdoctoral Researcher
Anders Sandberg	University of Oxford – Senior Research Fellow, Future of Humanity Institute
Walter Scheidel	Stanford University – Professor, Classics and History
sava saheli singh	Queen's University, Canada – Post-Doctoral Fellow, Surveillance Studies Centre
Nils Chr. Stenseth	University of Oslo – Professor, Mathematics and Natural Sciences
Joseph Tainter	Utah State University – Professor, Environment & Society
Temis Taylor	Stony Brook University – Message Design Instructor and Science Communication Researcher, Alan Alda Center for Communicating Science
Stefan Thurner	Santa Fe Institute, IIASA, & Complexity Science Hub Vienna
Benjamin Trump	US Army Engineer R&D Center – Research Social Scientist
Peter Turchin	University of Connecticut – Professor, Ecology and Evolutionary Biology, Anthropology, and Mathematics

Survey Responses

Participant	Marty Anderies
Affiliation	Arizona State University – Professor, School of Evolution and Social Change & School of Sustainability
Email	m.anderies@asu.edu
Primary Field	Mathematical BioEconomics/Sustainabilty Science
Brief Bio	Marty Anderies received his Ph.D. in Applied Mathematics from the University of British Columbia in 1998 where he developed mathematical models of social-ecological systems to study the impact of culture on the governance of shared resources. He subsequently spent 3 years at CSIRO in Australia developing basic theory on resilience in social-ecological systems. He has been at ASU since 2002 where he has a joint appointment in the School of Human Evolution and Social Change and School of Sustainability.
Description of Research	Anderies studies a range of archaeological, historical, and present-day examples of social-ecological systems using multiple methods including human subject experiments, qualitative case-study analysis, and formal mathematical modeling and analysis to develop an understanding of ecological, behavioral, social, and institutional factors that generate vulnerability and/or enhance resilience and robustness in social-ecological systems.
Website(s)	https://complexity.asu.edu/cbie https://seslibrary.asu.edu/,https://seslibrary.asu.edu/node/637, https://seslibrary.asu.edu/node/781
Definition of "Collapse"	Collapse is complexity failure/fragility
What is the opposite of "collapse"?	Robustness (smaller time scale) + resilience (larger time scale). Both are difficult to measure, i.e., they need to build a frequency response relation, but difficult/impossible for systems we live in.
Dependent Variable (What constitutes a collapse)	Infrastructure disconnect/dysfunction/dissolution
Casual Variable (What leads to collapse)	Regulatory networks that suppress variation.
How can "Systems Thinking" provide insight into understanding collapse?	By elucidating the robustness-fragility trade-offs in regulatory feedback networks that constitute stable structures (i.e., societies).
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Legal/institutional infrastructure and social infrastructure.

Relevant Case Studies	Hohokam
Readings for those cases	Abbott, David R., ed. *Centuries of decline during the Hohokam Classic period at Pueblo Grande*. University of Arizona Press, 2016.

Participant	**Haydn Belfield**
Affiliation	University of Cambridge – Academic Project Manager, CSER
Email	hb492@cam.ac.uk
Primary Field	Politics and International Relations
Brief Bio	Haydn Belfield is Research Associate and Academic Project Manager at the University of Cambridge's Centre for the Study of Existential Risk. Key papers include The Malicious Use of Artificial Intelligence: Forecasting, Prevention, and Mitigation and Existential risk: Diplomacy and governance. Has advised the UK, US, EU and Singaporean governments, leading technology companies and the United Nations. Previously a Policy Associate to the University of Oxford's Global Priorities Project and a Senior Parliamentary Researcher to a British Shadow Cabinet Minister. Degree in Philosophy, Politics and Economics from Oriel College, University of Oxford.
Description of Research	The Centre for the Study of Existential Risk is dedicated to the study and mitigation of risks that could lead to human extinction or civilizational collapse. Our research focuses on environmental risks, emerging risks from biotechnology and AI, and crosscutting issues in existential risk research. Collapse is clearly a key topic for us. In February 2018, I organized a workshop in Cambridge with Jared Diamond and other collapse scholars to discuss the feasibility of 'Modelling Societal Collapse'. My subsequent work has included a model of how climate change could lead to collapse, and 'Collapse and Recovery', which explores why civilizational collapse would be bad from a long-term perspective and offers some estimates of the likelihood and duration of recovery.
Website(s)	https://www.cser.ac.uk/
Definition of "Collapse"	This is a tricky question and I'm looking forward to discussing it. I currently view collapse as the end of a particular political, economic and cultural system of human cooperation – normally accompanied by large economic and population losses.
What is the opposite of "collapse"?	The continuation of that political, economic and cultural system – normally without large economic and population losses.
How do we avoid sampling along dependent variables?	One suggestion is a 'catalogue of collapses' to avoid cherry-picking. This methodology would involve adopting some definition of collapse, analyzing historical data, and seeing what examples meet that definition. One definition could, for example, be >75% decline in GDP in a decade or similar devastation for cases in which GDP data is unclear. One would need to decide whether to include averted collapses, with possible examples including Highland New Guinea, Tokugawa-era Japan, Tikopia, Iceland and Tonga. One would also need to decide whether to have a binary 'collapse or not?' classification or to allow gradations of collapse.
Dependent Variable (What constitutes a collapse)	I think there are several plausible variables that could serve as proxies for collapse, I'd be interested in discussing which should be included. Some examples include: - Population loss. - Severe reduction in wellbeing, such as healthy life years, HDI index, 'Weighted Index of Social Progress' or GDP. - Material culture production. - Reduction in complexity (variables could be trade, communication, political and diplomatic contact over large distances). - Energy use per capita. - Percentage of people in various classes of occupations: 1) industrialized occupations, both manual and services, 2) agriculture, or 3)

	hunter-gathering. Large shifts from former to latter classes might be a variable for collapse.
Casual Variable (What leads to collapse)	Several variables can lead to collapse. Ultimate causes include: - Climate change (leading to water/food/energy insecurity through droughts or weather events; or through changes to the usability of land). - Catastrophic ecosystem shifts (to a new equilibrium that produces less useful ecosystem services). - Infectious disease (accidentally or deliberately spread). - Hostile action (warfare or genocide). - Possibly in the future: accidents with very powerful technologies.
How can "Systems Thinking" provide insight into understanding collapse?	Our collapse workshop highlighted at least three ways systems thinking can provide insight. - Currie (2018) questioned whether our societies are too 'wild' (containing too much 'interference' and 'noise') for collapses to be usefully analyzed, or predicted. - Avin et al. (2018) offered a useful framework for analyzing the causal variables of collapse, according to three key components: (i) the critical systems whose safety boundaries are breached, (ii) the mechanisms by which this breach might spread and affect the majority of the population, and (iii) the manner in which the population might fail to prevent or mitigate both (i) and (ii). - Tzachor (2018) argued that preventing societal decline (of living standards and wellbeing) requires effective governance of a system of economic, natural, human and social capital stocks.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Critical systems identified by Avin et al. (2018) include both sociotechnolgical systems – climate control, food, health, resource extraction, security, shelter and utilities – and ecological systems – food chains, decomposition, mutualism and primary production.
Relevant Case Studies	Possible examples of collapse include: Rapa Nui (Easter Island), Mangareva, Norse Greenland, Puebloan US Southwest, Classic Maya Lowlands, Late Bronze Age collapse (Egyptians, Hittites, Canaanites, Cypriots, Minoans, Mycenaeans, Assyrians and Babylonians), Mesopotamia, Western Roman Empire, Inca, Post Columbian Americas, Indigenous Australians, Siberian colonisation by the Tsars. If one includes regions within a state then possible examples include Ukraine in USSR. If one includes examples of 'societal decline' in the 20th century then possible examples include Nauru, Sri Lanka, Jamaica, Iceland, Madagascar and Haiti. If one includes civil wars then possible examples include the Russian Civil War, 1920s China, 2nd Congo War, the Syrian War, Somalian War, or Afghanistan War. These fit the Mesopotamian story of failed states, decentralisation and warlordism. If one includes averted collapses, then possible examples include Highland New Guinea, Tokugawa-era Japan, Tikopia, medieval Iceland and Tonga.
Recommended General Readings	See the workshop report I sent. (It is posted in the "resources" section on this workshop's website at http://risk.princeton.edu/collapse)
Other Relevant Resources	In addition to those listed under 'general readings': UCL: Elisa Perego – on prehistory, Prof. Sue Hamilton on Rapa Nui, David Alexander - Professor of Risk and Disaster Reduction. There was a session on collapse at the Conference for World Affairs in Boulder in April 2018: If Sustainability Isn't Possible, Does Collapse Become Inevitable? Guy D. Middleton, David Orr, Gregory Tanaka, Suzanne Jones (video). Possibly Wolfgang Lutz from IIASA. Possibly Marten Scheffer on the stability and resilience of complex systems (ecological and social) e.g., on inequality in nature and society.

Participant	**Seth Baum**
Affiliation	Global Catastrophic Risk Institute – Executive Director

Email	seth@gcrinstitute.org
Primary Field	Risk Analysis
Brief Bio	Dr. Seth Baum is Co-Founder and Executive Director of the Global Catastrophic Risk Institute, a nonprofit and nonpartisan think tank. He leads an interdisciplinary research agenda of risk and policy analysis of catastrophic risks, focusing primarily on artificial intelligence and nuclear war. Baum received degrees in Optics, Applied Mathematics, and Electrical Engineering before completing a Ph.D. in Geography from Pennsylvania State University and a post-doctoral fellowship at Columbia University. He is based in New York City.
Description of Research	Dr. Baum's overall research focus is on developing effective solutions for reducing the risk of global catastrophe. This work has two specific thrusts. One is social science to understand the social processes that influence the global catastrophic risk. Current research in this thrust include (1) government application of AI for national security purposes and (2) corporate governance of AI, including tensions between social risks and profit motives. The other thrust is quantitative risk and decision analysis for evaluating risks and risk-reduction solutions. This includes attention to the considerable uncertainty inherent to the global catastrophic risks. This research agenda is coupled with outreach to relevant stakeholders and decision-makers in government, industry, and NGOs.
Website(s)	Global Catastrophic Risk Institute: http://gcrinstitute.org Personal website: http://sethbaum.com

Participant	**Richard Bookstaber**
Affiliation	University of California – Chief Risk Officer, Office of the CIO
Email	rbookstaber@gmail.com
Primary Field	Finance and complexity theory
Brief Bio	Richard Bookstaber is the Chief Risk Officer in the Office of the CIO for the University of California, with oversight across its $120 billion pension and endowment. He is the author of The End of Theory (Princeton University Press, 2017), and A Demon of Our Own Design (Wiley, 2007). These books use complexity and agent-based model approaches to look at financial crises. He is now applying these to issues of instability in civilizations. He has had chief risk officer roles at several large hedge funds and banks. From 2009 to 2015 he served in the public sector in the Department of Treasury where he focused in on developing an agent-based model to assess systemic financial vulnerabilities. His roles have put him at the center of some of the critical crises of the last three decades. He received a Ph.D. in economics from MIT.
Description of Research	Bookstaber's focus is applying the tools of complexity theory, and in particular agent-based modeling. As such, he is looking at the course of a civilization as a complex dynamical system. But he is not trying to apply these tools in a rigorous way, because he does not think that is reasonable in this area. However, he looks at the basic propositions underlying how a civilization develops and then falls with this lens.
Definition of "Collapse"	System failure based on complexity of interactions. There is no one cause for a collapse, but a propagation and non-linear feedback. One analogy would be the normal accidents that arise in complex engineering systems.
What is the opposite of "collapse"?	The opposite or antidote to collapse is a system that is leaner and not tightly coupled. Linear means it will not have points of unanticipated complexity and interaction, and not being tightly coupled means it will not have a runaway cascade, because the shock will not move forward more quickly than it can be addressed and contained.

How do we avoid sampling along dependent variables?	History is complex and interactive; it is non-linear and non-ergodic. But it is not a science. There is no theory and there is no basis for empirical tests. We should evaluate approaches based on adherence to what in some simulation settings are called stylized facts. Are we explaining things, is our approach consistent with things that we observe in many historical contexts?
Dependent Variable (What constitutes a collapse)	There is no dependent variable.
Casual Variable (What leads to collapse)	There is no causal variable, though there are places where shocks typically start. For example, famines, wars, natural disasters. But as the system moves forward, vulnerabilities and interactions might lead other areas to become more significant.
How can "Systems Thinking" provide insight into understanding collapse?	It can model how different parts of a civilization, whether in the government/military, economic, of social/cultural layers interrelate.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	There are three layers to a civilization in the way I model it: the government/military, the economic/trade, and the social/cultural. Each is organized in a different way. For example, from a network perspective -- and I am not rooted to a network approach -- the government/military is hierarchical, the economic is random, and the social/cultural is what is usually termed a small-world network.
Relevant Case Studies	I have at the following, which might not be considered different civilizations, but are sufficiently distinct to be addressed with my particular hypothesis: Late Bronze Age, Roman, Han, Roman, Byzantine, Inca, Eastern Roman, Sung, Polynesian, and Western Part I and Western Part II.
Recommended General Readings	Gaddis, Cline, Tainter.

Participant	**Ingrid Burrington**
Affiliation	USC – Fellow, Annenberg Innovation Lab Freelance Writer & Artist
Email	lifewinning@gmail.com
Primary Field	Feral, I'm not an academic
Brief Bio	Writer and artist working with technology, the built environment, and speculative fiction
Description of Research	Representations of dystopia in culture and media
Website(s)	https://datasociety.net/output/future-perfect-2018/, http://exhibits.haverford.edu/futureproof/

Participant	**Peter Callahan**
Affiliation	Princeton University – PIIRS Global Systemic Risk Research Community
Email	pwcallah@princeton.edu

Primary Field	History, Environmental Science
Brief Bio	Peter Callahan is a research assistant for the PIIRS research community on Global Systemic Risk. A graduate from Princeton University, Peter went on to earn his M.S. in Geography and Environmental Studies from the University of New Mexico.
Description of Research	Peter's research has focused on the study of systemic risk, resilience in socio-ecological systems, natural resource management, renewable energy technology, and environmental policy.
Website(s)	http://risk.princeton.edu

Participant	**Miguel Centeno**
Affiliation	Princeton University – Professor, Sociology & WWS, Director, PIIRS Global Systemic Risk research community
Email	cenmiga@princeton.edu
Primary Field	Sociology
Brief Bio	Miguel Centeno is Musgrave Professor of Sociology and International Affairs, and Director of PIIRS Global Systemic Risk at Princeton University where he has taught for 29 years. Professor Centeno has published many articles, chapters, and books including *War and Society* (Polity 2016), *State and Nation Making in the Iberian World* (Cambridge 2013) and *State Making in the Developing World* (Cambridge 2016). He is the founder of the Research Community on Global Systemic Risk funded by PIIRS from 2013-20 and recently published "The Emergence of Global Systemic Risk" in the *Annual Review of Sociology* (2015). From 2012-2017, he served as Chair of the Sociology Department.
Description of Research	Professor Centeno is interested in whether we can find patterns across different types of systemic risk in trade, health, finance, agriculture etc. He is particularly interested in identifying endogenous threats to system stability.
Website(s)	https://risk.princeton.edu
Definition of "Collapse"	I think the critical feature is disaggregation or de-centralization of a system or the increase in potential disorder.
What is the opposite of "collapse"?	I think robustness and resilience may be somewhat oppositional. Robustness is the extent to which a system can resist collapsing, but resilience is the ability to bounce back from a collapse.
How do we avoid sampling along dependent variables?	We can identify critical transitions and then identify cases where those transitions occurred, but where we do not see indications of collapse.
Dependent Variable (What constitutes a collapse)	Intra-systemic exchanges between semi-autonomous units--trade, communications etc.
Casual Variable (What leads to collapse)	The key is differentiating between exogenous variables (e.g., invasion) and endogenous (e.g., loss of elite legitimacy).
How can "Systems Thinking" provide insight into	It provides a holistic way of understand the processes that need to occur for a social status quo to preserver. It also allows us to map out a casual chain of failures (or the absence thereof)

understanding collapse?	
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Trade and communications are critical. "Softer" issues might be the legitimacy of the system overall or its ability to repress dissent.
Relevant Case Studies	The Baltics after 1989, Germany and Japan after 1945
Recommended General Readings	Publications by speakers at conference!
Other Scholars	We should devote some time to discuss future steps

Participant	**Eric H. Cline**
Affiliation	George Washington University – Director, Capitol Archaeological Institute
Email	ehcline@gwu.edu
Primary Field	Archaeology/ancient history
Brief Bio	Eric H. Cline is Professor of Classics and Anthropology, former Chair of the Department of Classical and Near Eastern Languages and Civilizations, and current Director of the Capitol Archaeological Institute at The George Washington University (GWU), in Washington DC. He has degrees in Classical Archaeology, Near Eastern Archaeology, and Ancient History, from Dartmouth, Yale, and the University of Pennsylvania. He is an active field archaeologist, with more than thirty seasons of excavation and survey experience in Israel, Egypt, Jordan, Cyprus, Greece, Crete, and the United States, including formerly serving as co-director at Megiddo (biblical Armageddon) and currently as co-director at Tel Kabri, both in northern Israel. He is also author, co-author, or editor of nineteen books, with three more in progress or in press; among them is 1177 BC: The Year Civilization Collapsed (Princeton University Press, 2014), which has been translated into fourteen languages to date.
Description of Research	Collapse of the Late Bronze Age in the Aegean and Eastern Mediterranean regions ca. 1200 BCE; resiliency and rebirth during the following centuries (which may not be as "dark" in some areas as usually believed)
Website(s)	https://gwu.academia.edu/EricCline; https://www.researchgate.net/profile/Eric_Cline3; https://cnelc.columbian.gwu.edu/eric-h-cline
Definition of "Collapse"	Systems collapse; also possible complexity failure
What is the opposite of "collapse"?	Resilience first; robustness second. Hard to measure; depends upon the situation and the society/culture
How do we avoid sampling along dependent variables?	Have not thought about it; not necessarily relevant to my case study

Dependent Variable (What constitutes a collapse)	In my case study (LBA Collapse), interconnected cultures/societies all happily interacting for several centuries suddenly each have a system's collapse within decades of each other – for each, centralized economy gone; elite gone; writing systems and large architecture gone; population decrease and movements of the survivors
Casual Variable (What leads to collapse)	This is a good question; in my case study, numerous drivers or stressors have been suggested, including invaders, drought, famine, earthquakes, possibly disease, etc; I have argued that it took a "perfect storm" of several of these interacting together, with a multiplier effect in action, in order to cause the collapse, otherwise they would have survived.
Relevant Case Studies	Collapse: Late Bronze Age in Aegean and Eastern Mediterranean regions, ca. 1200 BCE; Resilience: Possible/Some in same region in aftermath of 1200 BCE; e.g., Neo-Assyrians. Others eventually have rebirth, though took centuries in some cases, e.g., in Greece.
Readings for those cases	Cline, E.H. 2014. *1177 BC: The Year Civilization Collapsed* (Princeton University Press), with additional readings given in bibliography
Recommended General Readings	Same as above
Other Relevant Resources	David Kaniewski; research group in France doing pollen analysis at sites; also Neil Roberts, Eelco Rohling, Martin Finné, Jan Driessen, Brandon L. Drake have all published relevant articles or arranged conferences on the LBA Collapse

Participant	**Samuel Cohn, Jr.**
Affiliation	University of Glasgow – Professor, Medieval History
Email	Samuel.Cohn@Glasgow.ac.uk
Primary Field	History
Brief Bio	Professor Cohn received his Ph.D. from Harvard University in 1978. He is presently Professor of Medieval History at the University of Glasgow; was Distinguished Visiting Professor at the University of California, Berkeley in 2008; a Visiting Professor at the University of Antwerp in 2015; and the first Federico Chabod Visiting Professor, L'Università degli Studi, Milano (Statale) in 2017. Over the past two decades, he has focused on the history of popular unrest in late medieval and early modern Europe and on the history of disease and medicine. Funded by grants from the Wellcome and Leverhulme Trusts, his latest book, Epidemics: Hate and Compassion from the Plague of Athens to AIDS, was published by Oxford University Press in 2018.
Description of Research	Since the 1980s I have worked on the Black Death and plagues into the 20th century from various angles--changes in collective mentalities, popular protest, piety, art, family structure and inheritance, governmental reactions, regulations, and medical thinking. My latest book, Epidemics: Hate & Compassion from the Plague of Athens to AIDS, extends my analysis of reactions to epidemics over time, space, and, most significantly, disease. One driving argument of the book is that the character of the disease constitutes the most significant variable determining a population's reactions to epidemics, whether the responses are ones of prejudice, violence, and hatred or of compassion or will prompt political change.
Website(s)	www.gla.ac.uk/schools/humanities/staff/samuelcohn/#/publications,articles,supervision,grants
Definition of "Collapse"	I was asked to speak about the Black Death and resilience. In places such as Florence surviving documents allow historians to estimate population before and after the Black Death of 1348. Over the course of six months, its urban numbers may have collapsed by as much as 75%. Yet within a generation, this city along with others in Italy ushered in

	new mentalities of optimism, new notions of religious piety that hinged on secular ideas of social change and improvement, and new confidence in doctors and their medical experimentation. These sentiments did not represent a thin veneer of intellectual activity as Johann Huizinga once charged and others afterwards such as Ernst Gombrich. Yet not all places flourished after the Black Death. Towns such as San Gimignano have still to regain their population loses of 1348. Moreover, this town and many others lost their banking and commercial importance, not only in the generation after the Black Death but to the present. In some regions, villages disappeared entirely. These, however, were ones already in decline with impoverished lands and peasants. Migration more than the pathogen was the cause of their demise and 'collapse' here can be considered a blessing.
What is the opposite of "collapse"?	From the perspective of the Black Death perspective, collapse must be considered a relevant term; often we are measuring decline. The first measure is population (even if, as with the villages signalled above, a decline in population may have had positive consequences for inhabitants). The second variable concerns the economy, variables such as productivity, which across Europe appears to have declined steeply in the generation after 1348 but c. 1375 surged ahead for the next hundred years or more in many regions in agriculture and industry. A third variable is much harder to quantify—changes in attitudes or mentality and has been the centre of Renaissance studies for at least the past two centuries. For each of these variables, transformation rather than resilience would be the more appropriate word. A distinction should be made between resilience and transformation. For resilience, look at the immediate changes after the Great Famine of 1314-18.
Dependent Variable (What constitutes a collapse)	1) failure of populations to recover over the long term or complete disappearance as with lost villages from the 13th century to the present; 2) levels of out-migration; 3) levels of malnutrition or starvation
Casual Variable (What leads to collapse)	War, epidemics, climate change, extreme scarcity triggered in part by climatic change (but only in part).
Relevant Case Studies	Black Death and plague for both: the European-wide history of abandoning the ill in 1348-50 was followed by the creation of new institutions for succouring the sick, the poor, and orphans in the latter half of the 14th and 15th centuries. Collapse = War, as with the Italian wars, 1495-c. 1530; sacks of cities and villages, military occupation; civil unrest, the breakdown of representative governments. A small case study: the villages of Fusina, in district in the Venetian terraferma, directly across la laguna Véneta, where in September 1509 destruction and the cruelty of foreign troops led to a total evacuation of villages; over 4,000 peasants fled across the Alps. Today this region is a massive parking lot for the car-hungry inhabitants of Venice. As far as I know, there is little remembrance of these villages' pre-1509 existence.
Readings for those cases	For the Black Death= Maurice Beresford, *The Lost Villages of England* (1954); Christopher Dyer, 'Villages in crisis: social dislocation and desertion, 1370–1520', in *Deserted Villages Revisited*, ed. Dyer & Richard Jones, *Deserted Villages Revisited* (Hertfordshire, 2010), 28-45; David Herlihy, 'Santa Maria Impruneta: A Rural Commune in the Late Middle Ages', in Nicolai Rubinstein (ed.), *Florentine Studies: Politics and Society in Renaissance Florence* (London, 1968), 242-76; Cohn, Ch. 3: 'Black Death Persecution and Abandonment' in *Epidemics: Hate & Compassion from the Plague of Athens to AIDS* (Oxford, 2018), 48-67; *Marin Sanudo, I diarii di Marino Sanuto (MCCCCXCVI-MDXXXIII)*, 58 vols (1879-1903), IX, 161.
Recommended General Readings	Maurice Beresford, *The Lost Villages of England* (1954); Christopher Dyer, 'Villages in crisis: social dislocation and desertion, 1370–1520', in *Deserted Villages Revisited*, ed. Dyer & Richard Jones, *Deserted Villages Revisited* (Hertfordshire, 2010), 28-45; David Herlihy, 'Santa Maria Impruneta: A Rural Commune in the Late Middle Ages', in Nicolai Rubinstein (ed.), *Florentine Studies: Politics and Society in Renaissance*

Florence (London, 1968), 242-76; Cohn, Ch. 3: 'Black Death Persecution and Abandonment' in *Epidemics: Hate & Compassion from the Plague of Athens to AIDS* (Oxford, 2018), 48-67; Marin Sanudo, *I diarii di Marino Sanuto (MCCCCXCVI-MDXXXIII)*, 58 vols (1879-1903), IX, 161.

Participant	**Adam Elga**
Affiliation	Princeton University – Professor, Philosophy
Email	adame@princeton.edu
Primary Field	Philosophy
Brief Bio	After receiving a PhD in philosophy from MIT, I joined the philosophy faculty at Princeton in 2001
Description of Research	My areas of interest include decision and game theory, epistemology, philosophy of mind, and philosophy of science. Recently I have done experimental work on people's ability to assess and mitigate the risk of cascading failures.
Website(s)	https://www.princeton.edu/~adame/, https://www.princeton.edu/~adame/papers/cascade/policy-consequences-of-cascade-blindness-preprint-2018-11-29.pdf
How can "Systems Thinking" provide insight into understanding collapse?	Through formal modeling, systems thinking can help us figure out in advance which sorts of systems are at serious risk of suffering serious cascading failures, and what changes to those systems would mitigate that risk. In parallel, psychological research into such systems can help pinpoint blindspots in people's ability to recognize the risk of cascading failure, and can suggest interventions to compensate for those blindspots.

Participant	**Sheldon Garon**
Affiliation	Princeton University – Professor, History and East Asian Studies
Email	garon@princeton.edu
Primary Field	Modern Japanese history and transnational history
Brief Bio	Sheldon Garon is the Nissan Professor of History and East Asian Studies at Princeton University. A specialist in modern Japanese history, he also writes transnational history that spotlights the flow of ideas and institutions between East Asia, Europe, and the United States—notably in his book, Beyond Our Means: Why America Spends While the World Saves (2012). He is currently writing a transnational history of "home fronts" in Japan, Germany, and Britain in World War II, focusing on aerial bombardment, food insecurity, and civilian "morale." Previous publications include Molding Japanese Minds: The State in Everyday Life (1997) and The State and Labor in Modern Japan (1987).
Description of Research	A transnational history of "home fronts" in Japan, Germany, and Britain in World War II, focusing on aerial bombardment, food insecurity, and civilian "morale."
Website(s)	https://history.princeton.edu/people/sheldon-garon
Definition of "Collapse"	I'm most interested in the collapse of "home fronts" during the two world wars. In 1917-18, extreme dissatisfaction with war efforts in Germany, Austria, and Russia led to surrenders. In 1945, Nazi Germany largely "held," but I argue Japan experienced a collapse of civilian morale, followed by rapid reconsolidation.

What is the opposite of "collapse"?	Resilience, reconstruction. In Japan and Germany, the rapid rebuilding of cities was remarkable, compared to a much slower pace in Italy.
Dependent Variable (What constitutes a collapse)	Destruction of cities, millions of refugees fleeing cities, nationwide panic and paralysis
Casual Variable (What leads to collapse)	Aerial bombardment, food blockades.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Organization of neighborhoods, nationwide was key to postwar resilience in Japan and Germany
Relevant Case Studies	Post-WWII Japan and Germany
Recommended General Readings	Richard Overy, The Bombing War

Participant	**Jack Goldstone**
Affiliation	George Mason University – Professor, Public Policy
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Primary Field	Sociology
Brief Bio	Jack A. Goldstone (PhD. Harvard) is Hazel Professor of Public Policy and a Fellow of the Mercatus Center of George Mason University. He is also a Global Fellow at the Woodrow Wilson Center. He is the author of Revolution and Rebellion in the Early Modern World (winner of the 1993 Distinguished Contribution to Scholarship Award of the American Sociological Association), and has authored or edited ten additional books and over 150 book chapters and journal articles on comparative history, political conflict and social change. Goldstone has won Fellowships from the J.S. Guggenheim and MacArthur Foundations, and received the Myron Weiner Award for Scholarly Achievement in Political Demography from the International Studies Association, and the Arnoldo Momigliano Award from the Historical Society.
Description of Research	Revolutions and Comparative History
Definition of "Collapse"	Collapse involves the political leadership losing control over a substantial portion of the territory or population over which it exercised control.
What is the opposite of "collapse"?	Resilience, defined as the ability of the political system to endure local rebellion, economic crises and/or military defeat without losing control over most of the population and territory that it controls.
How do we avoid sampling along dependent variables?	Compare across long time intervals as well as across countries and empires.

Dependent Variable (What constitutes a collapse)	Ending of a dynasty or empire or kingdom
Casual Variable (What leads to collapse)	Vulnerability (gradual failure to reproduce institutions with changes in scale) plus accelerator or trigger event.
How can "Systems Thinking" provide insight into understanding collapse?	Systems can have stable or unstable equilibria; the ultimate cause of social collapse is a political regime shifting from stable (resilient) to unstable (vulnerable) equilibria.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	See my book, *Revolution and Rebellion in the Early Modern World*
Relevant Case Studies	Collapse: Ming Dynasty, Easter Island, Aztec Empire; Resilience: New Kingdom Egypt, Eastern Roman Empire, US in the Great Depression
Recommended General Readings	Jared Diamond, *Collapse* (for errors as well as insights); Peter Turchin and Sergei Nefadov, *Secular Cycles*, Joseph Tainter, *Collapse of Complex Societies*

Participant	**Christina Grozinger**
Affiliation	Penn State University – Professor, Entomology & Director, Center for Pollination Research
Email	cmgrozinger@psu.edu
Primary Field	Entomology
Brief Bio	Christina Grozinger is a Distinguished Professor of Entomology and the Director for the Center for Pollinator Research at Penn State, and a Fellow of the Entomological Society of America. She received her bachelor's degree in chemistry and biology at McGill University, and her master's and doctoral degrees from the Department of Chemistry and Chemical Biology at Harvard University, and was a Beckman Institute Fellow at University of Illinois, Urbana-Champaign. Grozinger uses an integrative approach – from genomics to ecology – to study health and social behavior in bees. The goal of the Center for Pollinator Research is to develop comprehensive approaches to improve pollinator health and reduce declines, working with researchers, stakeholders, educators and policymakers to address these issues. The Center is the largest group of pollinator researchers and educators in the world, with more than 30 faculty and their students and staff engaging in efforts to conserve pollinators.
Description of Research	Grozinger's research program consists of two main areas of study, which examine the mechanisms underlying social behavior and health in honey bees, bumble bees and related species. Her studies on social behavior elucidate the proximate and ultimate mechanisms mediating cooperation and conflict in insect societies. Her studies on pollinator health evaluate the impacts of biotic and abiotic stressors at the molecular, physiological and behavioral level, and examine how bees' resilience to these stressors can be bolstered by management practices and environmental contexts, particularly by improved nutrition.

Website(s)	https://www.grozingerlab.com/, https://ento.psu.edu/pollinators
Definition of "Collapse"	In the systems where I work, the system can no longer function if it is reduce below a certain size or a certain level of complexity. So, a social group cannot sustain itself if the numbers get too small, or a network of interacting species cannot sustain itself if the number of species is too reduced. This then would lead to systemic collapse of the system.
What is the opposite of "collapse"?	Resilience ensures that a system is either not perturbed by a stressor, or can recover quickly. One could measure some aspect of system function (growth, reproduction, mortality, network properties) and see how these change upon acute exposure to a stressor or for longer time thereafter.
How do we avoid sampling along dependent variables?	This is very challenging in biological/ecological systems. One approach is to develop a mechanistic model of your system, and evaluate these factors in field systems to look for correlations with your response variable, and then, ideally, modify the factor that your analysis finds as most significant and see how the response variable changes. Meta-analyses, which include large numbers of studies conducted by different researchers, in different regions, and with slightly different systems and approaches, can also be used to find factors that are consistently associated with a particular response variable. However, without doing highly controlled experiments, it can be nearly impossible to be able to determine which factor, specifically, is the critical factor for determining the outcomes.
Dependent Variable (What constitutes a collapse)	Do you mean the specific variable in our system? This would be the ability to reproduce the society or system. So, a honey bee colony's ability to survive the winter, or a bumble bee colony's ability to produce the next generation of reproductives, or a plant-pollinator networks' ability to sustain itself and reproduce to be present in the next growing season.
Casual Variable (What leads to collapse)	In our case, the direct variable would be the size of a colony, or the reproductive output of the individual. The indirect variables would be lack of nutrition, pesticide exposure, climatic extremes, pathogens or parasites.
How can "Systems Thinking" provide insight into understanding collapse?	Many of the indirect factors that lead to a social group or network being reduced to the point where it cannot recover are interconnected, and act additively or synergistically to cause collapse. Many of these factors (such as pesticide exposure) are the result of broader sociological processes (such as a desire by consumers for unblemished fruit).
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Distribution of tasks, ability of individuals to switch among tasks as needed, and sufficient size such that all tasks can be completed.
Relevant Case Studies	Collapses of honey bee colonies, collapses of plant-pollinator networks
Readings for those cases	https://www.sciencedirect.com/science/article/pii/S2214574515000541 https://onlinelibrary.wiley.com/doi/abs/10.1111/ele.12236
Recommended General Readings	This paper might be useful to think about how the factor leading to pollinator declines are rooted in sociological processes: https://www.sciencedirect.com/science/article/pii/S0048969719300166 and this one could be good for a general overview of what is driving declines: https://www.sciencedirect.com/science/article/pii/S0006320718313636

Other Relevant Resources	I worked with Jeff Gore before, and he seems like he would have an interesting perspective! https://mrl.mit.edu/index.php/123-physicist-jeff-gore-explores-population-dynamics-of-microbes

Participant	**John Haldon**
Affiliation	Princeton University – Professor, History
Email	jhaldon@princeton.edu
Primary Field	Byzantine history
Brief Bio	John Haldon is emeritus Shelby Cullom Davis '30 Professor of European History/Professor of Byzantine History in the History Department, Princeton University. Until 2018 he was Director of the Mossavar-Rahmani Center for Iran and Persian Gulf Studies at Princeton. He studied in the UK, Greece and Germany, has been a Senior Fellow at the Dumbarton Oaks Center for Byzantine Studies in Washington D.C., and is a Corresponding Member of the Austrian Academy of Sciences and a member of the advisory board to the WissenschaftsCampus Mainz and the Haifa University Center for Mediterranean Studies. He has published widely in the fields of medieval history and archaeology, premodern environmental history and the history of comparative state formation. He is Director of the Avkat Archaeological Project (Turkey) and Director the PIIRS Climate Change and History Research Initiative.
Description of Research	Impact of climate and environment on premodern states and societies, nature of state and societal collapse; causal associations between societal and environmental change
Website(s)	https://climatechangeandhistory.princeton.edu/
Definition of "Collapse"	All these terms are relevant, and we should be looking for functionally-relevant and heuristically helpful definitions determined by each specific program or research question.
What is the opposite of "collapse"?	Resilience and sustainability are key terms here, but any term depends on how we wish to deploy it and in what research context
How do we avoid sampling along dependent variables?	The best way is to work collaboratively and to ensure that methodological questions are clearly set out and understood from the start of an inquiry
Dependent Variable (What constitutes a collapse)	There is a wide range of criteria used by different analysts - Tainter presents one set, Cumming and Peterson another, and to list these here would pre-empt our discussion, or some of it!
Casual Variable (What leads to collapse)	Without simplistic over generalizations this has to be determined by reference to case studies and examples where specialists can assemble the necessary data and interpret within an appropriate heuristic framework
How can "Systems Thinking" provide insight into understanding collapse?	By setting out the range of system-specific structures from which one can generalize to a given set of case studies or examples and by taking into account the relationships within a given system of the various component elements (e.g., when is a tipping-point reached in an equilibrium)
What are the key systems underpinning the structure,	How specific an answer is required here? A whole article would be needed to respond usefully to this question! In brief, though: cultural identity; institutional continuity and

dynamics, and resilience of a society/civilization?	flexibility; economic relationships and processes of resource production, extraction, distribution and consumption
Relevant Case Studies	I would argue that most cases of 'collapse' are not in fact collapses at all, but are rather subject to a process of chronological conflation and analytical simplification that conceals substantial differences in spatial and temporal scale and impact. We should not describe longer-term, spatially-differentiated shifts and transformations, whether or not they result in a civilizational shift, as collapses unless a series of more-or-less major systemic tipping points coincide over a relatively short term (annual, decadal at most)
Readings for those cases	See, e.g., -G.D. Middleton, 'The show must go on: collapse, resilience and transformation in 21st-century archaeology', Reviews in Anthropology (2017), DOI: 10.1080/00938157.2017.1343025; -G.D. Middleton, *Understanding Collapse: Ancient History and Modern Myths* (Cambridge 2017); -G.S. Cumming and G.D. Peterson, 'Unifying research on social-ecological resilience and collapse', Trends in Ecology and Evolution 32 (9) (2017), 695-713; -Haldon, J., White, S., Akçer-Ön, S., Allcock, S., Bozkurt, D., Cassis, M., Doonan, O., Eastwood, W.J., Elton, H., Fleitmann, D., Izdebski, A., Laparidou, S., Lüterbacher, J., Mordechai, L., Newhard, J., Pickett, J., Preiser-Kapeller, J., Roberts, N., Sargent, A., Soroush, M., Toreti, A., Wagner, S., Xoplaki, E., Zorita, E., eds. Society and environment in the East Mediterranean ca 300-1800 CE. Resilience, adaptation, transformation. Special Issue of Human Ecology, 46/3 (June 2018);
Recommended General Readings	see above - a very large bibliography can be supplied.
Other Relevant Resources	Princeton CCHRI - https://climatechangeandhistory.princeton.edu

Participant	**Jeff Hass**
Affiliation	University of Richmond – Professor, Sociology and Anthropology
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Primary Field	Economic, political, and historical sociology
Brief Bio	I study tensions of change versus reproduction, power versus resistance, order versus disorder. My first project (beginning with my dissertation at Princeton) explored Russian post-socialism as a combination of collapse and contentious reconstruction. Contradictions between new rules and previous habits, between different collective fields and their rules of economic normality, were at the heart of that work. I return to this topic at times: I am working on post-socialist politics (invoking Barrington Moore's model), and with Russian colleagues I am analyzing contradictions of economic fields in Russian and Soviet history. My second project uses the Blockade of Leningrad to explore perceptions and practices under duress: again, tensions between compelled adaptation and durability of habits. (We are rational, but within limits.) When suffering and death stare us in the face, we do not entirely revert to homo economicus: empathy and symbols matter, crystalizing around anchors of valence.
Description of Research	My current work on war and survival, using the Blockade of Leningrad as a case, explores how people respond to extreme duress, when survival incentives threaten institutional efficacy, and all that seems left are intimate relations and empathy. This project uses archival materials: wartime diaries, interviews (during the war and later), and records of the elite, police and NKVD, Communist Party, and various bodies inside the command economy. The study analyzes how actors perceive their context, respond to it,

	and then reflect on consequences. One interesting trend is that empathy, social distance, and other entities of valence seem to affect decision-making: the more significant some Other (person or otherwise) is, the more likely one will shape his or her strategies with reference to that entity. The upshot is that local order seems grounded in no small part in empathy, not calculation or institutions.
Website(s)	https://socanth.richmond.edu/faculty/jhass/ http://richmond.academia.edu/JeffHass https://scholarship.richmond.edu/socanth-faculty-publications/
Definition of "Collapse"	(As I am probably the newbie in the room, all this might seem naïve or out there.) I understand "collapse" to vary empirically, but at heart my gut feeling is that "collapse" is a disaggregation of working practices and relations (e.g., structures, institutions) at a higher level of social organization (nation-states, empires), or a non-trivial failure of preexisting relations and practices to operate as they (e.g., situating people into relations of authority and coordination). It happens in a relatively uncontrolled, rapid, non-trivial, and dramatic fashion ("collapse" implies something dramatic, after all). Collapse can involve entire sets of relations unraveling, but more likely it involves higher-order relations that integrate or subordinate smaller-level communities and relations. This is what happens in revolutions: not chaos, but many more, smaller competing groups (and with less order, more possibility for violence). I'm not sure collapse is longer-term—a better term for that might be "decay," in that one sees relations and rules lose their import and has time to do something but does not do it (due to complexity, infighting, incompetency, egoism, etc.); collapse almost suggests beyond control.
What is the opposite of "collapse"?	Two possible opposites of "collapse" are: "concatenation" (stringing entities together into some order), or "resilience" (resisting forces of disambiguation or contention). Resilience suggests some strength in resisting shocks or assaults, whether by some defined force, or by a chaotic context. Concatenation suggests creating order, whether buttressing or rebuilding what is collapsing, or remaking existing relations to deflect forces of collapse. Both require mobilizing people and resources to fend off "social entropy." The challenge of measuring collapse and robustness is what we really are measuring. (Warning: chemistry geek moment.) The chemical bond is almost everything, and we measure bond strength by burning something and measuring change in temperature—we know the energy of molecular bonds and the molecule. Structure and overall energy level of the molecule determines its stability. In the social sciences, we have no equivalent of "energy," and the "bond" (e.g., networks) and "molecule" (systems) are cruder. Until we figure out social or institutional equivalents to "energy," this remains thorny issue. (The only equivalent would be to measure "remorse" or "grief" as an equivalent form of bond, whether to another or to a collective. I have no idea at the moment of how to so this. Sorry.)
How do we avoid sampling along dependent variables?	Caveat: If "collapse" is, like an "event," something we know only after the fact, can we think about sampling on dependent of independent variables (since the "dependent variable" is constructed afterwards)? Did the Roman Empire "collapse," or did it "mutate" into smaller sets of entities? Is "collapse" like obscenity (I know it when I see it)? The obvious answer is to sample on independent variables—but what are these? One area to look at would be from macroeconomics, especially work related to recessions and other shocks. For example, yield curve inversions (when the yield on long-term Treasury securities becomes less than the yield for short-term securities) supposedly are good predictors that a recession is on the near horizon—investors are losing confidence in the economy and don't want to tie up their money and lose maneuverability in the case of economic uncertainty. Shifts in availability of important material resources might be one predictor that a social system will be under duress and then subject to distributional conflicts and the like. However, "demography is not destiny"—institutional variables need to be added, especially those that might causally impact responses to duress.

Dependent Variable (What constitutes a collapse)	I'm not sure that "collapse," as a collective disaggregation (and reordering) of intersubjective relations and practices, has clear "variables," or at least clear relations of causation that more in one direction. One problem with measuring collapse is that, as "trauma culture" literature suggested (Jeffrey Alexander et al, see also William Sewell on "events"), we don't really know an event, such as collapse of something of high risk, when we are inside it. Those social things are defined afterwards. So, it might be difficult to pin down such a dependent variable in the first place. One idea might be to disaggregate "collapse" from consequences. One presumption of collapse and risk is that each results in a decline in well-being (at least for much of the population). Well-being, and provision for well-being, should be easier to measure (e.g., changes in health and resource availability, institutional effectiveness in delivering protection from want, resources, etc.)—I'm thinking of something similar to Goldstone's PSI measure that predicts the possibility of an oncoming revolution (institutional breakdown). A combination of "decline in well-being" and "speed" could be one step forward.
Casual Variable (What leads to collapse)	If I'm not sure about "collapse," then I'm not sure about variables to operationalize and measure, or if there are one-way causal relations. I suspect there are longer-term or steady-state dynamics that potentially weaken institutional and structural robustness, along with proximal shocks that stress and bring down those institutions. This conjunctural approach has been useful for revolutions. But what variables are in the conjuncture? Stresses or strains that 1) shift incentives to cooperate, obey, or otherwise play be existing rules and relations; 2) shifts in entities of personal or meaningful valence that alter one's sense of loyalties (to or with what or whom one orients and identifies interests, self, and the "normal"). But "stresses or strains" don't make for clean variables, and there are also contingent game-theoretic interpretations of stresses and responses. Or maybe the variables are at the level of emergent properties. But this still doesn't pin things down. Obviously, access to resources necessary for survival are key: greater scarcity means greater incentives or compulsions (the two are not the same) to disobey and defect, in the name of survival, matters, but is coercion grounded in legitimacy of the social order—enough people with "violent capital" will defend it?
How can "Systems Thinking" provide insight into understanding collapse?	This depends on how we think of systems. We should be careful of reifying "systems" as something real, when they are reifications and simplifications of many simpler, lower-order relations. I sometimes go back to ideas from John Martin, especially his work on structures. Local relations concatenate upwards into more complex structures that gain a life of their own (emergent properties, like fields) but that, at their core, are also rather fragile, based as these complex structures are on this concatenation of lower-level order. (Consider the cauliflower. It seems complex, but look closely and you see simple lower-order patterns aggregating "upward," almost fractally.) My own studies (post-socialist change and wartime survival) suggest the importance of that lower-level order that concatenated "upward." This gains from thinking this way might be: 1) We don't lose sight of lower-order fundamentals that are the bedrock of systems, a quantum mechanics; and 2) Those concatenated systems can have emergent properties. As Marx proposed, higher-order systems, with emergent properties, can create contradictions (within or between systems) that eventually break systems apart—duress shifts loyalty and sparks disaggregation into smaller units tied as much by empathy as interests. This is also the logic of field.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	For social systems, empathy is crucial to holding things together: sympathy and antipathy help us structure relations into meaningful order and give them some stability. In a sense, empathy is like electrostatics or a strong relation in quantum mechanics: a force that provides the foundation for other forms of order. (I take this idea from the work of Daniel Kahneman et al.). While empathy usually works in face-to-face interactions—it is easier to empathize, sympathize, and relate to an Other you see—empathy could extend somewhat beyond the visible. Benedict Anderson claimed shared language and literature created a sense of a shared community in which we could assume another in that group was similar to us. Perhaps—but I wonder if sufficient evidence of shared trials and

	tribulations, especially shared suffering, can extend empathy beyond those we see, to vast others whom we may never meet. Could this be why war helps make nations—creating a sense of shared suffering and sacrifice that extends empathy, so that other "Soviets" suffer as we did, and worse than other Europeans? Could this also be how war can break nations—by creating evidence or a sense that other groups don't suffer as much?
Relevant Case Studies	The history of Russia/USSR, and St. Petersburg/Leningrad specifically, in the first half of the twentieth century is intriguing: we have both collapse (Russian Revolution, sparked in Petrograd) in the context of world war, and teetering on the edge but survival (country and same city) in the next world war. The Blockade is interesting because you see both. Institutions were under duress, and while they did not fall apart as in 1917, that was an ever-present threat—and perhaps just as important, there was institutional decay, in part thanks to a growing and non-trivial shadow economy that was sapping the state of resources (especially food) that were a foundation for legitimacy and dependency power (authority). However, at lower levels (e.g., kith and kin), wartime duress could test and strengthen bonds of empathy, especially when visibility of suffering invoked not only sympathy, but also a sense of needing to defend dignity. One important buttress of the regime's institutional and symbolic foundations, arguably, was how Nazi ferocity generated resistance in the name of dignity and defending one's own. (This has been an anecdotal claim, but it needs more rigorous study.) Leningraders identified with others on the basis of shared suffering and indignity.
Readings for those cases	There is a plethora of readings on Petrograd/Russia and World War I and the Russian Revolution, from eyewitness accounts to later scholarly studies. Historical accounts do not always consider "systems" but provide data that we can use ourselves. Theda Skocpol's classic study of revolutions is useful for framing all those historical works. For the USSR in World War II, that scholarship is only beginning to emerge, and there are a handful of Russian-language sources that would provide a systematized analysis and interpretation beyond recounting what happened (which still requires much more work).
Recommended General Readings	I still find Jack Goldstone's work on revolutions to provide an intriguing way to approach potential for collapse (note that he redefines "revolution" as "state collapse"). Also, John Martin's work on social structures and fields are intriguing; see my earlier discussion. This is similar to fractal thinking.

Participant	**Sherwat Elwan Ibrahim**
Affiliation	American University in Cairo – Professor, Management
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Primary Field	Business Operations and Supply Chain Management
Brief Bio	Sherwat Elwan Ibrahim is Associate Professor of Management and Director of MBA Programs at the School of Business, American University in Cairo (AUC). She holds a Master's and Ph.D. in Technology Management from Stevens Institute of Technology, NJ. Ibrahim's research interests include sustainable supply chain management, global value chain governance, and technology adoption and diffusion. She has several publications in prestigious journals including Journal of Economic Geography, Strategic Outsourcing Journal, Journal of Manufacturing Technology Management, Management Decision, and has been jointly awarded the Ted Eschenbach prize for Best paper in Engineering Management Journal, and the "Bright idea" award, for her paper in New Jersey Publications. Sherwat teaches several courses in the area of Operations and Technology Management.
Description of Research	My research focus is on global value chains and network governance and how it could possibly relate to sources of systemic collapse. The sustainability of economic consumption and distribution within modern global systems of trade and transport are

	riskier and more dangerous than ever. Global inter-dependencies indicate that we are living through the most extensive economic aggregation of world history which is bound to dis-aggregate. My aim is to investigate the different components of this global system; the complexity of its network, the number and types of nodes and linkages, and to study the various governance structures that could survive in dis-aggregation. In parallel, I am also interested and have done some work on the effect of technology adoption and diffusion on 'sharing economies' and the resulting socio-economic aggregation and/or fragmentation of complex systems that require more and/or less order, complexity, coordination, and organization to function.
Website(s)	https://www.aucegypt.edu/fac/sherwatelwan
Definition of "Collapse"	I relate most to Perrow's perspective of "system accidents" (or normal accidents) where collapse is inevitable given the complexity and coupling characteristics of the system involved. A system accident is an "unanticipated interaction of multiple failures" in a complex system (despite efforts to avoid them). This complexity can be either of technology or people organization, and frequently has major aspects of both. A system accident can be easy to see in hindsight, but difficult in foresight because there are simply too many different action pathways to seriously consider all of them. Perrow's argument, based on systemic features and human error, is that big accidents tend to escalate, and technology is not the problem, but organizations are. And that big accidents almost always have very small beginnings, where events appear trivial to begin with before unpredictably cascading through the system to create a large event with severe consequences.
What is the opposite of "collapse"?	Both robustness and resilience
Dependent Variable (What constitutes a collapse)	Unanticipated interaction of multiple failures
Casual Variable (What leads to collapse)	The system is complex. The system is tightly coupled. The system has catastrophic potential.
Relevant Case Studies	Collapses: Three Mile Island: A Nuclear Crisis
Readings for those cases	Perrow, Charles (1984). *Normal Accidents: Living with High-Risk Technologies*, With a New Afterword and a Postscript on the Y2K Problem, Princeton, New Jersey: Princeton University Press, ISBN 0-691-00412-9, 1984, 1999
Recommended General Readings	Guillén, Mauro, (2015). *The Architecture of Collapse: The Global System in the 21st Century*

Participant	**Robert Jensen**
Affiliation	University of Texas – Emeritus Professor, School of Journalism
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Primary Field	Media studies, with interdisciplinary interests
Brief Bio	Robert Jensen is Emeritus Professor in the School of Journalism at the University of Texas at Austin, a founding board member of the Third Coast Activist Resource Center in Austin, TX, and part of the team developing Ecosphere Studies at The Land Institute in Salina, KS. He is the author of The End of Patriarchy: Radical Feminism for Men (2017);

	Plain Radical: Living, Loving, and Learning to Leave the Planet Gracefully (2015); Arguing for Our Lives: A User's Guide to Constructive Dialogue (2013); All My Bones Shake: Seeking a Progressive Path to the Prophetic Voice, (2009); Getting Off: Pornography and the End of Masculinity (2007); The Heart of Whiteness: Confronting Race, Racism and White Privilege (2005); Citizens of the Empire: The Struggle to Claim Our Humanity (2004); and Writing Dissent: Taking Radical Ideas from the Margins to the Mainstream (2002).
Description of Research	Journalistic writing on ecological sustainability and social justice
Website(s)	http://robertwjensen.org/
Definition of "Collapse"	When bio-physical realities force humans to abandon delusional thinking.
What is the opposite of "collapse"?	A return to a sustainable human presence on the planet. There is no way to measure that; it has to be worked out over time.
Casual Variable (What leads to collapse)	The temptations of dense energy and the unsustainable complexity that results from use of that energy.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Resilience requires people with the skills to live in a low-energy world and the values that are required to reject social hierarchies.

Participant	**Luke Kemp**
Affiliation	University of Cambridge – Research Associate, CSER
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Primary Field	Human Ecology
Brief Bio	Luke is a Research Associate at the Centre for the Study of Existential Risk (CSER) at the University of Cambridge. He focuses on how we can foresee and govern global risks. This includes understanding why societies collapse, the threats of emerging technologies and how to build an anti-fragile world. He advised the Australian Parliament on ratifying the 2015 Paris Agreement on climate change and his research has been covered by media such as the New York Times, the Guardian, the Washington Post, the BBC and the New Yorker. Luke holds both a Doctorate in International Relations and a Bachelor of Interdisciplinary Studies with first class honours from the Australian National University (ANU).
Description of Research	My research focuses on the relevance of systems collapses to today's global society. I seek to identify the contributors and patterns to collapse and how these can be used to foresee systems failures in our modern world. This includes selecting metrics for contributors to collapse and resilience and tracking these in current and historical societies. As part of this, I am an exploring how modern civilization echoes or differs from other complex societies, and why a deep future collapse could be comparatively better or worse. The end goal is to construct both an underlying theory of why societies fail and a strategy for making an anti-fragile world.

Website(s)	https://www.cser.ac.uk/team/luke-kemp/, https://scholar.google.co.uk/citations?user=Kd-EpXgAAAAJ&hl=en
Definition of "Collapse"	A tipping point phenomena in which the state is lost and socio-economic complexity falls. It must be quick and enduring (relative to the speed of the system) and involve a significant loss of population, social-economic capital and the identity of the system.
What is the opposite of "collapse"?	Anti-fragility. The ability to grow from randomness and variety without losing the fundamental identity of the system.
How do we avoid sampling along dependent variables?	Have more explicit, clear definitions and metrics for measurement.
Dependent Variable (What constitutes a collapse)	The presence of a central government, population, natural and social capital and energy use (as a proxy for socio-economic complexity).
Casual Variable (What leads to collapse)	Inequality, environmental degradation, climatic change, diminishing returns from complexity, external shocks, randomness (potentially self-organized criticality), a lack of resilience and systemic fragility. All of these coalesce together under the Red Queen Effect.
How can "Systems Thinking" provide insight into understanding collapse?	Collapse is a tipping point phenomenon. It is an emergent systems behavior. Understanding the underlying dynamics and feedback loops that lead to, or prevent it are indispensable. It is the only way to truly understand what collapse is, why it occurs, and how to limit it.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Food, water, energy, military, government (taxation and expenditure) and civil society institutions. The nature of the systems, such as whether they are tightly coupled, is critical to their resilience and fragility.
Relevant Case Studies	Collapse = Chacoan society, the Cahokia and the Western Roman Empire. Resilience-Harappan and the Third Dynasty of Ur.
Readings for those cases	Understanding Collapse: Ancient History and Modern Myths, Collapse of Complex Societies.
Recommended General Readings	Anti-Fragile: How Things Gain from Disorder, Normal Accidents, The Life-Span of Empires (Arbesman), Scale (Geoffrey West), Why do Societies Collapse (Brunk), 1177 BC.
Other Relevant Resources	We need to have greater involvement from complexity scholars. I would suggest recruiting participants from the Santa Fe Institute and the New England Complex Systems Institute.

Participant	**Ann Kinzig**
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Email	kinzig@asu.edu
Primary Field	Ecology

Brief Bio	Ann Kinzig is a Professor in the School of Life Sciences at Arizona State University (ASU). Her research and teaching focus broadly on ecosystem services, conservation-development interactions, the resilience of natural-resource systems, and transforming university research to be more socially relevant. Before arriving at ASU, Dr. Kinzig served for a year in the Office of Science and Technology Policy in the Executive Office of the President (1998-99) and was a post-doctoral researcher and lecturer at Princeton University (1994-1998). She received her B.A. in Physics from University of Illinois Urbana-Champaign (1986), her M.A. in Physics from University of California at Berkeley (1989), and her Ph.D. in Energy and Resources from Berkeley (1994).
Description of Research	I have, for over a decade, collaborated with archeologists concerning the transformation and disappearance of pre-Hispanic cultures in the American Southwest and Northern Mexico. We have examined how the magnitude of transformation can be related to the severity of environmental stressors, and the degree of social rigidity in each culture.
Definition of "Collapse"	Systemic collapse seems to best capture "collapse", but equally important for many human societies are processes of transformation and change.
What is the opposite of "collapse"?	Persistence would be the opposite of collapse. Of course, persistence is enabled by robustness and/or resilience. The measurement is the perennial problem in human systems.
Dependent Variable (What constitutes a collapse)	There is no single answer to this question
Casual Variable (What leads to collapse)	An overwhelming stressor. Agents in the system who benefit from bringing it to the edge of collapse.
How can "Systems Thinking" provide insight into understanding collapse?	It is often the properties of the system that are the measures of whether a collapse has occurred. But systems thinking would also help in identifying the ultimate, rather than proximate, causes of collapse.

Participant	**Tim Kohler**
Affiliation	Washington State University, the Santa Fe Institute, and Crow Canyon Archaeological Center – Archaeologist
Email	tako@wsu.edu
Primary Field	Archaeology
Brief Bio	I'm an archaeologist who works primarily in the US Southwest, affiliated with Washington State University, the Santa Fe Institute, and Crow Canyon Archaeological Center. My interests include social responses to climate change, and the explanation of variability in violence and wealth inequality.
Description of Research	For almost two decades I've coordinated the Village Ecodynamics Project in the northern US Southwest, a project that combines inferential approaches based on the archaeological record with modeling approaches stimulated by my interests in complex adaptive systems.
Website(s)	https://anthro.wsu.edu/faculty-and-staff/tim-a-kohler/; https://www.crowcanyon.org/index.php/village-ecodynamics-project

Definition of "Collapse"	"Every unhappy family is unhappy in its own way." There are all sorts of varieties of ways in which societies malfunction and fall apart.
What is the opposite of "collapse"?	"Happy families are all alike." Happy societies produce enough wealth and well-being for all their inhabitants to provide incentives to hang together.
How do we avoid sampling along dependent variables?	We have to be as interested in successful and productive phases of societies as we are in the downturns
Dependent Variable (What constitutes a collapse)	I like to look at the interplay of wealth differentiation, violence, aggregation, and productivity per capita.
Casual Variable (What leads to collapse)	Downturns in productivity per capita, a joint function of momentary population and agricultural production.
How can "Systems Thinking" provide insight into understanding collapse?	I'll suggest that societies that get isolated from larger social systems are particularly subject to collapse
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Societies must be appropriately coupled to both other societies and to their ecosystems.
Relevant Case Studies	I'm especially interested in the commonality of boom and bust cycles among Neolithic societies, and analyze an example from the northern US Southwest in detail.
Readings for those cases	-2016 Schwindt, D. M., R. K. Bocinsky, S. G. Ortman, D. M. Glowacki, M. D. Varien, & T. A. Kohler, The Social Consequences of Climate Change in the Central Mesa Verde Region. American Antiquity 81(1):74-96. -2016 Bocinsky, R. K., Johnathan Rush, Keith W. Kintigh, & T. A. Kohler, Exploration and Exploitation in the Macrohistory of the Prehispanic Pueblo Southwest. Science Advances 2, e1501532. DOI: 10.1126/sciadv.1501532. -2016 d'Alpoim Guedes, Jade, Stefani A. Crabtree, R. Kyle Bocinsky, & T. A. Kohler, 21st-Century Approaches to Ancient Problems: Climate and Society. PNAS 113:14483-14491.
Other Scholars	My impression from the list of invitees is that paleoclimatology is under-represented.
Other Relevant Resources	Felix Riede (Aarhus) and Payson Sheets (UC-Boulder) convened a workshop with a very similar title in Fall 2018, as did Tim Cunningham & Jan Driessen (University of Louvain). The latter produced an edited volume entitled *Crisis to Collapse: The Archaeology of Social Breakdown* (Presses Universitaires de Louvain, 2017).

Participant	**Paul Larcey**
Affiliation	University of Cambridge – Centre for Smart Infrastructure and Construction
Email	pl318@cantab.net

Primary Field	Resilience and risk in large scale infrastructure systems
Brief Bio	Paul Larcey studied engineering and materials science for both his undergraduate & master's degrees (Universities of Oxford & Cambridge respectively), and received an MBA in Finance (Imperial College Business School). He worked initially in a corporate research environment, followed by venture capital, before moving into global industrial sectors closely involved in funding strategies for major projects (public and private) primarily in the infrastructure/engineering sectors with a focus on risk analysis in challenging environments. He is currently working with the Centre for Smart Infrastructure at the University of Cambridge on infrastructure resilience.
Description of Research	Infrastructure systems have become so pervasive and essential to modern societies that their destruction or even partial incapacity would have huge implications across developed and developing economies. It is possible to argue, using classic definitions of technology, that infrastructure is the most fundamental of all technologies Both existing and emerging increasingly interconnected technologies have the capacity on failure to cascade and easily cross-national borders creating regional if not global systemic risks in a world that is increasingly seen as at the edge of stability politically, economically and environmentally. By studying sample systems of infrastructure, we are hoping to determine potential tipping points and cascade failure points within highly coupled systems, utilizing both engineering and financial modelling methodologies to understand the entire complexity of selected systems.
Website(s)	https://www-smartinfrastructure.eng.cam.ac.uk
Definition of "Collapse"	Understanding systemic risks requires the study of a system along with its boundaries. It's possible that boundary conditions may keep the system in a stable macroscopic state even with continuous micro change. However, when the boundary conditions exceed threshold values they can drive the system into a state of instability from which new dynamic structures may spontaneously emerge when appropriate internal conditions dominate.
What is the opposite of "collapse"?	Resilience is still evolving as a concept and there is as yet no fully accepted definition but it can be seen as the behavioral property of a system as it responds and recover to shock.
How do we avoid sampling along dependent variables?	Infrastructure systems failures contain both an engineering element and human agency failure so it is vital to examine all aspects of systems failure to avoid bias in the engineering/human interaction.
Dependent Variable (What constitutes a collapse)	The collapse of large scale organized structures.
Casual Variable (What leads to collapse)	Nodes within systems.
How can "Systems Thinking" provide insight into understanding collapse?	With increasing interconnectedness, the lack of information about the nature, scale, likelihood, and potential effects of systems failures or hazards is becoming harder to determine at international levels or smaller national levels. The very nature of these hazards, and the large number of potential events creates problems in preparing for all of them. By utilizing a systems approach we are able to set boundaries within which allows us to model a whole system, with caveats, to reduce the effects of dynamics operating within the system. By use of systems thinking models we can observe the leverage points to identify the main causes of systems tipping points.

Recommended General Readings	-Park J, Seager T, Rao P, Convertino M, Linkov I. Integrating risk and resilience approaches to catastrophe management in engineering systems. Risk Analysis, 2013; 23:356–367. -Newman, M. E. J. 2005. "Power Laws, Pareto Distributions, and Zipf's Law." Contemporary Physics 46 (5): 323–351. -Patrick Helm (2015) Risk and resilience: strategies for security, Civil Engineering and Environmental Systems, 32:1-2, 100-118, DOI: 10.1080/10286608.2015.1023793 -Perrow C. Normal accidents: living with high risk technologies. New York: Basic Books, 1984.

Participant	**Tim Lenton**
Affiliation	University of Exeter – Director, Global Systems Institute & Chair, Climate Change and Earth System Science
Email	t.m.lenton@exeter.ac.uk
Primary Field	Earth system science
Brief Bio	Tim Lenton is Director of the Global Systems Institute and Chair in Climate Change and Earth System Science at the University of Exeter. His research focuses on understanding the behavior of the Earth as a whole system, especially through the development and use of Earth system models. He is particularly interested in how life has reshaped the planet in the past, and what lessons we can draw from this as we proceed to reshape the planet now – as described in his books 'Revolutions that made the Earth' (with Andrew Watson) and 'Earth System Science: A Very Short Introduction'. Tim's work identifying climate tipping points won the Times Higher Education Award for Research Project of the Year 2008. He has also received a Philip Leverhulme Prize 2004, European Geosciences Union Outstanding Young Scientist Award 2006, Geological Society of London William Smith Fund 2008, and Royal Society Wolfson Research Merit Award 2013.
Description of Research	I work on tipping points in complex systems and early warning signals for them. In the past, I have focused mostly on the identification of climate tipping points and establishing whether and when there are early warning signals of them. Currently I am part of a small group working on identifying the human climate niche, where past civilisations arose in that niche, and whether their rise and fall is related to past cyclic climate variability. I am also working on identifying tipping points of positive change towards a more long-term sustainable and climate-resilient future civilisation.
Website(s)	https://www.exeter.ac.uk/gsi/ http://geography.exeter.ac.uk/staff/?web_id=Timothy_Lenton
Definition of "Collapse"	Systemic collapse is a good target definition in that it implies a complex interconnected system. My reservation with it is that it could be taken to imply everything goes when 'the system' goes. This is (Bruno) Latour's objection to the totalitarianism of 'the system' and the parts-whole distinction. If we view civilizations as networks of actors that have extended themselves in space and time and attained new levels of organization, then perhaps it is better to consider collapse as 'loss of level(s) of organization'. It could also be considered as loss of spatial (geographical) extent of influence. Obviously the word 'collapse' already implies loss of temporal extent of influence (i.e., something coming to an end).
What is the opposite of "collapse"?	Maintaining new/higher levels of organization and associated functionality, across an expanded spatial extent and over time. This requires some identification of what those levels of organization and functionality are (and I am not an expert on societies/civilizations).
How do we avoid sampling along	(Ask a good statistician!) It's probably worth looking at Bottiger and Hasting's critique of tipping point early warning indicator studies, highlighting 'the prosecutor's fallacy' and

dependent variables?	other pitfalls. Clearly there needs to be an appropriate null model to test against when looking for a signal.
Dependent Variable (What constitutes a collapse)	Something to do with higher levels of organization of societies/civilizations: I imagine this could relate to forms and mode of information transfer / communication within the society, as well as to structural measures of organization.
Casual Variable (What leads to collapse)	As many others note this could be multi-variate. Candidates for influence include aspects of climate (especially drought, noting this has several different climatological definitions), measures of resource availability/depletion (e.g., food production, forests if wood is a fuel source, water supply and state thereof), interaction with other societies/civilizations in a wider network, etc.
How can "Systems Thinking" provide insight into understanding collapse?	Perhaps 'complex systems thinking' as the key is to recognize and embrace complexity and interactions and recognize that new levels of organization can exist/emerge/be lost. I think 'evolutionary thinking' is also key to marry with 'systems thinking' – the result is what Si Levin and others would call 'complex adaptive systems thinking'. It can provide insight by helping us understand not just how things are, but how they came to be that way – i.e., what was the evolutionary (selection) process that gave rise to a preponderance of a particular things/outcome over other possible things/outcomes.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	All self-organizing complex systems require an energy input (here via food, human/animal labour, fuel sources…), a material input (food, all the material to build and maintain the structures of a society…), and internal information flows, in order to maintain a complex (low entropy, highly ordered) state. The society/civilization 'meta-system' may indeed be (self-)organized into sub-systems that help support its advanced functionality, but whether there is an analogy to 'organs' in a complex multi-cellular organism, I am not sure. It is hard to disentangle energy/materials/information to try to identify sub-systems for each, although clearly that is possible to a degree with notions of e.g., 'food system', 'communications system', etc.
Relevant Case Studies	(I am not an expert on society/civilization collapse so my examples will just be pop-cultural ones. I can give you examples of collapse/resilience in Earth systems if they provide helpful analogies?)

Participant	**Simon Levin**
Affiliation	Princeton University – Professor, Ecology & Evolutionary Biology
Email	slevin@princeton.edu
Primary Field	Ecology
Brief Bio	Simon Levin is James S. McDonnell Distinguished University Professor in Ecology and Evolutionary Biology at Princeton. His research investigates how macroscopic patterns and processes are maintained at the level of ecosystems, the biosphere, and societies. He has been President of the Ecological Society of America and the Society for Mathematical Biology. Levin is a Fellow or Member of the American Academy of Arts and Sciences, the National Academy of Sciences and the American Philosophical Society. He won the MacArthur, Eminent Ecologist and Distinguished Service Awards of the Ecological Society of America; the Okubo Prize of the Society for Mathematical Biology and the Japanese Society for Theoretical Biology; the Heineken Prize for Environmental Sciences; the Tyler Prize for Environmental Achievement; the Margalef Prize for Ecology; the Kyoto Prize for Basic Science; and the National Medal of Science. Levin has mentored more than 100 doctoral students and postdoctoral fellows.
Description of Research	His research interests are in understanding how macroscopic patterns and processes are maintained at the level of ecosystems and the biosphere, and in the interface between

	basic and applied ecology and socioeconomic systems. Of special interest is the existence of multiple basins of attraction in dynamical systems, the potential for regime shifts, early warning indicators, and the evolution, emergence and design of robustness.
Website(s)	https://slevin.princeton.edu/
Definition of "Collapse"	I would define collapse in terms of the mathematical notions of multiple basins of attraction and of structural stability. Those notions however include not only negative outcomes, but also escape from disadvantageous situations as well as critical phenomena in system development, in the sense of C.H. Waddington and Rene Thom
What is the opposite of "collapse"?	There are two different notions here. One, as developed in the previous bullet involves critical transitions that lead to regime shifts that are in some sense improvements. The second is robustness (or as some term it, resilience, which includes resistance to and recovery from displacement to alternative basins of attraction.
How do we avoid sampling along dependent variables?	In the absence of controlled experimentation, I would opt for mechanistic models
Dependent Variable (What constitutes a collapse)	Macroscopic system properties of relevance and interest
Casual Variable (What leads to collapse)	Common drivers as well as chains of collapse
How can "Systems Thinking" provide insight into understanding collapse?	Systems thinking is crucial, with a focus on scaling, interconnectedness, emergence and conflicts among agents at distinct levels.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Climate, nutrient cycles, biodiversity maintenance, culture, government, laws, economies
Relevant Case Studies	Easter Island, Roman Empire, Great Depression, Russian Federation
Readings for those cases	Jared Diamond, Collapse; Marten Scheffer, Critical transitions; Peter Turchin, multiple books
Recommended General Readings	Scheffer book listed above
Other Relevant Resources	Stockholm Resilience Centre, esp. website on critical transitions

Participant	**Igor Linkov**
Affiliation	US Army Engineer R&D Center – Lead, Risk and Decision Science Focus Area
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Primary Field	risk analysis
Brief Bio	Dr. Igor Linkov is the Risk and Decision Science Focus Area Lead with the US Army Engineer Research and Development Center, and Adjunct Professor with Carnegie Mellon University. Dr. Linkov has organized more than thirty national and international conferences and continuing education workshops. He has published widely on environmental policy, environmental modeling, and risk analysis, including twenty books and over 350 peer-reviewed papers and book chapters in top journals. He is Elected Fellow with the American Association for the Advancement of Science (AAAS) and Society for Risk Analysis. Dr. Linkov has a B.S. and M.Sc. in Physics and Mathematics (Polytechnic Institute) and a Ph.D. in Environmental, Occupational and Radiation Health (University of Pittsburgh). He completed his postdoctoral training in Risk Assessment at Harvard University. He served as the US Embassy Science Fellow at the US Mission to OECD in Paris in 2017 and in the US Embassy in Berlin, 2013.
Description of Research	Dr. Linkov has managed multiple risk and resilience assessments and management projects in many application domains, including critical infrastructure, environment, transportation, energy, homeland security and defense, supply chain and cybersecurity. He was part of several Interagency Committees and Working Groups tasked with developing resilience metrics and resilience management approaches, including the US Army Corps of Engineers Resilience Roadmap.
Website(s)	https://scholar.google.com/citations?user=HhYAbwkAAAAJ&hl=en

Participant	**Tim Maughan**
Affiliation	Author and Journalist
Email	timmaughan@gmail.com
Primary Field	N/A - primarily write fiction
Brief Bio	Tim Maughan is an author and journalist using both fiction and non-fiction to explore issues around cities, class, culture, technology, and the future. His work regularly appears on the BBC, New Scientist, and Vice/Motherboard. His debut novel INFINITE DETAIL will be published by FSG in 2019. He also collaborates with artists and filmmakers, and has had work shown at the V&A, Columbia School of Architecture, the Vienna Biennale, and on Channel 4. He currently lives in Canada.
Description of Research	Intersections between technology, class, labour, and cities
Website(s)	http://timmaughanbooks.com

Participant	**Doug Mercado**
Affiliation	Princeton University – Visiting Lecturer, Woodrow Wilson School
Email	dmercado@princeton.edu
Primary Field	Public Policy/International Humanitarian Assistance
Brief Bio	Doug Mercado is currently a visiting lecturer at Princeton University's Woodrow Wilson School of Public and International Affairs. He has worked in the field of international disaster assistance and post-conflict recovery over the past 30 years on assignments with the United Nations, the U.S. Agency for International Development (USAID), the Organization of American States and various non-governmental organizations. He has managed humanitarian relief operations, refugee assistance programs and disaster recovery efforts in more than a dozen countries including Nicaragua, Bosnia-

	Herzegovina, Kosovo, Iraq, Liberia, Sri Lanka, Sudan, Haiti, Myanmar, Angola, and Eritrea. Doug just completed an assignment as the emergency coordinator for the United Nations World Food Programme (WFP) in Colombia focusing on the needs of migrants from Venezuela. Other recent deployments include the West Africa Ebola response in 2015 and the mass internal displacement crisis in northeast Nigeria in 2017.

Participant	**Zia Mian**
Affiliation	Princeton University – Co-Director, Program on Science and Global Security
Email	zia@princeton.edu
Primary Field	Arms control and disarmament science
Brief Bio	Zia Mian is a physicist and co-director of Princeton University's Program on Science and Global Security, part of the Woodrow Wilson School of Public and International Affairs. His research interests include issues of nuclear arms control, nonproliferation and disarmament and international peace and security. He is the co-author of Unmaking the Bomb (MIT Press, 2014).
Description of Research	Technical and social and policy issues concerning nuclear weapons development, production, use, and abolition.
Website(s)	https://www.princeton.edu/sgs and http://fissilematerials.org

Participant	**Arka Mukherjee**
Affiliation	Global IDs & Princeton University – PIIRS Global Systemic Risks research community
Email	arka.mukherjee@globalids.com
Primary Field	Computational Chemistry
Brief Bio	Arka Mukherjee is the CEO of Global IDs, a data management software company with headquarters in Princeton, NJ. Dr. Mukherjee has led a global team of software developers in creating an innovative platform for understanding Data Ecosystems. The software is currently deployed in many organizations that have globally distributed data environments. The software helps organizations understand their data assets, and create value from data assets through cost reduction, revenue generation and risk mitigation initiatives. He holds a Ph.D. in Computational Chemistry from Princeton University (Princeton, NJ). He received his M.Sc. degree from the Indian Institute of Technology (Kanpur, India) and his B.Sc. degree from Presidency College (Calcutta, India).
Description of Research	Dr. Mukherjee has researched Complex Data Ecosystems for the last 20 years, building a systematic understanding of the data owned by large corporations. The goal of his research team has been to build software agents that can obtain a statistical and semantic understanding of complex data landscapes that are found inside most corporations. With this foundation, organizations can improve the efficiency, quality and security of their data environments and perform advanced analytics on large data sets. The complexity of large data ecosystems has often led to a poor understanding of systemic risk. The intent of our research is to surface hidden risk using computational approaches that construct knowledge graphs.
Website(s)	www.globalids.com

Participant	Deborah L. Nichols
Affiliation	Dartmouth College – Professor, Anthropology
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Primary Field	Anthropology/Archaeology
Brief Bio	Deborah L. Nichols is the William J. Bryant 1925 Professor of Anthropology at Dartmouth College. She is also a member of the faculty of the Ecology, Evolution, Ecosystems, and Society Graduate Program. She received her Ph.D. in anthropology from the Pennsylvania State University. Before coming to Dartmouth, she was the Assistant Director of the Black Mesa Archaeology Project at Southern Illinois University at Carbondale. She has served as Chair of the Anthropology Department and Latin American, Latino, and Caribbean Studies Program at Dartmouth. She is the past Treasurer and member of the Board of Directors of the Society for American Archaeology. She also served on the Board of Directors of the American Anthropological Association. She currently Chairs the T. and H. King Pre-Columbian Grant Review Committee for the Society for American Archaeology.
Description of Research	The principal focus of my research is the origins and development of cities and states in prehispanic Mesoamerica. I have directed archaeological projects in central Mexico, to investigate Aztec urbanism and development of Aztec city-states, from their origins through the regional organization of the Teotihuacan state system and the change to Postclassic city-states, and the role of agricultural intensification. My current research project supported by the National Science Foundation and the National Geographic society investigates the role of exchange and craft production in the development of early complex societies in Central Mexico. Among her publications, the Oxford Handbook of the Aztecs co-edited with Enrique Rodríguez-Alegría is a 2017 Choice Outstanding Academic Title. Her recent article, Teotihuacan in the Journal of Archaeological Research reviews research on the origins, functioning, and collapse of Teotihuacan, the city and state.
Website(s)	https://home.dartmouth.edu/faculty-directory/deborah-l-nichols
Definition of "Collapse"	I follow George Cowgill's (1998) thinking about the "trouble with words" because it is important to distinguish between collapse as termination or complete cessation, which is relatively, rare vs. fragmentation of power and influence over a large region. It is also important to be clear about what collapse because collapse usually does not entail total cessations or extinctions of cultures/societies.
What is the opposite of "collapse"?	Middleton's (2017) discussion of resilience as applied in archaeological studies is among the most useful. I find it useful to think of resilience as buffering capacity. Here Cowgill's "trouble with words" again becomes relevant, what kind of collapse, political system, demographic, great tradition. Butzer distinguishes among political, environmental, and cultural, including ideological resilience. Applications of resilience theory and complex adaptive systems, as applied to large scale ancient states in the Americas, have mostly been qualitative. Some scholars also have questioned the applicability of theories of cycling, adaptive or otherwise. Cowgill, Yoffee among others argue instead that since societies do not change in stages or as entire units, rather than cycles, it may be better to think of episodes of centralization, fragmentation, regeneration, but of different durations, scale, and even structures and organization.
How do we avoid sampling along dependent variables?	Here, I think comparative research can be especially valuable. Missing vs. negative evidence is always an issue in historical sciences and fields, such as archaeology. Comparative analyses can be a useful approach, along with using different types of evidence, e.g., textual and archaeological. Multi-scalar approaches are also important. Traditional ecological knowledge also is relevant for environmental and ecological issues. Models have to be operationalized and tested, and not become "just so stories."

Dependent Variable (What constitutes a collapse)	-political and economic structures; demographic size, density, movement/migration, -biophysical environment -culture/Great Tradition/ideology -consider also differential in terms of class stratification elite vs. commoner, working class, poor, slavery; -external vs. internal
Casual Variable (What leads to collapse)	Environment/ecology, external and anthropogenic (climate, volcanic eruption), degradation, erosion, deforestation, "invasive species," diversity; 2. Technology-much (too much) has been made of military technology in European imperial expansions in Americas, but maritime technology, ocean-crossing vessels ability to carry animals, people, arms was important; 3. Income problem" (Cowgill), marginal returns (Tainter) 4. Military, conquest and invasion, 5. Internal warfare and conflict/revolt 6. Leadership, form of political organization 7. Ideological
How can "Systems Thinking" provide insight into understanding collapse?	It is important to different between systems theory and systemic thinking both allow consideration of multiple variables and their interaction. I question that complex societies were event systems in equilibrium for fully functionally integrated. Concepts of complex adaptive systems as applied to states and cities in prehispanic Americas to date, have been mostly qualitative applications. At the same time, there can be value in modeling interdependencies (e.g., Sabloff and Turner).
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	1. local systems and households, 2. size and configuration of political units 3. ability to regenerate and reconfigure political units 4. degree of centralization 5. environmental productivity, resource abundance, and diversity 6. base size of population 7. scale and complexity, which can buffer in some circumstances and disadvantage in other 8. economic specialization, and diversity 9. rate of change 10. form/rigidity of leadership 11. collective action 12. ideological, ability to incorporate new ideas, hybridity
Relevant Case Studies	In the case of Teotihuacan that preceded the Aztec empire, the city and a regional state system, collapsed and reorganized; some institutions disappeared, others persisted. The city undergoes a significant demographic reduction, some think even short-term abandonment, both outmigration and immigration, fragmentation, reduction, and restricting of trade and commercial networks, and broader ideological and political restructuring. There is also regeneration and new political forms, the city-state or constellations of small states and political-military confederations develop. Some earlier small regional centers expand significantly in size. The Aztec empire collapsed and there also was a demographic collapse from new diseases and colonialism. The Nahua population did not disappear, nor did all aspects of their society of lifeways. On the other hand, there is also resilience and rural lifeways, some indigenous elites become incorporated into the colonial system. Other changes have been characterized as syncretism, hybridity, creolization. Lockhart offers staged sequences of changes in the case of Nahua and language as a proxy measure. At least in the first half or more century, many rural aspects of Aztec society persisted, some changed, sometimes forcibly, others took advantage of new opportunities. Some societal and ideological changes rapidly, others over decades. Mesoamerica and the Americas, generally, and Eurasia were no longer isolated from each other.
Readings for those cases	Chase, A. F., and D. Z. Chase. 2012. Complex Societies in the Southern Maya Lowlands. Handbook of Mesoamerican Archaeology, ed. by D. L. Nichols and C. Pool, pp. 255–267. Oxford University Press, New York. Cowgill, George 2015. Teotihuacan. Cambridge University Press, Cambridge. Fournier, Patricia G., and Cynthia Otis Charlton 2017. Post-Conquest Rural Archaeology. Oxford Handbook of the Aztecs, ed by D. L. Nichols and E. Rodríguez-Alegría, pp. 643-661. Oxford University Press, Oxford. Hassig, Ross, 2006 Mexico and the Spanish Conquest. Lockhart, James 1991 Nahuas and Spaniards: Postconquest Central Mexican History and Philology. Stanford University Press, Stanford, CA. Nichols, D. L. 2016. Teotihuacan. Journal of Archaeological Research 24:1–74. Oudijk, M. R. 2012 The Conquest of Mexico. In Oxford Handbook of Mesoamerican Archaeology, ed. by D. L. Nichols and C. A. Pool, pp. 459–470. Oxford

	University Press, New York. Oudijk, M. and Maria Casteñeda. 2017. Nahua Thought and Conquest. In Oxford Handbook of the Aztecs, ed. by D. L. Nichols and E. Rodríguez-Alegría, pp. 161-174. Oxford University Press, Oxford. Storey, R., and G. R. Storey. 2017. Rome and the Classic Maya: Comparing the Slow Collapse of Civilization. Routledge, New York. Webster, D. 2012. Classic Maya Collapse. Handbook of Mesoamerican Archaeology, ed. by D. L. Nichols and C. Pool, pp. 324-334. Oxford University Press, New York.
Recommended General Readings	Butzer, K. 2012. Collapse, Environment, Society. PNAS 109: 3632–3639. Cameron, C. M., P. Kelton, and A. C. Swedlund 2015. Beyond Germs: Native Depopulation in North America. University of Arizona Press, Tucson. Crosby, A. 2004. Ecological Imperialism. Cambridge University Press. Chase, A. F., and V. L. Scarborough, eds. 2014. The Resilience and Vulnerability of Ancient Landscapes: Transforming Maya Archaeology through IHOPE, AP3A Paper 24 American Anthropological Association, Arlington, VA, Cowgill, G. 2012. Concepts of Collapse and Regeneration in Human History. In Handbook of Mesoamerican Archaeology, ed. D. L. Nichols and C.A. Pool, pp. 301–307. Oxford University Press, NY. Faulseit, R. K. 2016. Beyond Collapse: Archaeological Perspectives on Resilience, and Transformation in Complex Societies. CAI Occasional Paper No. 42. Southern Illinois University, Carbondale. Middleton, G. D. 2017. Understanding Collapse: Ancient History and Modern Myths. Cambridge University Press, Cambridge. Restall, M. 2003. Seven Myths of the Spanish Conquest. Oxford University Press, New York. Schwartz, G. M. and J. J. Nichols 2006. After Collapse. University of Arizona Press, Tucson. Tuner II, B. L., and Jeremy A. Sabloff. 2012. Classic Period Collapse of the Central Lowlands: Insights about Human Environmental Relationships for Sustainability. PNAS 109: 13908-13914.. Tainter, J. A. 2006. Archaeology of Overshoot and Collapse. Annual Review of Archaeology 35: 59–74.
Other Relevant Resources	IHOPE. http://ihopenet.org/ NABO http://www.nabohome.org/

Participant	**Thayer Patterson**
Affiliation	Princeton University – PIIRS Global Systemic Risk Research Community
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Primary Field	Risk, Finance
Brief Bio	Thayer Patterson is a research fellow and coordinator of the PIIRS research community on Global Systemic Risk at Princeton University. Subsequent to receiving a Master in Finance from Princeton's Bendheim Center for Finance, his research has focused on the causes and consequences of catastrophic systemic risk.
Description of Research	Thayer's research has focused on the causes and consequences of catastrophic systemic risk.
Website(s)	http://risk.princeton.edu

Participant	**Benoît Pelopidas**
Affiliation	Sciences Po – Associate Professor, Security Studies
Email	benoit.pelopidas@sciencespo.fr
Primary Field	Politics, political theory, international security studies
Brief Bio	Benoît Pelopidas holds the junior chair of excellence in security studies at Sciences Po. He also remains an affiliate of the Center for International Security and Cooperation (CISAC) at Stanford University and is a visiting fellow with Princeton University's

	Program on Science and Global Security and PIIRS He focuses on the construction of confidence in the validity, acceptability, and sufficiency of the existing knowledge about nuclear weapons, and their ethical and political implications. Empirically, his focus is on nuclear "close calls" and French nuclear history. He edited a volume on the experience of the so called 'Cuban missile crisis' worldwide and lessons learned from it, expected to be published in 2017. His latest essay on self-censorship in nuclear security studies will be published in the Journal of Global Security Studies. Over the last six years, he has been engaging with policy making elites in the US and Europe as well as civil society groups to advocate innovative nuclear disarmament and arms control policies.

Participant	**Gwythian Prins**
Affiliation	London School of Economics – Emeritus Research Professor Ecole Spéciale Militaire de Saint-Cyr – Senior Academic Visiting Fellow
Email	gwythianprins@gmail.com
Primary Field	History, geo-politics, social dynamics, social and medical anthropology,
Brief Bio	Gwythian Prins is the Emeritus Research Professor at the London School of Economics and the British Senior Academic Visiting Fellow at the Ecole Spéciale Militaire de St Cyr. He was previously Alliance Research Professor jointly at Columbia University in New York and the London School of Economics; but for most of his university career he was a Fellow and the Director of Studies in History at Emmanuel College and University Lecturer in Politics, University of Cambridge. He has served in the Secretary General of NATO's Special Adviser's office, on the Strategy Advisory Panel of the British Chief of the Defence Staff, as Adviser to the Czechoslovak government, and was also Senior Visiting Fellow in DERA (the UK Ministry of Defence's former research establishment). In New York he advised and assisted Kofi Annan's High Level Panel on UN reform. 2007-17 he advised the Japanese government on energy and environmental issues.
Description of Research	The role of doubt in social analysis and the reasons for its demonisation in recent times. The dynamics of the collapse of over-complex and under-legitimate social structures
Website(s)	https://briefingsforbrexit.com/the-eu-is-at-clear-risk-of-collapse-and-the-remainiacs-just-dont-see-it/
Definition of "Collapse"	In social systems, systemic collapse due to negative marginal returns on increasing complexity in an environment of low or absent popular legitimation
What is the opposite of "collapse"?	Structural health when the marginal returns on added complexity are positive in conditions of strong popular legitimation. You don't measure this: you observe it
How do we avoid sampling along dependent variables?	N/A to historical and anthropological work where it is normal always to seek out a wide range of case studies to avoid the dangers of confirmation bias
Dependent Variable (What constitutes a collapse)	Loss of structural cohesion - rule of law; observance of constitutional norms
Casual Variable (What leads to collapse)	Loss of popular legitimacy which is not confined only to affirmation in democratic processes.
How can "Systems Thinking" provide	By providing a structured 'thought experiment' which can illuminate otherwise hidden causal interactions between factors

insight into understanding collapse?	
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Shared identity; shared investment in social compact; bonding in adversity against enemies
Relevant Case Studies	Interesting recent collapses: The USSR, The European Union. Interesting example of resilience: the British Commonwealth's emergence from the end of the formal British Empire.
Readings for those cases	There is copious literature on all three and no single definitive account for any one. On the most topical, the current European collapse, P. Mair, Ruling the Void; Y Varoufakis, Grown-ups in the Room; D.Goodhart, The Road to Somewhere
Recommended General Readings	-J. Tainter, the *Collapse of Complex Societies*; -J.C Scott, *Seeing Like a State*; -G.L.S.Shackle, *Decision, Order & Time in Human Affairs*; W Ross Ashby, *An Introduction to Cybernetics*

Participant	**Steve Pyne**
Affiliation	Arizona State University – Emeritus Professor, School of Life Sciences
Email	stephen.pyne@asu.edu
Primary Field	My academic training is in the humanities, with a minor in geology. I'm an environmental historian, specializing in fire.
Brief Bio	Stephen Pyne is an emeritus professor at Arizona State University and self-proclaimed pyromantic. I spent 15 seasons on a fire crew at the North Rim of Grand Canyon, and three more writing plans for the National Park Service. My academic training at Stanford and the University of Texas-Austin pointed me toward the histories of science, exploration, and the American West. Not until 1977 did I put those two lives together. I've been at ASU since 1984. I've written 35 books, mostly on fire, among them textbooks, a memoir, fire histories of the U.S., Canada, Australia, Europe (including Russia), and Earth overall, and anthologies of essays on fire in additional countries. Other books deal with Antarctica, the Grand Canyon, the Voyager space mission, a biography of Grove Karl Gilbert, and writing nonfiction.
Description of Research	I have two research clusters. One deals with exploration, science, and place. My major contributions are: How the Canyon Became Grand; The Ice: A Journey to Antarctica; and Voyager: Seeking Newer Worlds in the Third Great Age of Discovery. The other examines fire on Earth, particularly the long alliance between fire and humans. This has resulted in three textbooks (two co-authored); two collections of essays, World Fire and Smokechasing; big-screen fire histories for Australia (Burning Bush), Canada (Awful Splendour), Europe (Vestal Fire), and Earth (Fire: A Brief History; Fire: Nature and Culture); and the U.S. (Fire in America and recently, Between Two Fires: A Fire History of Contemporary America and a 9-book suite of regional surveys, To the Last Smoke). Currently I'm working on a fire history of Mexico and a book titled The Great Ages of Discovery. How Western Civilization Learned About a Wider World.
Website(s)	www.stephenpyne.com

Definition of "Collapse"	The organizing concept for fire ecology is the fire regime, which describes the patterning of fire across space and time. Fires occur within a regime as storms do within a climate. Collapse is not a recognized condition: researchers speak of landscape conversions, regime changes, or departures from the historic range of variability. Good fires keep the system operating and help prevent bad fires. Bad fires kill people, damage communities, and push landscapes beyond their capacity to reestablish their old arrangements. A collapsing system would be one dominated by bad fires.
What is the opposite of "collapse"?	The system can absorb changes without exceeding the capacity of the natural environment or society to adapt. By definition good fires prevail over bad fires.
Dependent Variable (What constitutes a collapse)	Since fire synthesizes its surroundings, possible examples of change are as unbounded as Earth's settings. Within landscapes (or cityscapes) fire can be cause, consequence, and catalyst. Almost all abrupt changes are due to human behavior. Sometimes this means active measures such as clearing forests, draining peatlands, or introducing livestock; sometimes, it means no longer doing what occurred historically such as routinely burning grasslands or savannas. The biggest reformation – still unsettled and barely studied – involves the shift from burning living landscapes to burning lithic ones. This pyric transition, like the demographic transition that accompanies industrialization, at first results in a population explosion of fires, then a recession below replacement values to the point that fire cannot do the ecological work required.
Casual Variable (What leads to collapse)	Fire requires a spark, something to burn, and a setting in which to combust. Any alterations in these conditions can result in regime change. Fire resembles a driverless car barreling down the road, integrating whatever is around it. Ignition: new sources include powerlines and machinery, but equally significant may be the replacement of old practices (no longer burning fallow or grasslands), or climate change that yields more dry lightning. Fuels: agricultural conversion or abandonment, urban sprawl, logging, overgrazing, exotic grasses (cheatgrass, Imperator), buildup or rearrangement of vegetation by fire exclusion – the possibilities are endless. Weather and climate: primarily shifts in the pattern of wetting and drying, of winds, and in places of dry lightning. In the near term, all these factors result from humans, who have become the keystone species for fire and who hold a species monopoly over its manipulation. Still, fire can thrive without humans; humans cannot exist without fire.
How can "Systems Thinking" provide insight into understanding collapse?	Fire makes an interesting subject for systems analysis because it is not a substance, creature, or process, but a reaction that integrates its surroundings. It takes its character from its context. It resembles a driverless car, barreling down the road integrating everything around it, responding variously as different features loom larger. Neither people nor nature is wholly in control. Sometimes fire must respond to road hazards called fuel left by previous wrecks; sometimes to a tricky intersection called the wildland urban interface; sometimes to a dangerous curve called climate change; sometimes to a distracted driver called carelessness, swerving onto the shoulder and throwing sparks; sometimes to a reckless approaching vehicle called politics, or to that crisis blizzard in which everything seems to happen at once and obscures the field of vision. If you want to reduce it all to a single cause, invoke the Anthropocene. It's a world powered by fossil fuels that is increasingly expressing itself in feral flames.
Relevant Case Studies	COLLAPSE:: Replacement vegetation: cheatgrass in the Great Basin; buffelgrass in the Southwest; cogon grass in the Southeast; eastern red cedar in the Great Plains; 'ladder fuels' in western montane forests. Urban sprawl recolonizing formerly rural landscapes. Conversion of rainforest to pasture, tropical peatlands to palm oil plantations. Land abandonment in Portugal and Greece. Fire suppression in naturally fire-prone landscapes (e.g., California). Climate change is too diffuse to be isolated. RESILIENCE:: prescribed fire in Florida; box-and-burn strategy in American West; light-hand responses in Alaska; reintroduction of natural fire in selected parks and wilderness.

Recommended General Readings	*Fire: A Brief History*, 2nd ed (out in August). *Fire on Earth: An Introduction*. Bottomless pit of studies on particular sites.

Participant	**Juan Rocha**
Affiliation	Stockholm Resilience Centre – Postdoctoral Researcher
Email	juan.rocha@su.se
Primary Field	ecology, sustainability science
Brief Bio	Juan C. Rocha is a postdoctoral researcher at the Stockholm Resilience Centre. His research questions are oriented to understanding critical transitions: from regime shifts in ecological systems, to collective action in society. Currently he is focusing on the idea of cascading effects, this is how a critical transition in an ecosystem in the world can increase or decrease the likelihood of another ecosystem tipping over. He develops mathematical models to explore the parameter space at which these interconnections are plausible. He is also looking for empirical signatures of cascading effects on trade networks and rainfall transport dynamics. Juan is interested in methods for identifying resilience surrogates -good observables of how resilient a system is- and misperception of feedbacks and their consequences. He finds inspiration in complex systems science, and the use of mathematical models, networks and other computational methods to understand social and ecological complexity.
Description of Research	His research questions are oriented to understanding critical transitions: from regime shifts in ecological systems, to collective action in society. Currently he is focusing on the idea of cascading effects, this is how a critical transition in an ecosystem in the world can increase or decrease the likelihood of another ecosystem tipping over. He develops mathematical models to explore the parameter space at which these interconnections are plausible. He is also looking for empirical signatures of cascading effects on trade networks and rainfall transport dynamics.
Website(s)	www.juanrocha.se
Definition of "Collapse"	A collapse to me is related to the loss of functions from a system perspective that is often observable in its structure. For example, if your system is Al-Qaeda (a social system) and the purpose is to perform terrorist attacks, then the collapse occur when its functional network is attacked to the point that it cannot perform terrorist activities anymore. An example from an ecosystem can be the collapse of coral reefs. If they are hit enough times with heat waves, pollution, and strong fishing pressure, the corals can die and being over grown by algae. The functions lost are related to recreational services, hosting biodiversity and protecting from coastal erosion.
What is the opposite of "collapse"?	Resilience and robustness (synonyms to me) are features of a system, say like colour. In a 3-dimensional system, resilience is the volume of the basin of attraction of the system (e.g., coral dominated). In a n-dimensional system, resilience is the hyper-space of the basin of attraction. Thus, it is all the possible configuration of N state variables where the system will return to equilibrium and maintain its dynamics within the same basin. Another common approximation that works for many systems is recovery time measuring critical slowing down: increases in variance, autocorrelation or skewness in time series is a leading indicator of proximity to tipping points (loss of resilience and potential for critical transitions).
How do we avoid sampling along dependent variables?	I don't quite understand the question. In the context of linear systems, one can use causality detection techniques to avoid biases and get to causal effects. Instrumental variables, matching regressions, back and front door criterium are useful approaches. However, whenever you are talking about critical transitions, you are really talking about non-linear dynamics, where the existence of feedbacks make your variables inherently

	dependent. In such context, causality detection techniques for non-linear dynamics are more suitable, such as empirical dynamic modeling or randomly distributed embeddings.
Dependent Variable (What constitutes a collapse)	Depends of the system. I work with collapses in ecosystems and usually the response variables are an aggregation of a global feature of the ecosystem (e.g., coral cover, % of tree cover). Note that the variable is a macro aggregate, it does not correspond to micro level dynamics such as what is the abundance of species X in time t, at microlevel, the dynamics are always chaotic. In a social system, it depends of the functions you are interested in and the scale, because a city can collapse without its country collapsing and vice versa. It's also important to define resilience of what to what. Going back to the city example, the economy can be great but what collapses is the sewage system or the language.
Casual Variable (What leads to collapse)	Again, it depends of the system. For ecological regime shifts I have documented over 70 different variables that can be drivers, and surely there is more. It depends of the system at hand and the function / structure that you're evaluating, the resilience of what to what?
How can "Systems Thinking" provide insight into understanding collapse?	Because what collapses is usually a system. A system is a set of interacting parts that forms more than the sum of its parts. In addition, the word collapse makes reference to an abrupt and persistent change. The system defines what is abrupt and what are the behaviors of reference (before and after) that makes your particular change a collapse. Without these points of reference (provided by the system) it's very difficult to call something a collapse.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Ecosystems, the climate, society (institutions, rules, politics), economics (flows of resources and knowledge), and culture.
Relevant Case Studies	Collapse: the current loss of the Great Coral reef barrier in Australia. Consecutive heat wave events (climate change) has kill about 89% of corals there, unlikely to recover, and if they do, current climate projections will make it very difficult for them to survive. Example of resilience: cocaine production in Colombia, despite a 5 decades war, over 200 000 fatalities, > 8 million victims and >6 million refugees, Colombia is still the main producer of coca for the world. It does not matter that all drug cartel leaders have been killed, or that a peace agreement has been signed with major guerrilla groups. Transactions and drug cartels are now based in Mexico, but Colombia still leads the production of cocaine and suffer the consequences.
Readings for those cases	-For Colombia in English, perhaps reports from DEA (good stats). -For coral reefs, work by Terry Hughes and others (the most recent): Hughes, T. P., J. T. Kerry, A. H. Baird, S. R. Connolly, T. J. Chase, A. Dietzel, T. Hill, A. S. Hoey, M. O. Hoogenboom, M. Jacobson, A. Kerswell, J. S. Madin, A. Mieog, A. S. Paley, M. S. Pratchett, G. Torda, and R. M. Woods. 2019. Global warming impairs stock–recruitment dynamics of corals. Nature 347:1.)
Recommended General Readings	-Scheffer, *M. Critical Transitions in Nature and Society*. (Princeton University Press, 2009). -Solé, R. V. *Phase Transitions*. (Princeton University Press, 2011).
Other Relevant Resources	Marco Janssen from ASU

Participant	**Anders Sandberg**

Affiliation	University of Oxford – Senior Research Fellow, Future of Humanity Institute
Email	anders.sandberg@philosophy.ox.ac.uk
Primary Field	Philosophy
Brief Bio	Dr. Sandberg is senior research fellow at the Future of Humanity Institute at University of Oxford. He has a background in computational neuroscience but works on existential risks, emerging technology, long-term futures and management of uncertainty.
Description of Research	Existential risk and global catastrophic risks; evaluation of low-probability events; systemic risks; long-term civilizational trajectories
Website(s)	http://gcrinstitute.org/papers/trajectories.pdf
Definition of "Collapse"	From the inside view a collapse occurs when a system fails drastically according to the standards of itself (it is relative to desired function and expected change speeds); from the outside view collapse occurs when the system loses cohesion or changes its apparent function(s) on a timescale short compared to the normal evolutionary scale of the system.
What is the opposite of "collapse"?	Longevity: the system avoids collapse, but may change in numerous ways - maturing, evolving, reorganizing or even deliberately disbanding. Consider how the Internet has nearly always been on the verge of collapse yet reinvented itself.
How do we avoid sampling along dependent variables?	Exploring systems that almost but not quite did not make it into the normal example category can be helpful.
Dependent Variable (What constitutes a collapse)	Complexity of function, network connectivity, overall efficiency in converting inputs to desired outputs
Casual Variable (What leads to collapse)	Network connectivity, control structure complexity, rate of errors/corrections
How can "Systems Thinking" provide insight into understanding collapse?	Bifurcations and tipping points are good models for many simple collapses. The *failures* of systems thinking at finding general rules are also helpful for being humble about there being a general collapse theory.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Information storage and processing that directs flows and stocks of matter and energy. Individual agents forming social structures that use and embody this information, and interact with each other and the overall system to generate an open-ended evolution of the system.
Relevant Case Studies	Many disasters are mini-collapses where the information processes underlying the system make them less resilient and unable to cope with a random challenge.
Readings for those cases	Sornette and Chernof, Information Concealment in Man-Made Disasters
Recommended General Readings	Tainter's *The Collapse of Complex Societies*

Participant	Walter Scheidel
Affiliation	Stanford University – Professor, Classics and History
Email	scheidel@stanford.edu
Primary Field	Roman history; premodern social and economic history and demography; comparative world history
Brief Bio	Dickason Professor in the Humanities, Professor of Classics and History, and Fellow in Human Biology at Stanford (since 2003). I have written 5 books and (co-)edited 15 others, mostly on various aspects of social and economic history.
Description of Research	I have studied ancient state formation, the comparative history of early empires (esp. Rome and China), and the impact of violent shocks on economic inequality.
Definition of "Collapse"	All of the above – I am attending to learn more about these different conceptualizations.
How do we avoid sampling along dependent variables?	By looking at the largest possible number of cases (societies) in a systematic fashion.

Participant	sava saheli singh
Affiliation	Queen's University, Canada – Post-Doctoral Fellow, Surveillance Studies Centre
Email	savasaheli@gmail.com
Primary Field	Interdisciplinary
Brief Bio	sava is a postdoctoral fellow at the Surveillance Studies Centre (SSC) at Queen's University, Canada. She has just completed Screening Surveillance – a knowledge translation project for the Big Data Surveillance project. For this project, sava co-created and produced three short near-future fiction films that call attention to the potential human consequences of big data surveillance. Specifically, this project (funded by the Office of the Privacy Commissioner of Canada), extends existing SSC work to examine the intersections and implications of big data systems, risk, and surveillance. Previously, sava completed her PhD on Academic Twitter from New York University's Educational Communication and Technology program.
Description of Research	sava's research interests include: ed tech as surveillance, digital labor and intimacy, platform capitalism, and smart cities.
Website(s)	https://www.sscqueens.org/people/sava-saheli-singh https://www.screeningsurveillance.com/

Participant	Nils Chr. Stenseth
Affiliation	University of Oslo – Professor, Mathematics and Natural Sciences
Email	n.c.stenseth@ibv.uio.no
Primary Field	evolutionary biology and ecology
Brief Bio	I am an evolutionary biologist having worked on a broad spectrum of systems, including the ecology and evolution of plague (not only the Black Death). Other topics of interest are my work on fluctuating populations (hare and lynx as well as lemmings). Finally, it should be mentioned that I've done quite a bit of the effect of climate variation.

Description of Research	The ecology and evolution of plague
How can "Systems Thinking" provide insight into understanding collapse?	As an ecologist, I believe we must think about how species interact in a dynamic way.
Relevant Case Studies	The Black Death - but also some fisheries.

Participant	**Joseph Tainter**
Affiliation	Utah State University – Professor, Environment & Society
Email	joseph.tainter@usu.edu
Primary Field	Anthropology, Complexity
Brief Bio	Joseph Tainter is Professor of Sustainability in the Department of Environment and Society, Utah State University. He is the author of The Collapse of Complex Societies, and co-author of Supply-Side Sustainability and Drilling Down: The Gulf Oil Debacle and Our Energy Dilemma. Dr. Tainter's research has been consulted in the United Nations Environment Programme, UNESCO, the World Bank, the Rand Corporation, the International Institute for Applied Systems Analysis, the Beijer Institute of Ecological Economics, the Earth Policy Institute, the Technology Transfer Institute/Vanguard, and other institutions. His research has been applied in economic development, energy, environmental conservation, health care, information technology, urban studies, and the challenges of security in response to terrorism.
Description of Research	Evolution of complexity; energy; innovation.
Definition of "Collapse"	A collapse is the rapid loss of an established level of complexity.
What is the opposite of "collapse"?	Continuity
Dependent Variable (What constitutes a collapse)	Rapid simplification
Casual Variable (What leads to collapse)	Several things could cause a collapse. I have focused on fiscal weakness induced by diminishing returns to complexity in problem solving.
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	Energy, economy, sociopolitical environment, natural environment, etc.

Participant	Temis Taylor
Affiliation	Stony Brook University – Message Design Instructor and Science Communication Researcher, Alan Alda Center for Communicating Science
Email	temis.taylor@stonybrook.edu
Primary Field	Communications, Environment and Society
Brief Bio	Dr. Temis G. Taylor is a Message Design Instructor and Science Communication Researcher at the Alan Alda Center for Communicating Science. As the Center's lead on Climate Change Communication, she is an advocate for the development of communication skills as a pathway to reduce polarization and improve trust among scientists, the public, and policy makers. Her work as Alda Center faculty is focused on helping scientists engage with stakeholders, decision makers, and colleagues by more effectively communicating their work across the broad range of knowledge, experience, worldviews, and values that people hold. Dr. Taylor's research addresses questions of sustainability, resilience, social complexity, and innovation within the context of natural resource and ecological limitations.
Description of Research	My current work focuses on public discourse, perceptions of risk, and trust alongside energy resource decisions and energy transitions. I also collaborate with Joseph Tainter on work related to energy and social complexity, collapse, sustainability, and resilience.
Definition of "Collapse"	Collapse is an abrupt and widespread simplification of a complex society. Collapse occurs when a society has depleted its capacity for problem solving and can no longer afford to maintain its level of complexity (i.e., the problem solving measures it has already implemented).
What is the opposite of "collapse"?	Complexity and resilience, where resilience is the reserve problem solving capacity that a society can draw on. We identify three strategies for resilience – spend, borrow, or innovate – all of which have energetic and opportunity costs.
How do we avoid sampling along dependent variables?	Luke Kemp has added crowd-sourcing to his data – an interesting approach to invite citizen science (and undoubtedly trolls happy to point out any perceived bias) into the discussion.
Dependent Variable (What constitutes a collapse)	Loss of organizational structure, centralized functions and services, specialization. Stagnation or reversal of previous levels of technology and innovation.
Casual Variable (What leads to collapse)	Increasing energetic costs of complexity, diminishing marginal returns on energy and complexity
How can "Systems Thinking" provide insight into understanding collapse?	Positive feedback loops of energy and complexity, high-gain resources and the maximum power principle, and the consequences of declining energy return on energy invested

Participant	Stefan Thurner
Affiliation	Santa Fe Institute, IIASA, & Complexity Science Hub Vienna
Email	stefan.thurner@muv.ac.at
Primary Field	science of complex systems

Brief Bio	born - physics - economics - medical university - complex systems - santa fe institute - IIASA - complexity science hub vienna
Description of Research	complex systems are co-evolutionary multi-layer networks. I study their mathematical principles and develop methods to extract meaning out of the data they generate. many applications in networked dynamical systems. focus on systemic understanding from microscopic building blocks
Website(s)	https://www.csh.ac.at
Definition of "Collapse"	collapse is a massive restructuring event of the interactions in a system that changes its function or performance
What is the opposite of "collapse"?	shock system --> nothing happens = robust. shock system --> it recovers or adapts = resilience; shock system --> breaks into parts (loses many or crucial interactions) = collapse
How do we avoid sampling along dependent variables?	observe all states of the elements and observe all interactions --> think freely and avoid biases by avoiding mental constraints and scientific dogmas
Dependent Variable (What constitutes a collapse)	way and rate at which reconfiguration of interactions takes place
Casual Variable (What leads to collapse)	whatever causes creation and destruction of links
How can "Systems Thinking" provide insight into understanding collapse?	it is the only way
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	co-evolutionary multi-layer networks: states of nodes and links between them co-evolve
Relevant Case Studies	example of resilience: last financial crisis
Readings for those cases	
Recommended General Readings	on co-evolving systems and its methods: *Introduction to the Theory of Complex Systems* (Thurner, Hanel, Klimek)
Other Relevant Resources	Maxi San Miguel, Mirta Galesic

Participant	**Benjamin Trump**
Affiliation	US Army Engineer R&D Center – Research Social Scientist

Email	bdt2011@gmail.com
Primary Field	Risk Governance
Brief Bio	Dr. Benjamin Trump is a Research Social Scientist for the US Army Corps of Engineers. Dr. Trump's work focuses on decision making and governance of activities under significant uncertainty, such as emerging and enabling technologies (synthetic biology, nanotechnology) and developing organizational, infrastructural, social, and informational resilience against systemic threats to complex interconnected systems. Dr. Trump served as a delegate to assist US presence in OECD's Global Science Forum in 2017, and is the President of the Society for Risk Analysis' Decision Analysis and Risk Specialty Group in 2018-2019. Dr. Trump was also an author of the International Risk Governance Council's Guidelines for the Governance of Systemic Risks, as well as their 2nd Volume of the Resource Guide on Resilience. Co-authored with Dr. Igor Linkov, his book The Science and Practice of Resilience provides a holistic review of the theory, methods, and application of resilience to various disciplines.
Description of Research	We are looking to apply logic of systemic resilience as an explanation for the capacity of complex societies to withstand, recover from, and adapt to adverse events. This requires an understanding of how endogenous societal functions contribute to a resilient or brittle society that may or may not be able to survive, in their current form, when introduced to an exogenous shock or stress.
Website(s)	https://www.springer.com/us/book/9783030045630#aboutBook
Definition of "Collapse"	From the lens of system resilience, I view this as a situation where a system encounters a shock or stress that it is unable to fully recover from or adapt to. The system becomes less robust in some measure relative to its previous state prior to disruption.
What is the opposite of "collapse"?	Resilience - the capability of a system to plan and prepare for, absorb and withstand, recover from, and adapt to adverse events.
How do we avoid sampling along dependent variables?	By removing emphasis upon the exogenous shock altogether. Instead, by visually constructing and modeling a system and its components, we can identify dependencies and critical functions. If these are degraded or disrupted, we can then model and review what nested sub-systems would lose functionality. This idea allows us to identify 'single points of failure' that make a system prone to widescale disruption and even total collapse.
Dependent Variable (What constitutes a collapse)	A critical loss in system operating capabilities due to an exogenous shock or stress/catalyst.
Casual Variable (What leads to collapse)	Unsustainable brittleness in system endogeneity.
How can "Systems Thinking" provide insight into understanding collapse?	Systems thinking is a fundamental requirement to understand the resilience, or lack thereof, of any system. It is unhelpful to review the health and safety of nations or organizations without understanding their dependencies and resource requirements to function normally - and what happens when they do not gain timely access to such resources.
What are the key systems underpinning the structure, dynamics, and	The 'domains' of a system's resilience: physical, social, informational, and other pertinent drivers of system performance.

resilience of a society/civilization?	
Relevant Case Studies	A case of both: The Kievan Rus' and the Mongol Invasion/domination. Most principalities were totally crushed and never recovered, while others were able to recover from and even strengthen themselves under the Mongols.
Readings for those cases	Pending - will share at the meeting. Medieval Rus' primary documents are scarce.
Recommended General Readings	Our book *The Science and Practice of Resilience*.
Other Relevant Resources	Craig Allen, Lance Gunderson, Jim Lambert (UVA)

Participant	**Peter Turchin**
Affiliation	University of Connecticut – Professor, Ecology and Evolutionary Biology, Anthropology, and Mathematics
Email	peter.turchin@uconn.edu
Primary Field	Cliodynamics
Brief Bio	Peter Turchin is an evolutionary anthropologist at the University of Connecticut. His research interests lie at the intersection of social and cultural evolution, historical macrosociology, economic history and cliometrics, mathematical modeling of long-term social processes, and the construction and analysis of historical databases (see Seshat: Global History Databank). His most recent books are Ultrasociety: How 10,000 Years of War Made Humans the Greatest Cooperators on Earth and Ages of Discord (both published in 2016).
Description of Research	His research interests lie at the intersection of social and cultural evolution, historical macrosociology, economic history and cliometrics, mathematical modeling of long-term social processes, and the construction and analysis of historical databases. Currently he investigates a set of broad and interrelated questions: How do human societies evolve? In particular, what processes explain the evolution of ultrasociality—our capacity to cooperate in huge anonymous societies of millions? Why do we see such a staggering degree of inequality in economic performance and effectiveness of governance among nations? Turchin uses the theoretical framework of cultural evolution to address these questions. Currently his main research effort is directing the Seshat Databank project, which builds and analyzes a massive historical database of cultural evolution that enables us to empirically test theoretical predictions coming from various social evolution theories.
Website(s)	http://peterturchin.com/
Definition of "Collapse"	I favor a multidimensional definition of collapse that includes such aspects as the loss of control by central authorities, population declines, territorial fragmentation
What is the opposite of "collapse"?	Social resilience
How do we avoid sampling along dependent variables?	By systematic sample that is stratified along various potentially important characteristics (e.g., world region)

Dependent Variable (What constitutes a collapse)	The degree of political control by the state, population dynamics, territorial dynamics
Casual Variable (What leads to collapse)	This is the research question that still needs answering
How can "Systems Thinking" provide insight into understanding collapse?	Systems approach is the way to answer this question
What are the key systems underpinning the structure, dynamics, and resilience of a society/civilization?	My focus is on the social dimension. The strength of the state (especially, fiscal health), the degree of cooperation among the elites, and the well-being of the population
Relevant Case Studies	The Seshat Databank samples c.500 past societies in all world regions between the Neolithic and the Industrial Revolutions
Readings for those cases	http://seshatdatabank.info/
Recommended General Readings	Turchin, Peter. 2016. *Ages of Discord: A Structural-Demographic Analysis of American History*. Chaplin, CT: Beresta Books. Turchin, Peter, and Sergey Nefedov. 2009. *Secular Cycles*. Princeton, NJ: Princeton University Press.