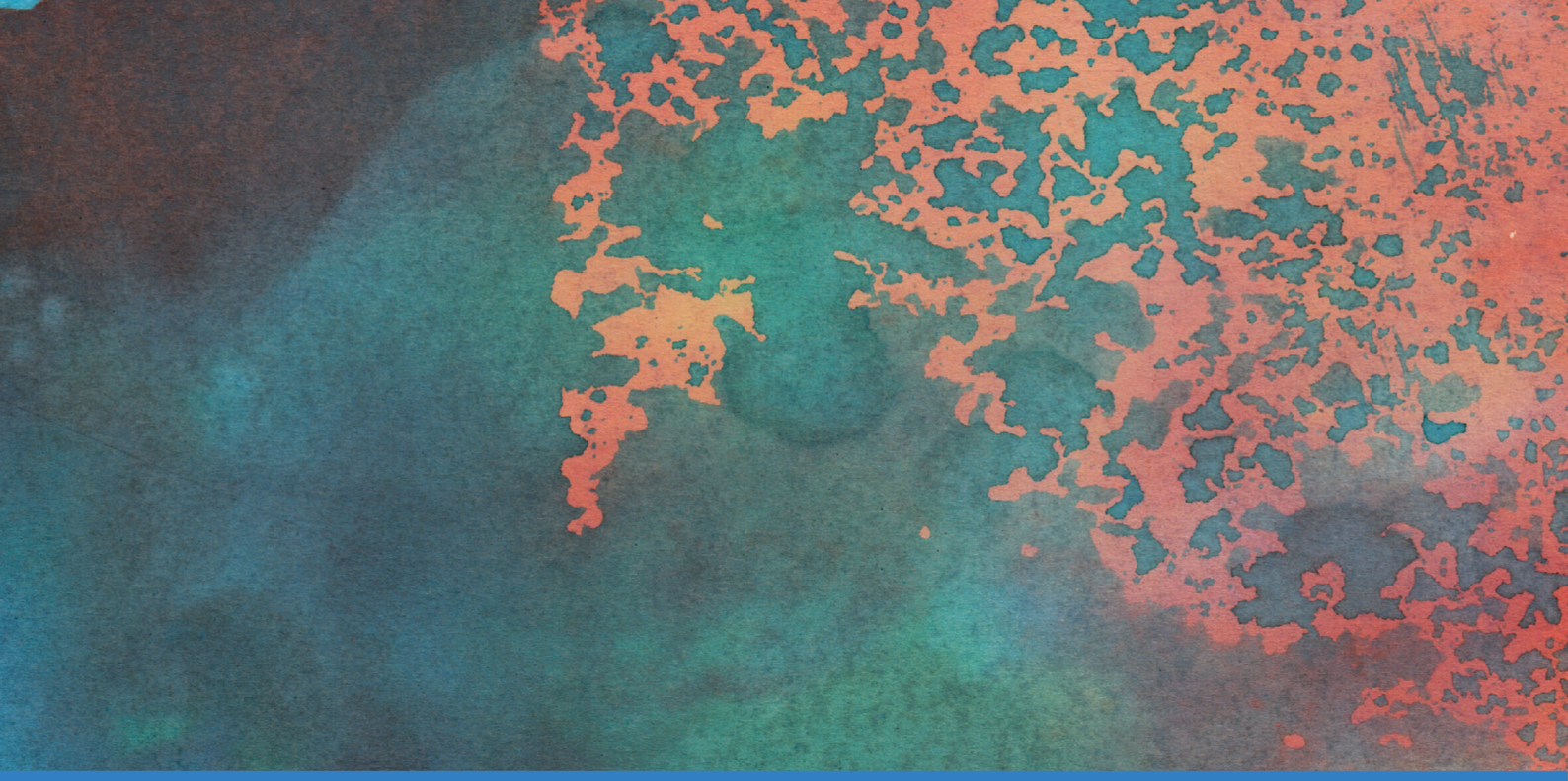

THE ANTHROPOCENE

Edited by
David R. Butler

The Anthropocene

This book is devoted to the Anthropocene, the period of unprecedented human impacts on Earth's environmental systems, and illustrates how geographers envision the concept of the Anthropocene.

This edited volume illustrates that geographers have a diverse perspective on what the Anthropocene is and represents. The chapters also show that geographers do not feel it necessary to identify only one starting point for the temporal onset of the Anthropocene. Several starting points are suggested, and some authors support the concept of a time-transgressive Anthropocene. Chapters in this book are organized into six sections, but many of them transcend easy categorization and could have fit into two or even three different sections. Geographers embrace the concept of the Anthropocene while defining it and studying it in a variety of ways that clearly show the breadth and diversity of the discipline.

This book will be of great value to scholars, researchers, and students interested in geography, environmental humanities, environmental studies, and anthropology.

The chapters in this book were originally published as a special issue of the journal *Annals of the American Association of Geographers*.

David R. Butler is Texas State University System Regents' Professor Emeritus, and University Distinguished Professor Emeritus in the Department of Geography at Texas State University, USA. His research interests include geomorphology in the Anthropocene, zoogeomorphology, dendrogeomorphology, and mountain environments and environmental change, especially in the Rocky Mountains.

The Anthropocene

Edited by
David R. Butler

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2022
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

and by Routledge
605 Third Avenue, New York, NY 10158

Routledge is an imprint of the Taylor & Francis Group, an informa business

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

ISBN13: 978-1-032-07668-3 (hbk)
ISBN13: 978-1-032-07669-0 (pbk)
ISBN13: 978-1-003-20821-1 (ebk)

DOI: 10.4324/9781003208211

Typeset in Goudy Oldstyle Std
by codeMantra

Publisher's Note
The publisher accepts responsibility for any inconsistencies that may have arisen during the conversion of this book from journal articles to book chapters, namely the inclusion of journal terminology.

Disclaimer
Every effort has been made to contact copyright holders for their permission to reprint material in this book. The publishers would be grateful to hear from any copyright holder who is not here acknowledged and will undertake to rectify any errors or omissions in future editions of this book.

Contents

Citation Information

The chapters in this book were originally published in the journal, *Annals of the American Association of Geographers*, volume 111, issue 3 (2021). When citing this material, please use the original page numbering for each article, as follows:

Introduction
The Anthropocene: A Special Issue
David R. Butler
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 633–637

Chapter 1
The Anthropocene: The One, the Many, and the Topological
J. Anthony Stallins
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 638–646

Chapter 2
The Geoethical Semiosis of the Anthropocene: The Peircean Triad for a Reconceptualization of the Relationship between Human Beings and Environment
Francesco De Pascale and Valeria Dattilo
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 647–654

Chapter 3
Placing the Anthropos *in Anthropocene*
Jeffrey Hoelle and Nicholas C. Kawa
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 655–662

Chapter 4
The Inhumanities
Kathryn Yusoff
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 663–676

Chapter 5
Language and Groundwater: Symbolic Gradients of the Anthropocene
Paul C. Adams
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 677–686

Chapter 6
Agri-Food Systems and the Anthropocene
Emily Reisman and Madeleine Fairbairn
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 687–697

Chapter 7
On Decolonizing the Anthropocene: Disobedience via Plural Constitutions
Mark Jackson
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 698–708

Chapter 8
Nothing New under the Sun? George Perkins Marsh and Roots of U.S. Physical Geography
Jacob Bendix and Michael A. Urban
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 709–716

Chapter 9
Synchronizing Earthly Timescales: Ice, Pollen, and the Making of Proto-Anthropocene Knowledge in the North Atlantic Region
Sverker Sörlin and Erik Isberg
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 717–728

Chapter 10
Geographic Thought and the Anthropocene: What Geographers Have Said and Have to Say
Thomas Barclay Larsen and John Harrington Jr.
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 729–741

Chapter 11
Floodplain and Terrace Legacy Sediment as a Widespread Record of Anthropogenic Geomorphic Change
L. Allan James, Timothy P. Beach, and Daniel D. Richter
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 742–755

Chapter 12
Hotter Drought as a Disturbance at Upper Treeline in the Southern Rocky Mountains
Grant P. Elliott, Sydney N. Bailey, and Steven J. Cardinal
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 756–770

Chapter 13
Onset of the Paleoanthropocene in the Lower Great Lakes Region of North America: An Archaeological and Paleoecological Synthesis
Albert E. Fulton II and Catherine H. Yansa
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 771–783

Chapter 14
Identifying a Pre-Columbian Anthropocene in California
Anna Klimaszewski-Patterson, Christopher T. Morgan, and Scott Mensing
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 784–794

Chapter 15
Wetland Farming and the Early Anthropocene: Globally Upscaling from the Maya Lowlands with LiDAR and Multiproxy Verification
Sheryl Luzzadder-Beach, Timothy P. Beach, and Nicholas P. Dunning
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 795–807

Chapter 16
Putting the Anthropocene into Practice: Methodological Implications
Christine Biermann, Lisa C. Kelley, and Rebecca Lave
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 808–818

Chapter 17
The Changing Nature of Hazard and Disaster Risk in the Anthropocene
Susan L. Cutter
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 819–827

Chapter 18
Seismic Shifts: Recentering Geology and Politics in the Anthropocene
Ben A. Gerlofs
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 828–836

Chapter 19
Understanding Urban Flood Resilience in the Anthropocene: A Social–Ecological–Technological Systems (SETS) Learning Framework
Heejun Chang, David J. Yu, Samuel A. Markolf, Chang-yu Hong, Sunyong Eom, Wonsuh Song, and Deghyo Bae
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 837–857

Chapter 20
Reframing Pre-European Amazonia through an Anthropocene Lens
Antoinette M. G. A WinklerPrins and Carolina Levis
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 858–868

Chapter 21
Forests in the Anthropocene
Jaclyn Guz and Dominik Kulakowski
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 869–879

Chapter 22
Abandoning Holocene Dreams: Proactive Biodiversity Conservation in a Changing World
Kenneth R. Young and Sisimac Duchicela
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 880–888

Chapter 23
Re-envisioning the Toxic Sublime: National Park Wilderness Landscapes at the Anthropocene
Nicolas T. Bergmann and Robert M. Briwa
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 889–899

Chapter 24
Climate Necropolitics: Ecological Civilization and the Distributive Geographies of Extractive Violence in the Anthropocene
Meredith J. DeBoom
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 900–912

Chapter 25
Cultures and Concepts of Ice: Listening for Other Narratives in the Anthropocene
Harlan Morehouse and Marisa Cigliano
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 913–920

Chapter 26
Ruins of the Anthropocene: The Aesthetics of Arctic Climate Change
Mia M. Bennett
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 921–931

Chapter 27
The New (Ab)Normal: Outliers, Everyday Exceptionality, and the Politics of Data Management in the Anthropocene
Katherine R. Clifford and William R. Travis
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 932–943

Chapter 28
What Does That Have to Do with Geology? The Anthropocene in School Geographies around the World
Péter Bagoly-Simó
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 944–957

Chapter 29
Geographic Education in the Anthropocene: Cultivating Citizens at the Neoliberal University
Lindsay Naylor and Dana Veron
Annals of the American Association of Geographers, volume 111, issue 3 (2021) pp. 958–969

Notes on Contributors

Paul C. Adams is Professor of Geography at the University of Texas at Austin, USA. His research occupies the intersection of media studies, communication theory, and human geography. He considers how perceptions, representations, actions, and infrastructures are intertwined through mediated communications. His books include *Geographies of Media and Communication* (2009).

Deghyo Bae is Professor of Civil and Environmental Engineering and President of Sejong University, Seoul, South Korea. His research areas include atmosphere and surface runoff interactions, flood forecasting, satellite hydrology, and GIS-based water resource engineering.

Péter Bagoly-Simó is Full Professor and the Chair of Geography Education in the Department of Geography at Humboldt-Universitat zu Berlin, Germany. His research interests include educational media and textbooks, geographical knowledge, and education for sustainable development.

Sydney N. Bailey is Graduate Student in the Department of Geography at the University of Missouri, Columbia, USA. Her research focuses on climate–vegetation interactions in the U.S. Rocky Mountains.

Timothy P. Beach is Guggenheim, Dumbarton Oaks, and AAAS Fellow. He holds a Centennial Chair in US Mexican Relations and is a Professor and directs the Soils and Geoarchaeology Labs at UT Austin, USA. His research ranges from soil profiles to watersheds, and from the Pleistocene to the present, especially in the Maya and Mediterranean worlds.

Jacob Bendix is Professor in the Department of Geography and the Environment at Syracuse University, USA. His research interests include plant biogeography and fluvial geomorphology, with particular interest in disturbance ecology and the interactions between ecological and geomorphological processes and patterns.

Mia M. Bennett is Assistant Professor in the Department of Geography and School of Modern Languages & Cultures (China Studies Program) at The University of Hong Kong, Hong Kong. Her research critiques the politics of development in regions commonly thought of as frontiers, namely, the Arctic.

Nicolas T. Bergmann recently earned his doctorate from Montana State University, Bozeman, USA. His research interests lie at the intersections of political ecology, historical geography, and environmental history.

Christine Biermann is Assistant Professor in the Department of Geography and Environmental Studies at the University of Colorado, Colorado Springs, USA. Her research addresses the ecosocial dynamics of forests and fisheries.

Robert M. Briwa is Assistant Professor of Geography within the Department of History at Angelo State University, San Angelo, USA. His research interests include historical and cultural geographies of the U.S. West and literary geographies.

David R. Butler is Texas State University System Regents' Professor Emeritus, and University Distinguished Professor Emeritus in the Department of Geography at Texas State University, USA. His research interests include geomorphology in the Anthropocene, zoogeomorphology, dendrogeomorphology, and mountain environments and environmental change, especially in the Rocky Mountains.

Steven J. Cardinal is Graduate Student in the Department of Geography at the University of Missouri, Columbia, USA. His research interests are repeat photography and subalpine forests in the U.S. Rocky Mountains.

Heejun Chang is Professor in the Department of Geography at Portland State University, USA. His research focuses on the combined impacts of climate change and urban development on water resource resilience, including water supply, quality, demand, floods, and water-related ecosystem services.

Marisa Cigliano is Graduate from the Environmental Program at the University of Vermont, Burlington, USA. Her research interests involve social geography, environmental justice, and feminist and decolonial political ecology.

Katherine R. Clifford is Researcher for the Western Water Assessment at the University of Colorado, Boulder, USA. Her research examines questions of environmental knowledge, regulation, and decision-making in the context of environmental change.

Susan L. Cutter is Carolina Distinguished Professor and Director of the Hazards & Vulnerability Research Institute in the Department of Geography at the University of South Carolina, Columbia, USA. Her research interests include vulnerability and resilience science, spatial and social inequalities, and hazards geospatial analytics.

Valeria Dattilo is Teaching Assistant of Semiotics and Philosophy of Language at the Department of Humanities at the University of Calabria, Arcavacata di Rende (CS), Italy. She holds a PhD in philosophy of communication and entertainment, theory, and history of languages from the University of Calabria.

Meredith J. DeBoom is Assistant Professor in the Department of Geography at the University of South Carolina, Columbia, USA. She is a political geographer whose research focuses on debates over development, distribution, extraction, and (geo)politics in southern Africa. Her current work examines how Africans are engaging with geopolitical and environmental changes to pursue their own political goals.

Francesco De Pascale is Teaching Assistant of Geography at the Department of Culture and Society at the University of Palermo, Italy. He holds a PhD in human geography from the University of Calabria after defending "the first thesis that deals specifically with geoethics", according to the IAPG.

Sisimac Duchicela is Doctoral Candidate in the Department of Geography and the Environment at the University of Texas at Austin, USA. Her research has focused on high mountain ecosystems, specifically of Andean forests, paramos, and punas. In her doctoral research, she is developing evaluation methods for ecological restoration practices used in Ecuador and Peru, with the goal of increasing human adaptability to global environmental change.

Nicholas P. Dunning is Professor in the Department of Geography & GIS at the University of Cincinnati, USA. His research interests include geoarchaeology and cultural ecology with a special focus in the Neotropics, especially the Maya Lowlands and West Indies.

Grant P. Elliott is Associate Professor of Geography at the University of Missouri, Columbia, USA. He is a biogeographer interested in studying ecological responses to climate change.

Sunyong Eom is Project Researcher in the Center for Spatial Information Science at the University of Tokyo, Chiba, Japan. His research interest covers spatial information science, land use planning, and transportation modeling for sustainable and resilient urban structure.

Madeleine Fairbairn is Assistant Professor in the Environmental Studies Department at the University of California Santa Cruz, USA. Her research interests include the financialization of farmland ownership and the emerging agri-food tech sector.

Albert E. Fulton II is Visiting Lecturer in the Department of Geography at the University of North Alabama, Florence, USA. His research interests include Quaternary paleoecology, pollen analysis, historical ecology, phytogeography, and prehistoric human–environment interactions.

Ben A. Gerlofs is Assistant Professor in the Department of Geography at the University of Hong Kong, Hong Kong SAR. His research interests include developing transnational perspectives on the aesthetics and politics

of neighborhood change and exploring the political and social contexts and consequences of catastrophic urban environmental events.

Jaclyn Guz is PhD Candidate in the Graduate School of Geography at Clark University, Worcester, USA. Her research interests include forest dynamics, climate change, and ecosystem management.

John Harrington Jr. is Independent Scholar and Professor Emeritus at Kansas State University, Manhattan, USA. His research interests include climatology, human dimensions of global change, GIScience, applied geography, geographic thought, and geography education.

Jeffrey Hoelle is Associate Professor in the Department of Anthropology at the University of California, Santa Barbara, USA. His research focuses on human–environment interactions in Amazonia, with a focus on cattle raising, deforestation, and ideologies of cultivation.

Chang-yu Hong is Research Fellow at the Jeju Research Institute, Korea. His area of concentration is sustainability, socio-hydrology, and environmental planning, with a focus on issues of stakeholder governance and conflict resolution.

Erik Isberg is Doctoral Student in the Division of History of Science, Technology and Environment at KTH Royal Institute of Technology, Stockholm, Sweden. His research interests include the history of paleoclimatology, the history of planetary-scale environmental knowledge, and the scientific and intellectual roots of the Anthropocene.

Mark Jackson is Senior Lecturer in the School of Geographical Sciences at the University of Bristol, UK. His research interests include decolonial and postcolonial thought and practice; critical theory, with an emphasis on critique, posthumanism, materiality, modernity, and ethics; political ecology; and critical urbanisms.

L. Allan James is Distinguished Professor Emeritus in the Department of Geography at the University of South Carolina, Columbia, USA. His research interests include fluvial responses to episodic sedimentation, interactions between anthropogenic sediment and flood risks, and applications of geospatial science in geomorphology.

Nicholas C. Kawa is Assistant Professor in the Department of Anthropology at the Ohio State University, Columbus, USA. His research centers on human relationships to plants, soils, and bodily waste in Amazonia and the U.S. Midwest.

Lisa C. Kelley is Assistant Professor in the Department of Geography and Environmental Sciences at the University of Colorado, Denver, USA. Her research combines political ecology, critical agrarian studies, and remote sensing to address diverse questions related to agrarian and forest change.

Anna Klimaszewski-Patterson is Assistant Professor in the Department of Geography at California State University, Sacramento, USA. Her research interests include reconstructing past environments and visualizing spatial processes through models and augmented or virtual reality.

Dominik Kulakowski is Professor of Geography in the Graduate School of Geography at Clark University, Worcester, USA. His research interests are centered on forest ecology and management, and include the causes and consequences of forest disturbances, interactions and feedbacks among ecological processes, effects of climate on tree demography, and effective ecosystem management in the face of global environmental change.

Thomas Barclay Larsen is Instructor of Geography at the University of Northern Iowa, Cedar Falls, USA. His research interests include human–environment relations, the Anthropocene, geographic thought, geography education, and the unity of knowledge.

Rebecca Lave is Professor in the Department of Geography at Indiana University, Bloomington, USA. Her research combines political economy, science and technology studies, and fluvial geomorphology to study the ecosocial dynamics of rivers and streams.

Carolina Levis is Postdoctoral Fellow in the Graduate Program in Ecology at the Federal University of Santa Catarina, Brazil. Her research interests include domesticated forests, Amerindian forest legacies, and Amazonian ecology.

Sheryl Luzzadder-Beach is Centennial Professor and the Director of the Water Quality and Environmental Hydrology Lab in Geography and the Environment at the University of Texas at Austin, USA. She is a past president of the American Association of Geographers. Her research interests include hydrology, geoarchaeology, and geostatistics, pursued in landscapes from Mesoamerica to the Mediterranean.

Samuel A. Markolf is Assistant Research Professor in the Department of Civil, Environmental, and Sustainable Engineering at Arizona State University, Tempe, USA. His research broadly focuses on urban and infrastructure systems, with an emphasis on analyzing the extent to which interconnected SETS can enhance (or hinder) resilience.

Scott Mensing is Gibson Professor of Geography and Foundation Professor in the Department of Geography at University of Nevada, Reno, USA. His research interests include reconstruction of past environments and the impact preindustrial societies have had in shaping ecology.

Harlan Morehouse is Senior Lecturer in the Department of Geography at the University of Vermont, Burlington, USA. His research interests lie at the intersection of political ecology and environmental philosophy, with a current focus on attunement and soundscape ecology.

Christopher T. Morgan is Associate Professor in the Department of Anthropology at the University of Nevada, Reno, USA. His research interests include the archaeology of hunter-gatherer adaptations to climate change and the evolution of human socioeconomic systems.

Lindsay Naylor (she/her) is Associate Professor in the Department of Geography at the University of Delaware, Newark, USA, and is the co-facilitator of the Embodiment Lab. She is the author of the award winning book *Fair Trade Rebels: Coffee Production and Struggles for Autonomy in Chiapas*.

Emily Reisman is Assistant Professor in the Department of Environment and Sustainability at the University at Buffalo, USA. Her research concerns the political ecology of agricultural knowledge, most recently in almond production and emerging agri-food technologies.

Daniel D. Richter is Professor of Soils and Ecology in the Nicholas School of the Environment at Duke University, Durham, USA. His research interests include how humanity is transforming Earth's soils, the biogeochemistry of Earth's critical zone, and particularly in North America's Southern Piedmont.

Wonsuh Song is part-time Lecturer in the School of Education at Waseda University, Tokyo, Japan. She has been researching weathering of rocks by microorganisms, but recently expanded the scope of her research to environmental effects caused by water, such as flood, drought, and wildfires.

Sverker Sörlin is Professor of Environmental History in the Division of History of Science, Technology and Environment, and its KTH Environmental Humanities Laboratory at KTH Royal Institute of Technology, Stockholm, Sweden. His research interests include the historical and geographical science politics of climate change with a focus on the cryosphere, and the history of global environmental governance.

J. Anthony Stallins is Professor in the Department of Geography at the University of Kentucky, Lexington, USA. His research focuses on the nature of boundaries among organisms, the intersection of science and social theory, and the middle ground of geographic thought.

William R. Travis is Associate Professor in the Department of Geography at the University of Colorado, Boulder, USA. His research focuses on human interaction with hazards and risks, especially in a changing global environment.

Michael A. Urban is Associate Professor in the Department of Geography at the University of Missouri, Columbia, USA. Research interests include human drivers of environmental change, related concepts such as the Anthropocene, and exploring how public policy responds to flood control, agricultural development, and climate change.

Dana Veron (she/her) is Associate Professor in the Department of Geography & Spatial Sciences and the School of Marine Science and Policy at the University of Delaware, Newark, USA. Her research focuses on the physical interaction between the lower atmosphere and the land–sea–ice surfaces, including coastal winds, cloud–radiation processes, and polar energy balance.

Antoinette M. G. A WinklerPrins is Deputy Division Director of the Division of Behavioral and Cognitive Sciences in the Directorate for Social, Behavioral, and Economic Sciences at the U.S. National Science Foundation. She is also Adjunct Professor of Environmental Sciences and Policy at the Johns Hopkins University, Baltimore, USA. Her research interests include the formation of cultural landscapes, anthrosols, urban agriculture, and smallholder livelihoods.

Catherine H. Yansa is Associate Professor in the Department of Geography, Environment, and Spatial Sciences at Michigan State University, East Lansing, USA. Her research interests include paleoecology, pollen and plant macrofossil analyses, plant colonization and succession after deglaciation, and prehistoric human–environment interactions.

Kenneth R. Young is Professor in the Department of Geography and the Environment of the University of Texas at Austin, USA. He investigates the ecological and social dimensions of biodiversity conservation, aiming to produce policy-relevant research.

David J. Yu is Assistant Professor with joint appointments in the Lyles School of Civil Engineering and the Department of Political Science at Purdue University, West Lafayette, USA. His research focuses on the resilience and governance of coupled systems (e.g., engineered–social, socio hydrological, or social–ecological) in which some natural or humanmade commons are shared by many and managed through collective choice.

Kathryn Yusoff is Professor of Inhuman Geography in the School of Geography at Queen Mary University of London, UK. She is the author of *A Billion Black Anthropocenes or None, Minneapolis* (2018), a special issue on "Geosocial Formations and the Anthropocene" (with Nigel Clark) in *Theory Culture and Society*, and *Geologic Life: Inhuman Intimacies and the Geophysics of Race* (forthcoming).

Introduction: The Anthropocene

David R. Butler

This special issue of the *Annals of the American Association of Geographers* is devoted to the Anthropocene, the period of unprecedented human impacts on Earth's environmental systems. The articles contained in this special issue illustrate that geographers have a diverse perspective on what the Anthropocene is and represents. The articles also show that geographers do not feel it necessary to identify only one starting point for the temporal onset of the Anthropocene. Several starting points are suggested, and some authors support the concept of a time-transgressive Anthropocene. Articles in this issue are organized into six sections, but many of them transcend easy categorization and could easily have fit into two or even three different sections. Geographers embrace the concept of the Anthropocene while defining it and studying it in a variety of ways that clearly show the breadth and diversity of the discipline. *Key Words: Anthropocene, environmental change, environmental degradation, geographic education, human impact, natural hazards, physical geography.*

The term *Anthropocene* originated in the year 2000 (Crutzen and Stoermer 2000), denoting the concept that humans have become the primary environmental influence on Earth systems. Although the concept of humans as the primary environmental influence on Earth systems has been around since at least the mid-1800s (Marsh 1864), this viewpoint slowly increased throughout the twentieth century (e.g., Sherlock 1922; Thomas 1956; Nir 1983) and has accelerated dramatically in the twenty-first century. New journals have appeared with a primary focus on the Anthropocene, including *Anthropocene* (first appearing in 2013) and *The Anthropocene Review* (which began publication in 2014). All of this begs the questions of what, precisely and exactly, is the Anthropocene, and when did it begin?

Geologists are attempting to define the Anthropocene as a new geological epoch, as "a potential formal unit of the Geological Time Scale, whether by a physical reference point, that is, a Global Boundary Stratigraphic Section and Point (GSSP, or 'golden spike'), as is typical for chronostratigraphic boundaries in the Phanerozoic, or by a numerical age, a Global Standard Stratigraphic Age (GSSA)" (Zalasiewicz and Waters 2017). As of this writing, the geologists' working group on the Anthropocene has not yet come to a conclusion or agreement as to the starting date (Zalasiewicz et al. 2017). Candidates for the starting date include the onset of agriculture in the early Holocene, the changes in the Earth's atmosphere associated with the period of European expansion and colonization, the onset of the Industrial Revolution, and the onset of the Nuclear Age (Figure 1) and the so-called Great Acceleration of widespread environmental change and deposition of nuclear fallout from atmospheric testing of nuclear weapons. Other environmental changes including human impacts on animal communities (Butler 2018; Zerboni and Nicoll 2019) and the extent of surface and subsurface mining activities and degradation (e.g., Sherlock 1922) have also been examined in the context of potentially identifying an Anthropocene starting point.

This special issue of the *Annals of the American Association of Geographers* makes it clear that geographers do not feel bound by the formal constraints of identifying a starting date or even a definition for the Anthropocene that geologists must employ in identifying a stratigraphic boundary. A call for papers on the Anthropocene for this special issue produced a wide array of contributions representing the broad diversity that is our discipline. This issue contains twenty-nine articles chosen from a greater number of submitted abstracts for potential papers. The articles include conceptual considerations and definitions of the Anthropocene (seven articles), historical perspectives on the concept prior to its definition in 2000 (three articles), physical geography (both classic and critical; six articles), examinations

Figure 1. The dawn of the so-called Nuclear Age, one proposed starting date for the Anthropocene, occurred on 16 July 1945, at the Trinity Site in southern New Mexico when the world's first atomic bomb was detonated on the northern end of what is today the White Sands Missile Range. The Trinity bomb was detonated about 30 m above the ground atop a steel tower. The site is memorialized by the stark 4-m-high stone monolith shown here. Photo by author.

of natural hazards and disasters (three articles), the environment and environmental degradation (eight articles), and geographic education (two articles). Some articles could have been categorized in more than one of these artificial groupings, and each one should be read bearing in mind that these categories have no "hard and fast" boundaries.

Definitions and Conceptual Considerations

The first seven articles make very clear how broad and unconstrained geographers are in their consideration of the concept and definition of the Anthropocene. Stallins (this issue) uses topology to illustrate that the Anthropocene should be viewed as a moving window of human and natural processes rather than a fixed point in time. De Pascale and Dattilo (this issue) use geoethics and Peircean semiotics to develop a triangle heuristic as a metaphor for the Anthropocene. Hoelle and Kawa (this issue) identify two periods of the Anthropocene. Their "old Anthropocene" begins with human food production, whereas their "new Anthropocene" coincides with the start of the Industrial Revolution. Yusoff (this issue) seeks to examine the Anthropocene through lenses of race and geopower, arguing that geopower is the product of historical geologies of race.

Adams (this issue) argues that geographers must study the power of words to intervene more effectively in the Anthropocene. He examines stakeholders in the portion of Texas underlain by the Ogallala aquifer in the context of language and its relationship with the concept of the Anthropocene. Reisman and Fairbairn (this issue) use agri-food systems to examine and foster an understanding and a challenging of the concepts of the Anthropocene. The final article in this section, by Jackson (this issue), uses examples from Afro-Caribbean and Indigenous geographies and scholarships to better understand and to perhaps refuse the concept of the rationalizations emanating from Anthropocene horizons.

Historical Perspectives on the Anthropocene

Three articles on the historical perspectives and precursors to the formal definition of the Anthropocene illustrate the history of how geographers have examined the concept of human impact on the environment long before the term *Anthropocene* came into being. Bendix and Urban (this issue) discuss George Perkins Marsh's (1864) classic book *Man and Nature* and illustrate its historical influence and importance in shaping how many (especially physical) geographers conceptualize the Anthropocene and its modern interconnections among geomorphic, biotic, and human elements of the environment. Sörlin and Isberg (this issue) provide a distinctly European perspective on how studies in glaciology, palynology, and biogeography set the groundwork for integrating understandings of time and the human–earth relationship within the context of the Anthropocene. Larsen and Harrington (this issue) conclude this section with an examination of the premise of the Anthropocene through studying early modern as well as contemporary geographic thought.

Physical Geography and the Anthropocene

The articles in physical geography illustrate how numerous starting points for the Anthropocene can be posited, based on a variety of geomorphic, stratigraphic, palynological, and vegetative evidence. The role of critical physical geography (CPG) is also discussed.

James et al. (this issue) use three specific examples of long-term anthropogeomorphic change recorded in bottomland alluviums to illustrate three distinctly different potential starting dates for the Anthropocene based on alluvial stratigraphy and related landforms. Elliott et al. (this issue) examine upper treeline in the southern Rocky Mountains and show how hotter, drier conditions (especially on south-facing slopes) caused by Anthropocene-related climate change are enveloping and affecting upper treeline along topoclimatic gradients. Fulton and Yansa (this issue) use paleoecological and archaeological records from the lower Great Lakes region of northeastern North America to identify three periods of developing and progressively intensifying anthropogenic influence, each of which could be considered a starting point for a Paleoanthropocene. A pre-Columbian Anthropocene in California is described by Klimaszewski-Patterson et al. (this issue), who argue for a flexible, anthropologically and ecologically informed conceptualization of the Anthropocene that is time-transgressive rather than based on a stratigraphically distinct starting date. Luzzadder-Beach et al. (this issue) present detailed light detection and ranging and multiproxy ecological and pedological verification for an early Anthropocene in Mesoamerica, again illustrating how geographers do not feel constrained by the need for a worldwide, distinct, stratigraphic starting point that geologists require to embrace the concept of the Anthropocene.

The final article in this section, by Biermann et al. (this issue), takes a bibliometric analysis approach from a CPG perspective to examine the nature of academic articles on the Anthropocene published between 2002 and 2019. They posit that all biophysical questions are also social and showcase the utility of a CPG approach for analysis of the Anthropocene.

Natural Hazards, Disasters, and the Anthropocene

The articles on natural hazards and disasters continue the trend of being unconstrained by a specific starting date or even a definition of the Anthropocene. Natural hazards of a diverse group ranging from floods to earthquakes are examined through the Anthropocene lens, and the social and economic costs and inequalities come to the fore. Cutter (this issue) describes the changing nature of hazard and disaster risk from local to global scales in the Anthropocene and shows that those risks have accelerated since the "golden spike" of C^{14} in 1964. Gerlofs (this issue) examines the Mexico City earthquakes of 1985 and 2017 as they relate to the politics of geology and political economy in the Anthropocene. The final article in this section, by Chang et al. (this issue), presents case studies of urban flood risk management in the Anthropocene from three cities, in the United States, South Korea, and Japan. They illustrate the utility of resilience and social learning perspectives for analyzing and interpreting the various cities' strategies in coping with flooding over time.

The Environment and Environmental Degradation

Climate change, nature conservation, soil and vegetation impacts, and the degradation of natural landscapes are examined in this section, with at times depressing clarity. The section begins with an article by WinklerPrins and Levis (this issue). They examine Amazonia as an Anthropogenic space, via studying three forms of landscape transformation there—anthrosols, cultural or domesticated forests, and anthropogenic earthworks. Their goal is to understand the past in Amazonia and to guide its conservation. Guz and Kulakowski (this issue) describe and study the ecological resilience of forests in the Anthropocene and compare and contrast management of protected versus intensely used forests through the lens of resilience theory. The article by Young and Duchicela (this issue) considers the state of biodiversity conservation in the changing world of the Anthropocene. The authors suggest that it is appropriate to rethink implications for sustainability and human–nature relationships in general and for biodiversity in particular as a result of human-induced Anthropocene stress(es).

Bergmann and Briwa (this issue) investigate the role visual imagery plays in shaping geographical imaginations of the Anthropocene, through the use of a unique set of posters of U.S. National Parks. (Rothstein n.d.). These posters evoke the aesthetic of the toxic sublime, which the authors suggest is appropriate for the new wilderness landscapes of the Anthropocene. DeBoom (this issue) develops a theoretical framework—climate necropolitics—for developing integrated analyses of the distribution of both environmental and social violence in the Anthropocene. She draws on fieldwork using multiple methods and illustrates the applied value of climate necropolitics through a case study of the Chinese Communist Party's ecological civilization.

The next two articles in this section examine the effects of the Anthropocene on Arctic landscapes. Morehouse and Cigliano (this issue) examine glacial recession in the Anthropocene and describe how the loss of glacial ice needs to be considered not only in quantifiable terms of amount of ice lost but in terms of the effects of ice loss from the human perspective. They discuss this perspective through considering everyday encounters, generational experiences, and stories generated at the interface of ice and culture. Bennett (this issue) continues the examination of Arctic ice and discusses how humanity needs to refocus its gaze and redefine its perceptions of beauty to accommodate the rapidly developing ice-free landscapes of the Anthropocene. This section concludes with an article by Clifford and Travis (this issue), who examine the politics of data management for emerging environmental conditions in the Anthropocene. They call for a need to construct new perspectives as to what constitutes a "normal" or "abnormal" environmental event.

The Anthropocene and Geographic Education

The final two articles examine the role of geographic education and how it represents the Anthropocene in curricula and determine how students can find their "fit" in the Anthropocene. Bagoly-Simo (this issue) illustrates how the geography curricula in lower secondary education in fifty countries represent the Anthropocene and discusses commonalities and differences among the numerous curricula. Finally, Naylor and Veron (this issue) consider the question of how best to teach the environmental changes of the Anthropocene to assist students in determining where they fit in the Anthropocene. They suggest that teaching from both a climate science and from a social or cultural perspective assists in this process and aids an understanding of the place of geographic education in universities in the Anthropocene.

Concluding Remarks

Regardless, then, of which specific definition or start time is chosen, geographers seem to agree that the Anthropocene is upon us. The strength of the discipline is shown by its ability to escape the constricting bonds of required definitions and time frames for the Anthropocene. The Anthropocene can be studied as a starting point or as an ongoing, time-transgressive phenomenon. The Anthropocene is a concept that geography and geographers clearly embrace, and the articles of this special issue hopefully illustrate this well.

Acknowledgments

Putting together a special issue of a journal is a somewhat daunting proposition in the best of times.

Doing so in the midst of a global pandemic is truly challenging. Yet, the authors of the articles contained herein persevered despite lockdowns, transitions to virtual classrooms, illnesses among families and selves, home schooling, and other unprecedented extended parenting needs. Reviewers also heroically stepped forward when asked, despite the increased burdens on their time and mental and physical health. I am extremely grateful to all of the authors and reviewers who have made this special issue possible.

In addition, special recognition should be given to Jennifer Cassidento, Managing Editor of the *Annals*, who worked with me to keep the special issue on track and whose gentle reminders were always given with a smiling attitude. Thanks also to Dr. Stephen Hanna, the AAG Cartographic Editor, who was called on heavily during the global pandemic, and Lea Cutler, Production Editor at Taylor & Francis.

I also gratefully acknowledge the efforts of Camilla Montoya, Public Affairs Specialist at the White Sands Missile Range (WSMR) in New Mexico, for arranging permission for my visit to the Trinity Site prior to the semiannual "open house" at the site in October 2017. Thanks are also due to Drew Hamilton, Public Affairs Specialist, and Robert Carver, Chief of Public Affairs, both from WSMR, for accompanying me to the Trinity Site and providing background and commentary that was very useful.

References

Butler, D. R. 2018. Zoogeomorphology in the Anthropocene. *Geomorphology* 303:146–54. doi: 10.1016/j.geomorph.2017.12.003.

Crutzen, P. J., and E. F. Stoermer. 2000. The Anthropocene. *Global Change Newsletter* 41:17–18.

Marsh, G. P. 1864. *Man and nature; or, physical geography as modified by human action*. New York: Scribner.

Nir, D. 1983. *Man, a geomorphological agent*. Dordrecht, The Netherlands: D. Reidel.

Rothstein, H. n.d. *National Parks 2050*. Accessed January 15, 2021. https://www.hrothstein.com/national-parks-2050

Sherlock, R. L. 1922. *Man as a geological agent—An account of his action on inanimate nature*. London: HF and G Witherby.

Thomas, W. L., Jr., ed. 1956. *Man's role in changing the face of the earth*. Chicago: The University of Chicago Press.

Zalasiewicz, J., and C. N. Waters. 2017. Arguments for a formal global boundary stratotype section and point for the anthropocene. In *Encyclopedia of the anthropocene*, ed. M. Goldstein. Oxford, UK: Elsevier Science & Technology.

Zalasiewicz, J., C. N. Waters, C. P. Summerhayes, A. P. Wolfe, A. D. Barnosky, A. Cearreta, P. Crutzen, E. Ellis, I. J. Fairchild, A. Gałuszka, et al. 2017. The Working Group on the Anthropocene: Summary of evidence and interim recommendations. *Anthropocene* 19:55–60. doi: 10.1016/j.ancene.2017.09.001.

Zerboni, A., and K. Nicoll. 2019. Enhanced zoogeomorphological processes in North Africa in the human-impacted landscapes of the Anthropocene. *Geomorphology* 331:22–35. doi: 10.1016/j.geomorph.2018.10.011.

Part 1

Definitions and Conceptual Considerations

The Anthropocene: The One, the Many, and the Topological

J. Anthony Stallins

Given the many discourses about markers for the Anthropocene, those peripheral to one's academic niche might elicit indifference or even dismissal. Conversely, a shallow pluralism can take root in which any Anthropocene demarcation matters equally as others. I propose a more diplomatic coexistence of ideas regarding the Anthropocene boundary issue. In this perspective, the choice of when to delineate the Anthropocene's start and how to signify its presence is analogous to a modifiable areal unit problem. Boundaries can be drawn from a range of anthropogenic phenomena. Geographic subdisciplines have acquired distinctive ways of sublimating socioecological patterns and processes into a timestamp. Less attention, however, is given to how their respective temporal modes and ensuing markers of anthropogenic change overlap and relate to one another. I show how topology, as invoked in the biophysical sciences and social theory, integrates these temporalities of the Anthropocene. The Anthropocene can be framed as a cusp catastrophe, a folded surface in which different modes of change emerge from and coexist with each other. These trajectories of change, the gradual, the threshold driven, and those exhibiting hysteresis, encapsulate the interdependencies among past, present, and future invoked across different delineations of the Anthropocene. The Anthropocene might be less a fixed point in time as it is a moving window where human and natural processes are folded into one another. An Anthropocene represented as a folded surface rather than a timeline incorporates the importance of unpredictably productive responses to the present Anthropocene moment. *Key Words: Anthropocene, diplomacy, hysteresis, pragmatism, topology.*

From its inception, the concept of the Anthropocene has been a debate about boundaries. Among geographers, these boundaries have often corresponded with subdisciplinary affinities. Critical geographers target the rise of colonialism and global capitalism. Biophysical geographers identify the uptick in the extent of agriculture 10,000 years ago or the peak signature of radioactive fallout from nuclear bomb testing. These and other markers, however, do more than signify academic self. Intent is also implicit to their designation. Any Anthropocene boundary prioritizes a particular view of the past that steers anticipation of a future and the kinds of actions we take in the present (Anderson 2010). Consequently, the choice of an Anthropocene marker can be made to support the perception of the long-term influence of humans. Anthropocene boundary work can make appeals to our ecomodernist hopes for a flourishing of new ways to live on Earth (Ellis 2015). Anthropocene boundaries might even be rejected because they mask underlying social processes and no clear date identifies when humans became geophysical agents (Bauer and Ellis 2018).

In this manner, the concept of Anthropocene allows people to reinforce and perpetuate preferred views about the implications of human interaction with the Earth. As Castree (2017) noted, "What counts as epochal change is a matter of perspective, since it emerges from judgements about when quantitative change morphs from qualitative transformation" (289). The inevitable dichotomies that result, like the good versus a bad Anthropocene, drive conversation toward confusion as individuals argue preferred versions of an Anthropocene concept and its markers. Philosophical and political perspectives become entangled with scientific measures of human impacts and proposed geological stratigraphic units for the start of the Anthropocene (Autin 2016). As the number of demarcations and interpretations of the Anthropocene have grown, perhaps so, too, has the temptation to advocate for one's favored temporal representation of the Anthropocene and the discourse surrounding it.

Following Anderson (2019), I take the position that Anthropocene markers are representations in relation. They are entangled and coevolving rather than isolated. Any individual demarcation of the

Anthropocene is lived with in the midst of other events and processes. Accordingly, the pertinent question might not be when the Anthropocene began but how to summarize the relationality of its many demarcations (Castree et al. 2014). Such a pluralistic approach aims for a diplomatic coexistence of boundaries, a negotiation among parties often distrustful of each other (Castree 2015a, 2015b). For example, designating a stratigraphic marker for the Anthropocene has been productive in ways beyond earth science. Initial proposals to reduce the Anthropocene down to a geologic unit fueled wide-ranging debate on the causes and correlates of the Anthropocene. Similarly, knowledge of how racial and class inequities signal the Anthropocene can be useful in ways that do not obviate all of the practices of global change science (Castree 2015a, 2015b). Yet Anthropocene demarcations are often presented as single agential cuts (Barad 2007) along partisan lines of academic identity. As an alternative, Anthropocene boundaries should be conceived as productive insofar as their relational character is foregrounded as difference but not necessarily contradiction. Following Conway (2019), rather than "dissolving all antagonisms, such that a sea of mutuality might then rise," this perspective on the Anthropocene diplomacy seeks "to dispel unnecessary antagonisms so that necessary ones might come to the fore. It explores the folds that are possible so as to enable the cuts that are necessary" (22).

From this point of view, the Anthropocene can be conceived as a temporal analogue of the modifiable areal unit problem (MAUP), a central concept of geography. Yet this is not simply the observation that the Anthropocene began at different times in different places. Instead, having contrasting, even conflicting demarcations of time (and space) to infer the Anthropocene can be viewed as constructive. In this sense, the MAUP and its counterpart in time, the modifiable temporal unit problem, are not just fallacies of interpretation, the usage most geographers associate with this concept. As I have argued (Stallins 2012), these modifiable unit issues encapsulate the topological character of environmental problem solving performed by organisms. Biological life operates through a constant engagement with the modifiable unit challenge of making predictable sense (cuts) out of the shifting boundaries that define its environment. Accordingly, for humans, any single Anthropocene boundary is a local negotiation that reduces environmental pattern and process down to a point or interval on a timeline. Yet it is only through collective negotiation among many different demarcations of the Anthropocene that this boundary work can become more fully productive.

As an example, one proposed marker for the Anthropocene is the Orbis spike of the early 1600s (Lewis and Maslin 2015). This boundary sublimates the economic processes of European colonization into a timestamp of abruptly lowered carbon dioxide concentrations due to forest regrowth after the genocidal depopulation of the Americas. As a biophysical marker, the Orbis spike also signals a start to the colonialist, global-scale transformations of people and landscapes that continues today. That diffuse political and economic processes become less visible in the stratigraphic designations of the Anthropocene underscores the challenge of finding representations of the Anthropocene that accommodate what seem to be subdisciplinary irreconcilabilities. Yet it is not that we do not understand how these environmental signals and economic processes relate (Saldanha 2019). The challenge is linking the geometries of process and form encompassing colonial power and carbon dioxide levels in Antarctic ice cores. Hence, the Anthropocene is also a task of visualization, of cartographic imagination to bring together objects and processes that defy traditional mapping.

In this article, I show how a topological approach inspired by this reformulation of MAUP lessens some of the partisanship of defending any one Anthropocene boundary from among many. Topology provides a means to represent how different temporal modes of environmental and social change jointly contribute to a more continuous form for the Anthropocene. By allowing many perspectives to exist in relation, topology avoids reifying a single Anthropocene boundary as preeminent; that is, as guilty of committing the fallacy version of MAUP. This hews to Castree's (2015a) advice about how the Anthropocene moment should avoid narratives that "risk perpetuating an emaciated conception of reality wherein Earth systems and social systems are seen as knowable and manageable if the 'right' ensemble of expertise is achieved" (1). This topological view emphasizes a diplomatic coexistence or "presence" (Kaika 2018) among the different

temporalities of the Anthropocene rather than any final delineation of origin or single best marker.

Topology in the Biophysical Sciences and Social Theory

Formally, topology is a branch of mathematics that studies shapes. Topologists treat shapes as spaces whose coordinates are not necessarily contained within a Cartesian coordinate system. Instead, they are intrinsic to the surface itself. Topologists focus on what aspects of a shape remain constant, such as its dimensionality or number of edges, when the surface is deformed. In topological data analysis, high-dimensional visualizations are created from large data sets of many interacting variables. Analysis of the shape of these data provides insight into the relationships among variables. The shape of this data cloud is abstract, but the surfaces and distances within it convey insights about relationships among real-world processes.

Topology has a long history in the biophysical sciences through the use of ball and cup diagrams and fitness surfaces (Inkpen and Petley 2001). These topological ways of seeing can be mathematically formal as well as descriptive and conceptual (Prager and Reiners 2009). One of the more well-known topological forms invoked in the biophysical and social sciences is the cusp catastrophe (Zeeman 1976; Graf 1979; Thorn and Welford 1994). This shape formalizes how a few variables can interact and create a surface where distances between points on it represent transitions among different states. These transitions can range from gradual to sudden depending on the location on the surface. Studies on lakes, coral reefs, oceans, forests, and arid lands have shown that smooth gradual change can be interrupted by sudden drastic switches to a contrasting state (Scheffer et al. 2001). Anthropocene scholars have invoked these abrupt transitions to suggest that the Earth might irreversibly tip and lock into a degraded state once planetary boundaries are exceeded (Barnosky et al. 2012). It is now recognized, however, that the potential for these large jumps in state is more varied in space and time (Dakos et al. 2015). Gradual and less sudden threshold dynamics can coexist with them.

For social theorists, topology is a way of thinking about relationality, space, and movement without mathematical constraints. Topology in human geography provides a way to map out how people and things change and how they relate without quantification (Martin and Secor 2014). Social theorists have used topology metaphorically to account for how presences and absences no longer correspond to measures of physical proximity. For example, power can extend itself in ways that are nonterritorial in the sense that its reach is present in quieter but more pervasive forms irrespective of traditional measures of proximity (Allen 2016). The social relations of home are topological in that they are a collection of attachments that consist of people, places, ideas, and things that are both near and far (Kallio 2016). In human geography, topology has come to be a shorthand for the contextual, relational constitution of the world that defies physical proximity and spaces defined by absolute distances. Social theorists invoke topology as metaphor and rhetorical construct in accounts of the Anthropocene. Their Plantationocene and the Capitalocene encompass the destructive structural logics of resource depletion and petrochemical dependency embedded in the world system of capitalism (Davis et al. 2019). The Chthulucene is a foil to the Anthropocene, a multispecies unfolding and "tentacularity" connecting disparate realms of life in potentially collaborative and creative webs of kinship (Haraway 2015).

Topology provides a means to integrate the pluralistic and often competing delineations of Anthropocene. The diversity of qualitative and quantitative interpretations of the Anthropocene and the markers for them defy conventional space and time boundary making. Topological approaches, however, can meld temporal perspectives on the Anthropocene in ways that timelines and absolute measures of space and time cannot.

Shapes and Surfaces of the Anthropocene

As a conceptual rather than formal mathematical topology, the Anthropocene can be represented as a cusp catastrophe demarcated by three axes (Figure 1). One axis represents the variable of time. A second axis is ecological malleability. This variable conveys the degree to which ecological systems can become entrained by humans. High ecological malleability denotes a socioecological system in which a subset of nonhuman organisms and processes are readily shaped by humans. Low ecological malleability implies ecological systems

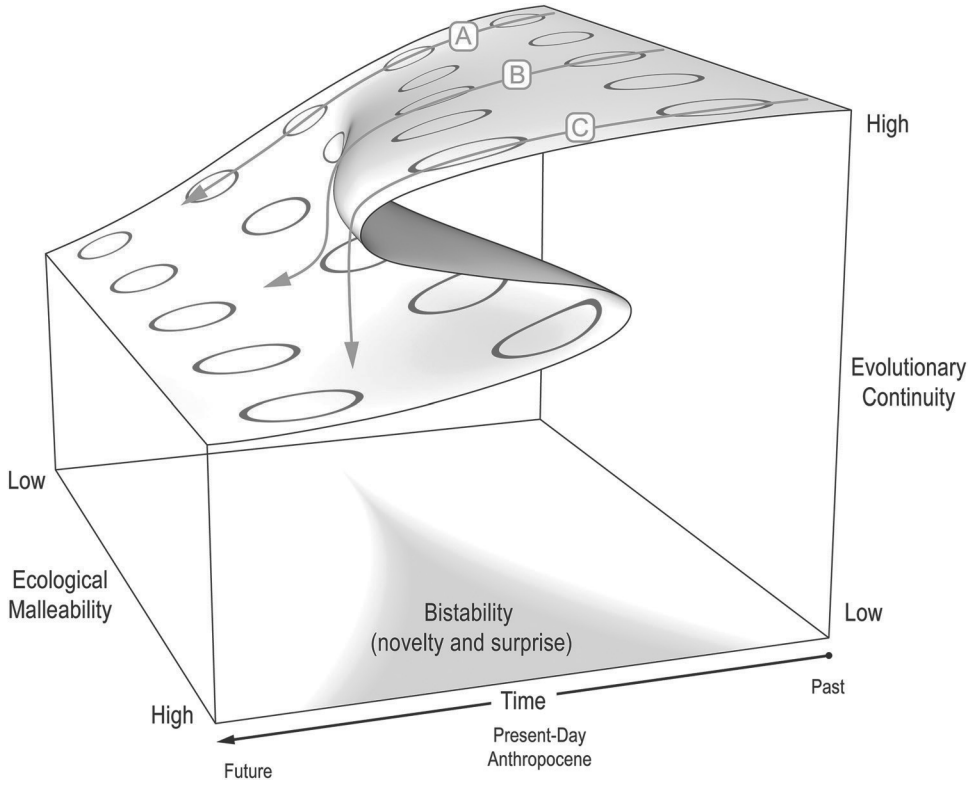

Figure 1. Cusp catastrophe for the Anthropocene with three temporal trajectories: (A) gradual, (B) threshold, and (C) hysteretic. Changes in the shape of the distortion ellipses along each trajectory represent how past, present, and future inform one other. Consistent ellipse shape along a trajectory indicates predictable correlations among past, present, and future. Distortions indicate less predictability of the future based on the past and present. The gray shaded area represents where novelty and surprise arise from bistability and tipping.

with properties that resist human incorporation or domestication, an unruliness of nature. The third axis represents evolutionary continuity. This response variable is a measure of the depth of time comprising evolutionary development in the absence of human impacts. Lower positions on this axis represent a greater divergence from past nonhuman evolutionary context. Higher positions represent systems more temporally continuous with nonhuman environmental change and ecological processes. These three axes demarcate regions on the surface of this fold that parallel a trend of increasing human impacts through time, from the past, to a present-day Anthropocene, and a future.

The movement from an unmodified, evolutionarily conserved past to the ecologies of the humanized present traces multiple paths on this surface. Although many trajectories are possible along the contours of this surface, the three predominant ones shown in Figure 1 range from the gradual, to threshold-driven, and a path that exhibits irreversibility, or hysteresis, associated with sudden changes in state. These three trajectories also possess contrasts in how the past is correlated with present and how they anticipate the future. The changing shapes of the distortion ellipses projected on this surface represent the past, present, and future correlate and inform one another. For example, for a ball moving along a gradual trajectory (A), change is relatively predictable. The unchanged shape of the distortion ellipses conveys a consistent predictability in how the past informs the present and the future through time. With threshold trajectories (B), the past has much less capacity to inform the present and the future, as represented in the shrinking of the distortion ellipse where the surface bends inward in the center. With hysteresis (C), the distortion ellipses stretch more in one direction, indicating how the past can inform the present only within increasingly narrow bounds. Trajectories here become more blind to the future. These three predominant trajectories and their contrasts in how past, present, and future relate to one another give form to the many Anthropocenes that coexist as one.

Gradual Anthropocenes

Although the Anthropocene is often described as sudden, others have argued for a longer run-up to the present. For this trajectory, its low ecological malleability results in greater evolutionary continuity and a stronger correlation of the past with the present and future in the accumulation of human impacts. Early agricultural societies by 3,000 years ago had set in motion the large-scale anthropogenic modification of soil and biota (Jenny et al. 2019; Stephens et al. 2019). Human behavior has been a long-term ecological driver of plant and animal evolution for at least 50,000 years (Sullivan, Bird, and Perry 2017). These gradual trajectories reflect how some environmental and evolutionary constraints have not vanished in the Anthropocene. Aspects of our environment, nonhuman organisms, and human behavior and biology can exhibit a resistance to anthropogenic influences. For example, our mammalian qualities have not suddenly disappeared because we focus more on sociocultural identities and have secured the title of planetary engineer (Laist 2015). In these ways, a gradualist framing of the Anthropocene reinserts nature into the Anthropocene moment. Even the governmental and economic systems operative today remain correlated over a length of time with the past. Their futures are path dependent. As many critical geographers recognize, new envisionings of society do not easily escape the ruts left by old economic orders just because their radically transformative potentials are recognized. The colonial past remains entrenched in different economic and political forms. Defining the Anthropocene as a point on a timeline obscures many biophysical as well as social features of the past that are continuous and predictably correlated with the present and near future (Figures 2A–2B).

Threshold Anthropocenes

Many of the variables of the post–World War II Great Acceleration map as threshold trajectories. For this trajectory, malleability increases and allows greater deviation from historical precedents as axis position shifts toward less evolutionary continuity. These more industrialized Anthropocenes have sharper deviations from long-term trends, as exemplified by rapid increases in the number of humans on Earth, in rates of fossil fuel consumption, and in the pace of environmental change. Consequently,

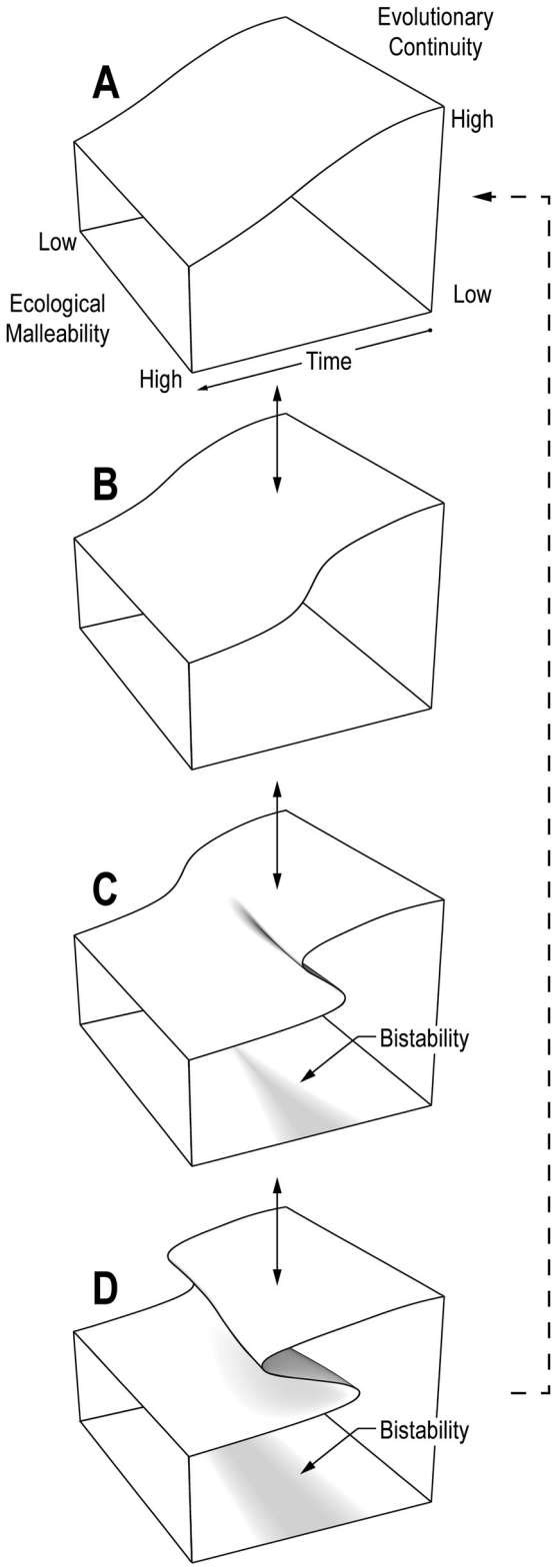

Figure 2. The emergence of the Anthropocene fold: (A) gradual transition surface; (B) initiation of threshold change where malleability is high; (C) hysteresis develops as system is managed for predictability, thereby increasing potential for sudden change in state; (D) with greater folding, more bistability and uncertainty but also greater potential for novelty and surprise. Sequence is not intended to be deterministically developmental.

rainfall, temperature, and river flows no longer have a stable mean around which they predictably fluctuate. This loss of stationarity, an inability to predict the future based on the past, is often taken to be the defining feature of the Anthropocene. The Great Acceleration, however, forms out of the velocity of a gradual past. Its threshold trajectories and loss of stationarity have a dependence on the degree to which the details of past can be resolved. This dependence arises because the accumulation of knowledge and technology that makes this acceleration possible also helps resolve the details of environmental histories extending back millennia. In other words, the more we know about the past, the more we know about the threshold slope leading to the future and what constitutes stationarity.

This dependency of thresholds on the resolution of the gradualist past is not confined to biophysical characterizations of the Anthropocene. With this rapid accumulation of knowledge has come a broadening in awareness of the inequities of the Anthropocene, of who has gained and who has borne the costs of this acceleration not only in the present but also in the past. To imagine a more equitable decolonized political future analogously depends on interpretations of history and awareness of the global present to serve as anticipatory guides. As seen on the Anthropocene surface (Figures 2A–2C), threshold trajectories are continuous with gradualist trajectories of change. Threshold and gradual trajectories inform one another whether they highlight biophysical or social and political interpretations of the Anthropocene.

Hysteretic Anthropocenes

Axis positions for this trajectory signal the capacity of human systems to utilize ecological malleability to the extent that abrupt shifts to novel systems can occur. With hysteresis, threshold change is delayed. Tipping points are eventually reached, resulting in a sudden jump to a historically novel state. These transitions can be irreversible. The tipping metaphor has gained prominence in many fields. Human economic systems can undergo these kinds of critical transitions (Battiston et al. 2016). Climate also has a propensity to tip irreversibly (Steffen et al. 2018). The potential for tipping has been overstated, however, particularly for ecological systems. Tipping might be more variable in space and time than early studies suggested, largely because the experimental designs that informed them downweighted the role of spatial heterogeneity (Kefi et al. 2013). As reflected in Figures 2C–2D, tipping and hysteresis coexist with and emerge from gradual and threshold trajectories of change.

The relationships between past, present, and future are more uncertain on the hysteretic region of the Anthropocene surface. This uncertainty is a trade-off, though, for the generation of novelty. The hysteresis fold demarcates a region where multiple states manifest within the same general conditions. In this bistable region between tipping points, seemingly oppositional states can coexist (Figure 3). The good Anthropocene of the technological optimists and ecomodernists, as achieved through scientific mitigation of human impacts, coexists with the protectionist and cautionary outlook for a bad Anthropocene. Robbins (2020) framed this as a coexistence between the forward-looking ecomodernist's more-is-less world and a skeptic's look backward to a less-is-more world. Similarly, bistability allows for conservation to coexist as preservationist, neoliberal, or decolonialist (Collard, Dempsey, and Sundberg 2015). In this bistable region, the Capitalocene coexists with the Chthulucene. Through the property of bistability, hysteresis can foster a mosaic of contrasting, even seemingly contradictory social and biophysical states despite their proximity on the Anthropocene fold.

Due to its propensity to tip and to allow different states to coexist, the Anthropocene fold produces not only problems but also solutions and new ways for humans to encounter and modify nature. The "Anthropo-scene," according to Lorimer (2017), is unique in that it makes possible novel forms of knowledge and sets the stage for new arrangements for knowledge production to emerge. It is where humans construct their sociocultural niche through constant experimental action and reaction (Ellis 2015). It is on this folded region of the surface that the past coexists with the emergence of new biophysical and sociopolitical entities and unexpected events in ways that generate the ongoing reconfiguration of the world.

This bistable region should not be viewed as the only source of solutions, however. Gradual trajectories lessen the generation of novelty, but they are more likely to provide deeper evolutionary solutions,

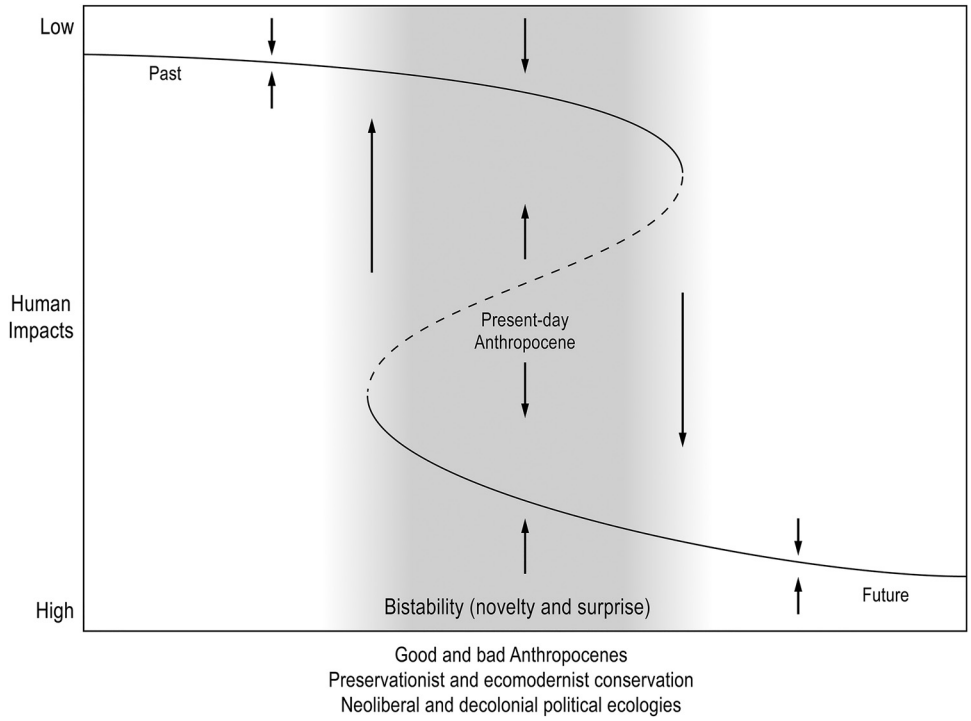

Figure 3. Bistability, novelty, and the tensions of the Anthropocene. Arrows indicate the direction in which the system tends to develop in response to feedbacks. The dashed line indicates a dynamically unfavored region as the feedbacks tend to direct organization to one of two states. Time is along the horizontal axis.

ones that have been recognized by indigenous cultures and conserved through time. In sum, a wide range of solutions, traditional as well as novel, can be present at the same time across this surface (Figure 2C). Too much bistability (Figure 2D) or too little (Figure 2A) would not offer as wide a range of solutions for humans to manage their influence on Earth.

Coda: Topology and Pragmatism

The present-day Anthropocene consists of multiple trajectories of change. It is relational with characteristics of paradox, pluralism, and perspectivism (de la Cadena and Blaser 2018; Wells 2018; Fagan 2019). Instead of a timeline emanating from the past that crosses some threshold, the Anthropocene is an involution, a topological folding over of human and natural processes. This Anthropocene is less a fixed point in time than it is a moving window where the fluxes of nature coexist with the cultures of nature. It is an evolving, propagating boundary where human sociocultural processes shape and are shaped by ecological theory and practice.

This topological interpretation of the Anthropocene is built on more than the truism that boundaries are impermanent and imprecise. Instead, it conveys how the conflicting boundary interpretations that animate the modifiable temporal and areal unit problems are not necessarily fallacies to avoid. They leverage productive differences to negotiate new yet temporary meanings from among antagonisms. As an attempt at diplomacy, topology negotiates among the oneness and manyness of debates over Anthropocene boundaries and signifiers. As for the hazard of reifying any one definition of the Anthropocene and a marker for it, care should also be taken as to how the pluralism of the Anthropocene is construed. Philosophical pragmatists would hold that this pluralism should not be a simplistic celebration of the many, nor the grounds for hardening one's favored belief and discourse. Instead, this pluralism provides "first and foremost a pragmatics, an experimental, exploratory and unpredictably productive response to our present moment" (Savransky 2019, 5).

Acknowledgment

In addition to my anonymous reviewers, my thanks go to William Reihard (https://williamreinhard.

artstation.com/) for providing his skills in the development of the three-dimensional graphics.

ORCID

J. Anthony Stallins http://orcid.org/0000-0002-3911-828X

References

Allen, J. 2016. *Topologies of power: Beyond territory and networks*. London and New York: Routledge.

Anderson, B. 2010. Preemption, precaution, preparedness: Anticipatory action and future geographies. *Progress in Human Geography* 34 (6):777–98. doi: 10.1177/0309132510362600.

Anderson, B. 2019. Cultural geography II: The force of representations. *Progress in Human Geography* 43 (6):1120–32. doi: 10.1177/0309132518761431.

Autin, W. J. 2016. Multiple dichotomies of the Anthropocene. *The Anthropocene Review* 3 (3): 218–30. doi: 10.1177/2053019616646133.

Barad, K. M. 2007. *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning*. Durham, NC: Duke University Press.

Barnosky, A. D., E. A. Hadly, J. Bascompte, E. L. Berlow, J. H. Brown, M. Fortelius, W. M. Getz, J. Harte, A. Hastings, P. A. Marquet, et al. 2012. Approaching a state shift in Earth's biosphere. *Nature* 486 (7401): 52–58. doi: 10.1038/nature11018.

Battiston, S., J. D. Farmer, A. Flache, D. Garlaschelli, A. G. Haldane, H. Heesterbeek, C. Hommes, C. Jaeger, R. May, and M. Scheffer. 2016. Complexity theory and financial regulation. *Science* 351 (6275):818–19. doi: 10.1126/science.aad0299.

Bauer, A. M., and E. C. Ellis. 2018. The Anthropocene divide obscuring understanding of social-environmental change. *Current Anthropology* 59 (2):209–27. doi: 10.1086/697198.

Castree, N. 2015a. Geography and global change science: Relationships necessary, absent, and possible. *Geographical Research* 53 (1):1–15. doi: 10.1111/1745-5871.12100.

Castree, N. 2015b. Unfree radicals: Geoscientists, the Anthropocene, and left politics. *Antipode* 49 (Suppl. 1):52–74. doi: 10.1111/anti.12187.

Castree, N. 2017. Anthropocene: Social science misconstrued. *Nature* 541 (7637):289. doi: 10.1038/541289c.

Castree, N., W. M. Adams, J. Barry, D. Brockington, B. Buscher, E. Corbera, D. Demeritt, R. Duffy, U. Felt, K. Neves, et al. 2014. Changing the intellectual climate. *Nature Climate Change* 4 (9):763–68. doi: 10.1038/nclimate2339.

Collard, R. C., J. Dempsey, and J. Sundberg. 2015. A manifesto for abundant futures. *Annals of the Association of American Geographers* 105 (2):322–30. doi: 10.1080/00045608.2014.973007.

Conway, P. R. 2019. The folds of coexistence: Towards a diplomatic political ontology, between difference and contradiction. *Theory Culture & Society* 37 (3):23–47. doi: 10.1177/0263276419885004.

Dakos, V., S. R. Carpenter, E. H. van Nes, and M. Scheffer. 2015. Resilience indicators: Prospects and limitations for early warnings of regime shifts. *Philosophical Transactions of the Royal Society B-Biological Sciences* 370 (1659):10. doi: 10.1098/rstb.2013.0263.

Davis, J., A. A. Moulton, L. Van Sant, and B. Williams. 2019. Anthropocene, Capitalocene, Plantationocene? A manifesto for ecological justice in an age of global crises. *Geography Compass* 13 (5):e12438–15. doi: 10.1111/gec3.12438.

de la Cadena, M., and M. Blaser. 2018. *A world of many worlds*. Durham, NC: Duke University Press.

Ellis, E. C. 2015. Ecology in an anthropogenic biosphere. *Ecological Monographs* 85 (3):287–331. doi: 10.1890/14-2274.1.

Fagan, M. 2019. On the dangers of an Anthropocene epoch: Geological time, political time and post-human politics. *Political Geography* 70:55–63. doi: 10.1016/j.polgeo.2019.01.008.

Graf, W. L. 1979. Catastrophe theory as a model for change in fluvial systems. In *Adjustments of the fluvial system*, ed. D. D. Rhodes and E. J. Williams, 13–32. London: Allen and Unwin.

Haraway, D. 2015. Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making kin. *Environmental Humanities* 6 (1):159–65. doi: 10.1215/22011919-3615934.

Inkpen, R., and D. Petley. 2001. Fitness spaces and their potential for visualizing change in the physical landscape. *Area* 33 (3):242–51. doi: 10.1111/1475-4762.00028.

Jenny, J.-P., S. Koirala, I. Gregory-Eaves, P. Francus, C. Niemann, B. Ahrens, V. Brovkin, A. Baud, A. E. K. Ojala, A. Normandeau, et al. 2019. Human and climate global-scale imprint on sediment transfer during the Holocene. *Proceedings of the National Academy of Sciences* 116 (46):22972–76. doi: 10.1073/pnas.1908179116.

Kaika, M. 2018. Between the frog and the eagle: Claiming a "scholarship of presence" for the Anthropocene. *European Planning Studies* 26 (9): 1714–27. doi: 10.1080/09654313.2018.1484893.

Kallio, K. P. 2016. Living together in the topological home. *Space and Culture* 19 (4):373–89. doi: 10.1177/1206331216631290.

Kefi, S., V. Dakos, M. Scheffer, E. H. Van Nes, and M. Rietkerk. 2013. Early warning signals also precede non-catastrophic transitions. *Oikos* 122 (5):641–48. doi: 10.1111/j.1600-0706.2012.20838.x.

Laist, R. 2015. Why I identify as mammal. *New York Times*, October 24. Accessed October 24, 2019. https://opinionator.blogs.nytimes.com/2015/10/24/why-i-identify-as-mammal/.

Lewis, S. L., and M. A. Maslin. 2015. Defining the Anthropocene. *Nature* 519 (7542):171–80. doi: 10.1038/nature14258.

Lorimer, J. 2017. The Anthropo-scene: A guide for the perplexed. *Social Studies of Science* 47 (1):117–42. doi: 10.1177/0306312716671039.

Martin, L., and A. J. Secor. 2014. Towards a post-mathematical topology. *Progress in Human Geography* 38 (3):420–38. doi: 10.1177/0309132513508209.

Prager, S. D., and W. A. Reiners. 2009. Historical and emerging practices in ecological topology. *Ecological Complexity* 6 (2):160–71. doi: 10.1016/j.ecocom.2008.11.001.

Robbins, P. 2020. Is less more … or is more less? Scaling the political ecologies of the future. *Political Geography* 76:102018. doi: 10.1016/j.polgeo.2019.04.010.

Saldanha, A. 2019. A date with destiny: Racial capitalism and the beginnings of the Anthropocene. *Environment and Planning D-Society & Space* 38 (1): 12–34. doi: 10.1177/0263775819871964.

Savransky, M. 2019. The pluralistic problematic: William James and the pragmatics of the pluriverse. *Theory, Culture & Society*. Advance online publication. doi: 10.1177/0263276419848030.

Scheffer, M., S. Carpenter, J. A. Foley, C. Folke, and B. Walker. 2001. Catastrophic shifts in ecosystems. *Nature* 413 (6856):591–96. doi: 10.1038/35098000.

Stallins, J. A. 2012. Scale, causality, and the new organism–environment interaction. *Geoforum* 43 (3):427–41. doi: 10.1016/j.geoforum.2011.10.011.

Steffen, W., J. Rockstrom, K. Richardson, T. M. Lenton, C. Folke, D. Liverman, C. P. Summerhayes, A. D. Barnosky, S. E. Cornell, M. Crucifix, et al. 2018. Trajectories of the Earth system in the Anthropocene. *Proceedings of the National Academy of Sciences* 115 (33):8252–59. doi: 10.1073/pnas.1810141115.

Stephens, L., D. Fuller, N. Boivin, T. Rick, N. Gauthier, A. Kay, B. Marwick, C. Geralda Armstrong, C. Michael Barton, T. Denham, et al. 2019. Archaeological assessment reveals Earth's early transformation through land use. *Science* 365 (6456): 897–902. doi: 10.1126/science.aax1192.

Sullivan, A. P., D. W. Bird, and G. H. Perry. 2017. Human behaviour as a long-term ecological driver of non-human evolution. *Nature Ecology & Evolution* 1 (3):1–11. doi: 10.1038/s41559-016-0065.

Thorn, C. E., and M. R. Welford. 1994. The equilibrium concept in geomorphology. *Annals of the Association of American Geographers* 84 (4):666–96. doi: 10.1111/j.1467-8306.1994.tb01882.x.

Wells, J. 2018. Mind the gap: Bridging the two cultures with complex thought. *Ecological Complexity* 35: 81–97. doi: 10.1016/j.ecocom.2017.11.001.

Zeeman, E. C. 1976. Catastrophe theory. *Scientific American* 234 (4):65–83. doi: 10.1038/scientificamerican0476-65.

The Geoethical Semiosis of the Anthropocene: The Peircean Triad for a Reconceptualization of the Relationship between Human Beings and Environment

Francesco De Pascale and Valeria Dattilo

This article seeks to reconcile, as well as operationalize, two different methodological approaches on the basis of some important basic affinities: geoethics and Peircean semiotics. For this purpose, Peirce's triangle is conceived as a "translator mechanism" to parse the human–planet relationship that cannot be dealt with through actions in pairs but must be considered as a triadic relationship in which geoethics comes into play to develop a new relationship between human beings and environment. Following this, the triangle heuristic will employ the vertices Geoethics–Illness of the Earth–Society as a metaphor of the Anthropocene era through the lens of Peircean semiotics. This triangle method will help investigate some research questions: (1) Is planet illness an icon, index, or a symbol of the negative impact of the society? (2) When do we encounter environmental phenomena constituting images of planet illness? (3) What is the salient perspective from which to study the phenomenon of the Anthropocene? In discussing these issues, the authors call into play the concept of noosphere and propose a new ethical framework guiding human behavior toward the environment. *Key Words: Anthropocene, geoethics, Hippocratic triangle, noosphere, Peirce's semiotics.*

This article proposes a nuanced, semiotic conception of the relationship between human beings and the environment. On the one hand, the analysis challenges a dualistic approach that considers nature as something autonomous or independent of human action (Vogel 2015, 2016). On the other, the article extends and nuances the argument that in the Anthropocene era, there are no longer examples of a completely separate and independent nature from humans (Chakrabarty 2012; Hamilton, Bonneuil, and Gemenne 2015; Latour 2015; Hamilton 2017). Rather, the article combines the perspectives offered by geoethics and semiotics to examine the processes of the Anthropocene era and offer an intermediate position that considers environment itself as a semiotic product. In the first move, the article draws on the heuristic of Peirce's triangle, a fundamental theory of semiotics. In the second move, the analysis turns to the geoethical paradigm as a possible framework for parsing the processes of the Anthropocene era and for instituting a planetary Hippocratic oath. Together, these analytical frameworks will guide the survey to answer the following research questions: (1) Is planet illness an icon, index, or a symbol of the negative impact of the society? (2) When do we encounter environmental phenomena constituting images of planet illness? (3) What is the salient perspective from which to study the phenomenon of the Anthropocene?

The Anthropocene: An Introduction to the Concept in the Human and Social Sciences

The concept of the Anthropocene, currently controversial in geology due to issues concerning temporal and stratigraphic limits, has, in the human and social sciences, been a driving force for the development of new research paradigms that run parallel to the declensions of the posthuman, political ecology, and the environmental humanities, as well as a medium to strengthen the link between environmental research and sociopolitical commitment (Farrier 2019; Yusoff 2019). In addition, the term's reference to *anthropos*—that is, to human without distinction—has given rise to a new wave of

reflections, theoretical constructions and deconstruction of the relationship between nature and culture, human and nonhuman, genders, cultures, and, more broadly, the alleged essence or authenticity of something like "human beings" (Bogues 2006; McKittrick 2015; Baranzoni, Lucci, and Vignola 2016). The Anthropocene, although not without its limitations, still remains a productive interdisciplinary tool, creating a meeting place between socioanthropological, historical–political, philosophical, and ethical perspectives on questions of environmental change, agency, and ethics. The term also captures and calls forth a cross-disciplinary approach—one that allows us to formulate a solid framework of ethical, social, and cultural values—useful to the geoscience community as well as humanities scholars. Responding to the complexity of the Anthropocene, as a critical term and a potential geological epoch, both research communities extend their pedagogical and research inquiry, their more traditional disciplinary foci, and integrate questions explored earlier by ethicists and philosophers with an analysis of issues that affect society as a whole. Within this wider framework, geoethics (Němec 2005; Wyss and Peppoloni 2014; Peppoloni, Bobrowsky, and Di Capua 2015; Nikitina 2016; Gundersen 2017; Peppoloni et al. 2017) is concerned with the ethical implications of the most relevant phenomena of our time, from climate change to environmental pollution and from the exploitation of resources to disasters caused by hazards and vulnerability (De Pascale and Dattilo 2019). Specifically, geoethics brings the social, human, and natural sciences together in different ways to confront current ecological crises from various ethical, cultural, philosophical, political, social, and biological perspectives (Oppermann and Iovino 2017). Putting the concept of noosphere in the Anthropocene era in dialogue with Peircean semiotics, as the article goes on to demonstrate, allows us to analyze the signs that represent the processes related to these crises and the wider relationship between ethics and semiotics in times of environmental crises.

Conceptual and Methodological Framework

In its broadest sense, semiotics studies signs both in the field of communication (signs intended as tools for communicating, for exchanging information) and in the field of knowledge (signs understood as mediators of reality that surrounds us; Eco 1975). In the humanities, semiotics, unlike linguistics, also studies nonlinguistic signs. This article, building on the distinction made by Eco (1975), focuses on general semiotics that takes into account the sign in the cognitive field, relating it to the notion of the Anthropocene. To this end, the article draws on Peirce's (1931–1935) notion of the sign. Peircean semiotic theory should not be understood simply as a theory of interpersonal communication, a limited and limiting view of his theory. Rather, Peirce applied semiotic categories typical of human beings to the whole universe. According to Peirce, the sign is a category that embraces the whole universe (Peirce 1931–1935). To be perceived as "real," extralinguistic objects must be seen as signs, and the concepts of objects must be considered semiotically. This leads to the assertion that environment and, in general, the universe are also semiotic products.

Within this much more inclusive definition (Peirce 1931–1935), the sign is not limited to the linguistic-communicative sphere only but must be considered as a cognitive tool. There are three elements that make up the sign. Translated into graphic terms, the structure that comes out of Pierce's vision of the sign is a triangle that requires the presence of three elements: *representamen*, or sign *tout court*, object, and interpretant, at the vertices of the triangle (Figure 1). The definition of

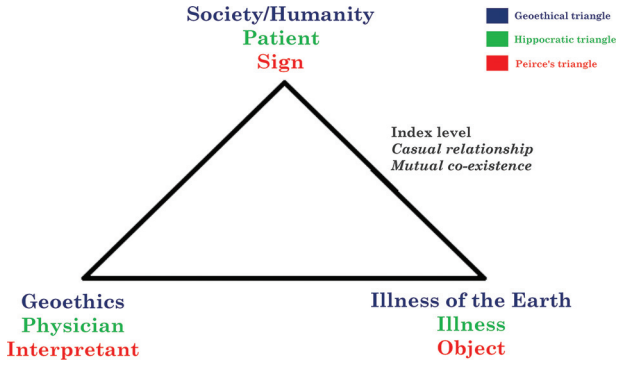

Figure 1. All of the elements that characterize the triangles of Peirce, Hippocrates, and geoethics. *Sign* or *representamen*, *object*, and *interpretant* are the elements of Peirce's triangle (red writing). *Physician*, *illness*, and *patient* are the factors affecting the Hippocratic triangle in medicine (green writing). *Geoethics*, *Illness of the Earth*, and *Society/Humanity* are the elements of the geoethical triangle proposed by the authors (blue writing). The causal relationship and the mutual coexistence between Society and Illness of the Earth correspond, in Peirce's triangle, to a causal relationship between sign and object (index level). Sources: Peirce (1931–1935, 1958), Matteucci et al. (2012), De Pascale and Dattilo (2019).

sign implies the beginning of the process of semiosis. Semiosis is defined as "an action, or influence, which is, or involves, a cooperation of three subjects, such as a sign, its object, and its interpretant, this tri-relative influence not being in any way resolvable into actions between pairs" (Peirce 1931–1935, 5.484). A sign can stand in the place of something else, in someone's eyes, only because this relationship is mediated by an interpretant, which is another sign that translates and explains the previous one. This process, which lasts indefinitely, is called "unlimited semiosis" (Eco 1975). It is an infinite series of interpretations that can have as its final interpretant what Peirce calls *habit*, or the point of arrival of unlimited semiosis. The starting point of semiosis (i.e., of the process of creation, of formation of meaning) is the external reality: a dynamic object. The sign (or *representamen*) refers (stands for) to a dynamic object. The immediate object does not correspond with the dynamic object (which is, instead, the object in itself, the real one). This happens because a sign (a *representamen*) always represents something from a certain point of view. The immediate object (content) is the way in which the dynamic object (real object) is focused (Proni 1990; Pisanty and Pellerey 2004). The interpretant is not the interpreter. The interpreter is the one who grasps the link between sign and object; the interpretant is a second sign that highlights in what sense it can be said that a certain sign refers to a given object.

For example, the word *table*, which is the sign or *representamen*, refers to the part that is meant; that is, the content (immediate object) that is "a piece of furniture consisting of a horizontal plane supported mostly by four legs". The dynamic object is the table intended as a real or extralinguistic object. The interpreter is the one (the individual) who grasps the relationship between the word *table* and the table intended as a real object. The interpretant is the idea of the individual that characterizes and motivates this relationship. This understanding depends on the idea in the interpreter's mind. To put it simply, a chef might interpret the word or sign table in a different way than a pupil at school.

Precisely because Peirce does not reduce semiotics to a theory of communicative acts, Peirce's triad can also be productively used to analyze environmental phenomena that have a human recipient, as, for example, in the case of climatic symptoms (Eco 1975) or the manifestations of anthropogenic climate change in the Anthropocene. What are these manifestations? Many researchers argue that the Anthropocene represents a new division of geological time, claiming that human activity, through its use of fossil fuels, has warmed the planet, raised sea levels, degraded the ozone layer, and acidified the oceans (Crutzen and Stoermer 2000; Crutzen 2002; Zalasiewicz et al. 2008; Bonneuil and Fressoz 2013; Monastersky 2015). This means that, to take just one of these examples, the degraded ozone layer signifies that something has happened. It then becomes necessary to understand what this is a sign of.

The relationship between human beings and the environment cannot be reduced to action between two elements but must be considered as a triadic relationship, one in which geoethics would come into play as *habit* (final logical interpretant) and as an attempt to develop a new relationship between human beings and the environment. Geoethics can be defined as the investigation and reflection on a human's operational behavior toward the geosphere (Peppoloni, Bobrowsky, and Di Capua 2015). As a field, geoethics draws from the work of Leopold, who, already in the 1940s, proclaimed the need to develop a new relationship between humans and the environment. Leopold identified the concept of "conservation" as an ethical criterion indicating "a state of harmony between human and the Earth" (Leopold 1949, 202). For Leopold, the premise of ethics is to forge an awareness that the individual is a member of a community of interdependent parts. Hence, for him, the role of *Homo sapiens* must change from conqueror of the Earth to a mere member and citizen of his community.

Equally, geoethics appeals to the noosphere, a concept proposed by Le Roy and de Chardin, then amplified by Vernadsky (1987), and seen as a third stage of development. Stage one is the physical geosphere of inanimate matter, stage two is the biosphere of animate or biological matter, and stage three is the noosphere, as proposed by Vernadsky. The term denotes a "commonsense" biosphere, meaning that the functioning, dynamics, and evolution of the Earth must largely be determined by reasonable human activity, an activity that focuses its efforts on creation rather than destruction (Vernadsky 1987). At the core of the concept of noosphere, however, is not the universality of the

human species but the universality of common human faculties, such as intellect, language, and intelligence, as well as the ability to appeal to responsibility. It is precisely to these capacities and to the sense of responsibility that geoethics appeals in addressing the problems related to adaptation and mitigation of the effects of climate change. This appeal implies the need for reviewing our ways of "building our future" and taking care of the place where we dwell (De Pascale and Dattilo 2019; De Pascale and Roger 2020). Consequently, by combining Peircean semiotics and geoethical concerns, this article aims to propose a semiotic theory of the Anthropocene that opens up to a much wider considerations of the range of signs and possible explanations for attitudes toward and perceptions of the environment.

Geoethics and Semiotics for a Reconceptualization of the Human–Environment Relationship

The first step toward such a joint geoethical and semiotic approach to the Anthropocene and the questions of responsibility and agency that it calls forth involves a reconceptualization of the human–environment relationship. Inspired by the work of Matteucci et al. (2012), we propose a tripartite division of signs in a Peircean triangle with the respective vertices: Geoethics, Illness of the Earth, and Society/Humanity (Figure 1). In contrast to the work of these scholars, who attribute ethical obligations solely to the field of geology (Figure 1), however, we contend that geoethical responsibility needs to be represented by a synthesis between geology, geography, and philosophy. By first extending this ethical obligation to the field of geoethics and combining it with a semiotic approach, in the second move we can consider the meaning and function of this geoethical triangle and the analogies with the Hippocratic triangle.

According to Peirce, mental images correspond to the iconic level, where the relationship between sign and object is based on similarity (Farinelli 2004). When, instead, something is said to be the index of something else, it means that something is related to something else from a causal point of view. The third level of interpretation coincides, for Peirce, with the symbolic one. The symbol is linked to the object by virtue of a shared convention of a recognized mental association. To explain this better, we can give some examples. A photograph of a table is not a table but an icon, because it resembles the table. Written numbers (e.g., 5) are symbols, because there is nothing inherent in that figure that represents five of anything; it is just a convention that we all follow. Natural signs are part of the index category and are the footprints in the sand, the smoke that rises from the fire. These signs communicate by cause–effect connection (i.e., the lightning is the index of a possible storm).

This definition of the sign helps us understand how a certain number of environmental phenomena and processes, including climate change, constitute a historical sign that stands for planet illness and the impacts that global societies have on the planet. Peirce's statements, if analyzed from an ecological perspective, lead to a confirmation that such a relationship cannot be an icon or symbol of the impacts that such a society has on the Earth. Therefore, disasters are an immediate effect, an index's sign, of a society's negative impact (e.g., increasing environmental pollution, building abuses, overexploitation of mineral resources, etc.; De Pascale and Dattilo 2019). In this context, the Anthropocene geological era placed greater emphasis on the incidence and direct responsibility of human (social, political, and economic) factors in catastrophic events and in the changes in the dynamics of the Earth system. Thus, a semiotic link of indical type is established, based on the consequences and coexistences between the signs Society and Illness of the Earth.

Geoethics and semiotics, seen in an interdisciplinary perspective, envision a radical and strategic ecology, capable of mirroring another conceivable world. Geoethics, as an emergent discipline, can help us reflect on planetary illness, a discipline that can contribute to the construction of an ethical and social knowledge, strengthening the idea that planetary health is a common heritage to be shared. Furthermore, this field of inquiry can foster a culturally sensitive renewal and way of relating to the planet, through a growing sensitivity to the defense of human life and health and wealth of all Earth systems. In particular, geoethics and semiotics can provide useful indications to develop new behavioral responses, such as the ethical and ecological reorganization of the economy, politics, and society to address the problems, processes, and threats manifested by the Anthropocene.