

CLIMATE CHANGE AND HUMAN RESPONSES

THE DEPARTMENT OF ANTHROPOLOGY'S VISITING LECTURE RESEARCH SERIES

The Department of Anthropology's Visiting Lecture Research Series is an ongoing edited volume compiling research products created by (under)graduate students for the Department of Anthropology's Visiting Lecture Program at the University of Tennessee, Knoxville. Each volume in the series, compiled by its own (under)graduate student editors and approved by the Department Head, includes original research products by participating (under)graduate students.

The Department of Anthropology's Visiting Lecture Program, also known as Current Trends in Anthropology (ANTH357/550), is a symposium held annually each fall semester with a different theme for the purpose of exposing students to anthropologists from around the world and their relevant research. Led by Dr. David Anderson, the main theme of the Department of Anthropology's Lecture Program in the fall of 2020 was *Climate Change and Human Response*. Presentations from visiting researchers covered a wide variety of anthropologically influenced work that touched upon the following subthemes:

- Global Climate and Environmental Change, and Human response
- Social Inequality and Access to Resources (i.e., water, oil, agricultural and marine resources)
- Human Demographic Change
- Migration and Relocation (i.e., due to conflict, resource scarcity, climate change, repression)
- Structural Violence, Warfare, and Genocide

Participating (under)graduate students took inspiration from these visiting lectures, and the underlying subthemes for the series, and created relevant research products that ranged from research papers and visual presentations to creative fictional short stories, podcasts, and mixed media art installations. All students were invited to submit their research products for inclusion in the inaugural volume for *The Department of Anthropology's Visiting Lecture Research Series*.

1. Climate Change and Human Responses (2020)
Edited by Caroline Znachko, Armando Anzellini, Katherine Parker, Christa Hicks
Faculty Sponsor: Barbara Heath

CLIMATE CHANGE AND HUMAN RESPONSES

Edited by

Caroline Znachko, Armando Anzellini, Katherine Parker, Christa Hicks

Department of Anthropology
University of Tennessee, Knoxville

© 2020, The Editors. Each individual chapter is © 2020, the respective author(s).

Contents

<i>Notes on Contributors</i>	iii
<i>Series Editors' Preface</i>	vi
Part I Human Responses to Global Climate and Environmental Change	
1 Late Archaic Persistence: Climate, Environment, and Human Resilience in the Lower Midwest and Midsouth of the Eastern United States <i>Justin S. Bailey</i>	2
2 Climate Change: Myth or Reality <i>Jessyca Antley</i>	13
3 Adaptive Agricultural Responses to Climatic Variability and Change: A Case Study from Peru <i>Keri Burge and Navit Nachmias</i>	17
4 Climate Change Impacts on Louisiana's Wetlands <i>Sierra Neugent</i>	25
Part II Climate Induced Migration and Relocation	
5 The Atlantis of the North and What We can Learn from the Rising Sea Levels of the Past <i>Logan Ostrom</i>	54
6 Climate Influenced Migration and Resulting Necroviolence at the U.S-Mexico Border <i>Sarah Schwing</i>	59
7 Katrina: Climate Change, Response, Displacement, and Forensics <i>Hadley Allison, Jarrett Burgess, Bryn Dalrymple, Destiny Dismore and Hannah Leso</i>	64
Part III Social Inequality, Structural Violence, and Policy	
8 "Environmentality," The Politics of Climate Change and Climate Justice: The Efficacy/Inefficacy of Institutional/Legal Frameworks, Apocalyptic Discourses and Critical Education in Addressing Climate Change and Environmental Injustice <i>K. Raymond Da-boi</i>	70
9 Climate Change and the Inequity of its Biological Impacts <i>Caroline Znachko and Armando Anzellini</i>	79
10 Fast Fashion: The World's Second Highest Poison <i>Dante Parker</i>	85

Part IV Climate Change and Applied Anthropology

11	Postmortem Interval Estimation (PMI) Ramifications of a Newly Recorded Forensically Relevant Blow Fly Species in East Tennessee <i>Hayden McKee-Zech and Sara Fatula</i>	92
12	Relations Between Wildfires and Forensic Anthropology <i>Riley Wal, Samantha Beier, Kamryn Dagel, Eric Tucker, and Alexa Reins</i>	100
13	Cemeteries and Climate Change: What Can We Learn from the Past, do in the Present, and Plan for the Future? <i>Marta Marie Paulson</i>	111
14	The Interconnection Between Climate Change and Mental Health <i>Lydia Lindsey and Shelby Saut</i>	115

Notes on Contributors

Hadley Allison is an undergraduate senior at the University of Tennessee and majors in both anthropology and forestry and wildlife management. He is currently working towards graduate programs. Hadley has experience in zooarchaeology, forensic science, and land management and hopes to find a career where these interests and experiences can meld.

Jessyca Antley is an undergraduate student at the University of Tennessee and majors in anthropology with a concentration in forensics. Jessyca attended Lewis University previously, where she obtained her B.A. in forensic criminal investigation with minors in natural science and psychology. Originally from Bolingbrook, IL, she currently resides in Knoxville, TN.

Armando Anzellini is a Ph.D. candidate in biological anthropology at the University of Tennessee and holds a Diversity Dissertation Fellowship at Middle Tennessee State University. He is a Bioarchaeologist and Forensic Anthropologist with research focusing on the embodiment of inequality in the past and pushing for decolonizing bioarchaeology. Armando is a Registered Professional Archaeologist (RPA) and has surveyed and excavated archaeological sites, prehistoric burials, and historic cemeteries in the United States, Peru, Romania, and the Caribbean.

Justin S. Bailey is an M.A. student in biological anthropology at the University of Tennessee, where his research interests include the study of Late Archaic hunter-gatherer lifeways and resilience. He received his B.A. in anthropology and history at Indiana University in 2014. After completing his B.A., Justin has worked in cultural resource management in both the public and private sectors throughout the western and southeastern United States.

Samantha Beier is an undergraduate student at the University of Tennessee and majors in anthropology with a concentration in forensics and a minor in Sociology with a concentration in Criminology and Criminal Justice. They have volunteered at the Forensic Anthropology Center since 2018 and have collaborated on research that explores the effects of climate and desiccation on skeletonization rates at the Anthropological Research Facility. Samantha plans to graduate in Fall 2021 and continue their education at the graduate level.

Keri Burge is an undergraduate student at the University of Tennessee and majors in anthropology, with an honors concentration, and a minor in biological sciences. She is originally from Madison, Alabama. Her research interests include the use of stable isotope analysis and archaeogenetics to better understand past human-environment interactions and past responses to climate change. She is also interested in including a genetic component with the purpose of using ancient DNA to better understand how environmental stressors and social changes influenced the genetic structure and demography of past human populations.

Jarrett Burgess received his B.A. in anthropology from the University of Tennessee in 2021 and is currently applying to graduate programs. He has volunteered at the Forensic Anthropology Center as an undergraduate research assistant since 2019, where he gained first-hand experience in human anatomy, forensic science, and biological anthropology.

K. Raymond Da-boi is a Ph.D. student in cultural anthropology at the University of Tennessee. He has a combined ten years' experience in research and development and humanitarian work. He was a Rotary world peace scholar at the Chulalongkorn University (Bangkok) in 2008, a United Nations University fellow at the United Nations University (Tokyo) in 2007, and a peace, security, and development fellow at King's College London, in 2010, where he obtained certificates and an M.A. degree in armed conflict and peacebuilding, peace and conflict studies, and conflict, security, and

development, respectively. His current work focuses on the nexus between, and the political ecology of borders, conflict, transboundary spaces, immigration, citizenship, state-building, and the Mano River Basin subregion of West Africa.

Kamryn Dage received her B.A. in anthropology and sociology with a concentration in criminology and criminal justice from the University of Tennessee in 2021. She has served as a volunteer and intern with the Forensic Anthropology Center and Anthropological Research Facility since 2018.

Bryn Dalrymple received her B.A. in anthropology with a concentration in forensics from the University of Tennessee in 2021. As an undergraduate student, she completed an honors thesis entitled "Pterion and Broca's Area: an exploration of Asymmetry of the K-S distance". Bryn is currently applying to graduate programs.

Destiny Dismore is an undergraduate student at the University of Tennessee and majors in sociology and anthropology with concentrations in criminology and forensics, respectively. She is interested in both the workings of the criminal justice system and its impacts on society, as well as biological anthropology due to her past volunteer experience at the Forensic Anthropology Center.

Sara Fatula is a Ph.D. student in biological anthropology at the University of Tennessee. Her research interests include paleopathology, disease detection and diagnosis, and the effects of the environment on disease manifestation throughout time. Sarah completed her B.A. in anthropology at Mercyhurst University and her M.A in anthropology at the University of Tennessee.

Christa Hicks is currently a senior undergraduate student at the University of Tennessee-Knoxville originally from Scott County, Tennessee. She is set to graduate in May 2022, with a bachelors in Anthropology with a concentration in Forensic Science and a minor in Biological Sciences. She has taken multiple classes with the Forensic Anthropology Center.

Hannah Leso received her B.A. in anthropology with a minor in psychology from the University of Tennessee in 2020. Her research interests include forensic anthropology and bioarchaeology. She has volunteered at the Forensic Anthropology Center for four years, gaining valuable experience in the field, and is working towards applying to graduate programs.

Lydia Lindsey is an undergraduate student at the University of Tennessee and majors in anthropology with a concentration in forensic science and a minor in biological sciences. She is the current president for both the Undergraduate Italian Club and the Undergraduate Association of Forensic Science. She has volunteered at and taken classes from the Forensic Anthropology Center since 2019.

Hayden Mckee-Zech is a Ph.D. student in biological anthropology at the University of Tennessee. Her research interests include decomposition ecology, intrinsic factors of decomposition and their ecological effects, post-mortem interval estimation, and forensic entomology.

Navit Nachmias is an honors undergraduate student at the University of Tennessee and majors in anthropology with a concentration in forensics and a minor in Spanish. Her research interests include ancestry estimation methods, specifically focused on Hispanic populations. Originally from Minneapolis, MN, Navit is interested in pursuing graduate school and a career in forensic anthropology working to identify victims of border crossing deaths in the Southwestern US.

Sierra Neugent is an undergraduate student at the University of Tennessee and majors in anthropology with a concentration in forensics. She received her Associate of Applied Sciences (A.A.S.) degree in criminal justice with a concentration in death investigation at SOWELA Technical Community College in Lake Charles, Louisiana in 2019.

Logan Ostrom received his B.A. in anthropology from the University of Tennessee in 2021. He is currently seeking career opportunities in his field of study.

Dante Parker received their B.A. in anthropology from the University of Tennessee in 2021. They have been accepted as an M.A. student at Florida International University in Latin American and Caribbean Studies, where they will be working as a graduate teaching assistant for the Kimberly Green Latin American and Caribbean Center. Their research interests include sustainability and development, structural violence, resistance movements, and urban studies.

Katherine Parker is a Ph.D. candidate in archaeology at the University of Tennessee. Her research interests include the study of identity and power at the intersections of heritage, memory, and landscapes in the Postbellum South, along with the critical study of archaeological modeling and practice. She received her B.A. in anthropology with distinction in archaeology at the University of South Carolina and has nine years' experience in cultural resource management across the Southeast, Mid-Atlantic, and Midwest regions in both the private and public sectors. Katherine is a member of the Society for Historical Archaeology's Heritage at Risk committee and has recently been part of a national panel on climate change discourse in archaeology.

Alexa Reins received her B.A. in anthropology with a concentration in Disasters, Displacement, and Human Rights from the University of Tennessee in 2021.

Shelby Saut is an undergraduate student at the University of Tennessee and majors in anthropology with a concentration in forensics and a minor in biological sciences. She has held several leadership roles including service as the Treasurer and Biology Representative in the Undergraduate Association of Forensic Science and the Events Chair for the Undergraduate Italian Club. She has volunteered and taken classes at the Forensic Anthropology Center since 2020.

Sarah Schwing received her M.A. in anthropology with a concentration in biological anthropology from the University of Tennessee in 2021. Her current research interests are in human skeletal variation, virtual anthropology, human decomposition, taphonomy, and migration, and she hopes to pursue a doctorate degree at the University of Tennessee in the near future.

Eric Tucker is an undergraduate student at the University of Tennessee and majors in both anthropology with a concentration in forensics and in sociology with a concentration in criminology and criminal justice. Eric has volunteered at the Anthropological Research Facility and the Forensic Anthropology Center since 2019.

Riley Wal is an undergraduate student at the University of Tennessee and majors in anthropology with a concentration in forensics and a minor in entomology and plant pathology. Riley has volunteered at the Anthropological Research Facility and the Forensic Anthropology Center since 2019.

Caroline Znachko is a Ph.D. student in biological anthropology at the University of Tennessee. She earned her M.A. in anthropology from Texas State University and B.A. in anthropology from the University of Arizona. Her research focuses on the biological consequences of social inequality, including epigenetic and skeletal changes and resulting health outcomes, and the application of these findings to forensic and humanitarian contexts. Caroline has worked on bioarchaeological and forensic projects in Italy, Belize, Mexico, Peru, and the United States.

Series Editors' Preface

This series was conceived as a collection of online, open-source books designed to showcase the research projects completed by (under)graduate students in the Department of Anthropology's Visiting Lecture Program at the University of Tennessee, Knoxville. Each volume in the series, edited by volunteer (under)graduate anthropology students, includes original research products created for the Department of Anthropology's annual Visiting Lecture Program. By inviting submissions from all participating anthropology students, the series encourages collaboration between students, presents the perspectives of different anthropological subfields, and incorporates junior scholars from varying levels (i.e., undergraduate, master, and doctoral students) into the conversation.

The series is created and edited by (under)graduate students with themes touched upon in the series are relevant to contemporary issues in global anthropology. Each volume within the series will include a brief introduction by the volume editors to describe the theme and focus of the annual symposium. Individual volumes, and the series as a whole, exemplify the various perspectives in current trends in anthropology and promote the engagement of emerging scholars in these discussions. The series invites the participation of students across the subfields and is therefore reliant on student self-submission and not necessarily all encompassing.

This series aims to appeal to a broad audience through the inclusion of diverse media, all of which have undergone multiple rounds of peer review by the editors. For more information on the department's Visiting Lecture Program, please visit the department's website (<https://anthropology.utk.edu/visiting-lecture-series/>). More information on the 2020 lecture series, including the visiting lecturer program, can also be found on the department's website (<https://anthropology.utk.edu/2020-visiting-lecture-series-climate-change-and-human-response/>).

The Department of Anthropology's Visiting Lecture Research Series aims to showcase the research projects of junior scholars studying anthropology at the University of Tennessee while also illuminating important contemporary trends, encouraging collaboration with colleagues, and exposing readers to conversations relevant to the field of anthropology. For this first volume, we would like to thank Dr. David Anderson for his encouragement and support throughout the process and for leading a Visiting Lecture Series that led to the insightful discussions presented in this text.

Caroline Znachko, Armando Anzellini, Katherine Parker, Christa Hicks

Part I

Human Responses to Global Climate and Environmental Change

CHAPTER 1

Late Archaic Persistence: Climate, Environment, and Human Resilience in the Lower Midwest and Midsouth of the Eastern United States

Justin S. Bailey

Keywords: Archaeology, cultural persistence, climate change, human response, resilience

Abstract. The cultural manifestation known as the Shell Mound Archaic persisted in the lower Midwest and Midsouth region of the Eastern United States for over four millennia beginning in the Middle Archaic ca. 8900 cal yr B.P. and terminating at the end of the Late Archaic ca 3200 cal yr B.P. A synthesis of current archaeological and climatological evidence and theory is presented for the Late Archaic (ca. 5800-3200 cal yr B.P.) to assess how foraging peoples persisted despite their environmental and societal challenges. A model of resilience is presented to account for the persistence of the Shell Mound Archaic peoples.

Introduction

The modern fixation on climate change unsettles many of us today with good reason. Fundamentally, it isn't so much about the changes in climate but the uncertainty many of us sense about the imminent future consequences for human society that demand immediate and sustained global attention. Knowing that the actions we take today will have lasting significance on those in the future is a heavy burden to carry, so we must do our best to ensure those actions are well-grounded in wisdom, compassion, and a body

of knowledge that can speak to how humans respond and persist despite diverse sets of challenges. Anthropology and archaeology seem well-equipped to answer important questions on how people have weathered their own storms across time and space and what factors contribute to cultural persistence and human resilience. Amidst the many unrelenting perils stemming from our modern global climate crisis, studies attempting to understand how humanity has remained resilient across time and space despite its social and environmental challenges seem imperative.

The foraging peoples who inhabited the lower Midwest and Midsouth region of the eastern United States for the approximately twenty-six centuries of the Late Archaic period (ca. 5800-3200 cal yr BP) (Anderson and Sassaman 2012: 66) may represent a case study in human resilience and cultural persistence. Although our modern climate crisis is unique in many ways, what we share in common and what peoples living during the Archaic period could probably appreciate was the deep anxiety we feel toward the unpredictability of each changing season and the troubling implications that can arise from heightened social and political

pressure and volatility under such uncertainty. They too had to cope with varying levels of social, political, and environmental changes and risks. Such instances of droughts, floods, long winters, unsuccessful hunts, food shortages, conflict, violence, and the many decisions to buffer against these risks had to be reckoned with. Amid the short- and long-term fluctuations of climate and environmental changes, how did various foraging groups respond to sudden or gradual changes in their environment and make decisions in terms of their mobility, trade and interaction, subsistence practices, and settlement organization? Can the combined archaeological and climatological data offer us any guidance today, if only to be another story of adaptiveness and resilience? After all, understanding past human resilience has been stated as one of the primary grand challenges for archaeologists in the 21st century (Kintigh et al 2014) and the disciplines of archaeology and anthropology appear poised to inform future global sustainability practices (Redman 2005).

In this chapter, the goal is to synthesize the current evidence on climate, environment, and subsistence of the Late Archaic period of the lower Midwest and Midsouth regions of the eastern United States. The purpose is to provide the archaeological and climatological context of the cultural manifestation known as the Shell Mound Archaic with the intent to begin an outline of the cultural patterns of how people were interacting and responding to societal and environmental challenges over 2600 years of occupation and persistence in this region. The author contends that archaeologists think more critically about how Archaic lifeways were sustained and renewed by adopting a perspective that speaks to human resilience and cultural persistence.

Theoretical Reorientation: From Collapse to Resilience

The archaeological and bioarchaeological evidence of the Late Archaic period in the southeastern United States reveals a time of increasing population sizes, mound-building and burial designation, status differentiation inferred from burials, interpersonal conflict, and interregional long-distance trade and interaction, among other notable cultural changes and

continuities (Anderson 1996: 166, 175; 2013: 924; Bissett 2014; Charles and Buikstra 1983; Claassen 2010: 200-201; Sassaman 2010, 2011; Schmidt et al 2010; Smith 1995, 1996a, 1996b, 1997). Although definitions and metrics of resilience and cultural persistence are nascent within the disciplines of archaeology and anthropology and are not without their critics (see Rashidian 2021), such sustained practices and events of population growth, mortuary construction, and exchange and interaction may be argued to represent positive measures of resilience (see Buikstra 2019: 376). Relative to the preceding Paleoindian and Early Archaic and the subsequent Early Woodland periods, the Late Archaic has been argued to be a more socially complex time with the emerging Early Woodland witnessing diminished social complexity (Anderson 2013: 924; Kidder 2006; Thomas and Sanger 2010: 24; Thompson 2010: 217). A dramatic culture change (some suggesting collapse, see Thompson 2010: 227-228) seems to have occurred across much of the southeast at the end of the Late Archaic with several explanations being proposed. Climate changes resulting in cooler temperatures and increased precipitation are argued to have caused substantial flooding events (Claassen 1991: 290-291, 2015: 45-48; Fiedel 2001; Kidder 2006; Thompson 2010: 226). The termination of certain ritual practices and belief systems are also implicated along with evidence for settlements shifting to more upland areas during the ensuing Early Woodland (Claassen 1991: 290-291, 2015: 45-48; Thompson 2010: 226-227). In one instance, the traditions associated with and occupation of shell and earthen sites along the Green River in Kentucky, a major Shell Mound Archaic nexus, ended around 3400 cal yr BP and were not reoccupied until the Mississippian period (Thompson 2010: 226).

While such inflection points of rapid social, cultural, and political change and notions of collapse in history have captured public and academic interest alike, recent interpretive approaches in both archaeology (Faulseit 2016; Redman 2005) and bioarchaeology (Temple and Stojanowski 2019) have proposed reorienting discussions that concentrate on aspects of past human resilience and sociocultural persistence. In other words, instead of homing in exclusively on the instances and causes of societal collapse, as

important as that is in our research, we may also pose the question of what makes certain cultural features and social organizations persist over time and resilient in the face of varying environmental and social challenges? Applying this thinking here, we can ask how Shell Mound Archaic peoples persisted for 2600 years in a region that came to be imbued with millennia of historical, social, and cultural meaning? What made this particular region of the lower Midwest and Midsouth a “persistent place” (*sensu* Schlanger 1992; see also Thompson 2010: 217-228)? What challenges were people facing and how did varying cultures maintain resilience despite their social and environmental risks?

Late Archaic Climate and Environment

The Late Archaic is comprised of approximately twenty-six centuries dating from 5800-3200 cal yr BP or 5000-3000 rcbp and is geologically referred to as the Initial Late Holocene (Anderson 2001: 161; Anderson and Sassaman 2012: 66). Marked increases in global temperatures after the Younger Dryas, the end of which demarcates the onset of the Early Archaic at ca. 11,500 cal yr BP brought about the northward expansion of hardwood oak and hickory forests across the lower southeast (Anderson and Sassaman 2012: 71). Another significant climatic event that influenced local climates and vegetation occurs during the mid-Holocene and includes a warm, dry period known as the Hypsithermal lasting from approximately 8000-5000 years BP (Lapham 2011: 408). Climate and vegetation approach modern conditions during the Late Archaic (Anderson 2001: 161; Anderson et al. 2007: 459; Anderson and Sassaman 2012: 74; Jefferies 2009: 653, 657; Kidder and Sassaman 2009: 677; Lapham 2011: 409). An extensive analysis of fossil-pollen data for the northern and eastern regions of North America revealed the environmental history and dynamics of late Quaternary species taxa and biomes over the last 21,000 years (Williams et al. 2004). The inferred vegetational biome distribution of the lower Midwest and Midsouth regions from Williams et al. (2004: 312-313) shows that from approximately 7,000-3,000 years BP the predominant biomes were warm mixed conifer forests in the Midsouth region and temperate deciduous forests in the lower Midwest region which have been relatively

stable and slow to change up to the present day. It is worth noting that land-use practices from European colonization during the last 500 years have significantly altered vegetational land cover across much of the region from extensive logging and agricultural development (Williams et al. 2004: 321; Springer et al. 2010: 275). This bears mentioning because such contrasting modern developments can obscure our ability to envision what the region’s biome looked like in historic and pre-contact times and what this landscape and ecology would have provided Archaic groups in terms of their opportunities for subsistence, mobility, and settlement.

With this last note in mind, the climate and vegetation of the Late Archaic are therefore comparable to what it is today with temperature, precipitation, and lake levels approaching those of modernity (Anderson 2001: 161). However, Kidder and Sassaman (2009: 682) caution that such sweeping generalizations should still not be casually made and caution that:

...researchers should be wary of the idea that the Late Archaic was a time of so-called modern climate conditions. Late Holocene climates were highly variable, and evidence for periodic climate perturbations is abundant. Large-scale atmospheric reorganization after ca. 3150 cal B.P. demonstrates that modern conditions did not truly emerge during the Late Archaic.

The limits of this chapter only allow for a brief mention of a selected number of recent relevant climate studies. Perhaps one of the more notable studies for the climate within the time and region of interest comes from cave data recovered from southeastern Tennessee. Speleothem data (both U-Th isotopes and ultraviolet fluorescence (UVf) layers) recovered from Racoon Mountain Cave in Chattanooga, Tennessee revealed that, relative to the middle Holocene, the late Holocene experienced overall wetter conditions with rainfall oscillating from low to high more consistently over 50-100 year cycles (Driese et al. 2015: 15). Arguably the most significant finding from this study was that UVf layers revealed that thinner UVf layers and more negative $\delta^{13}\text{C}$ values corresponded with cooler, wetter conditions while the thicker UVf layers and less negative $\delta^{13}\text{C}$ values corresponded with warmer, drier conditions (Driese et al. 2015: 13).

Furthermore, drought conditions were not as long in duration (5-50 years) as previous times of the middle Holocene (Driese et al. 2015: 15). Such high resolution seasonal and annual rainfall data is a remarkable scientific feat and lends itself to be increasingly important for archaeology in determining when things like droughts and floods occurred and how they may have affected past peoples' responses.

Another important series of recent studies on past climate and vegetation of the area of interest comes from Anderson Pond located in north-central Tennessee. Micromorphological analysis of a 1.5-meter core from Anderson Pond was analyzed to test hypotheses on past climate and vegetation of the late Pleistocene and Holocene and to reevaluate previous studies conducted there (Driese et al. 2017). Data confirms a warm dry period existed during the middle Holocene thermal maximum and that increased fire activity is evident at this time (8200-5600 cal BP) (Driese et al. 2017: 91). A significant discovery of this study, countering previous interpretations of the geochronology at Anderson Pond (and unfortunate for those researchers looking into the Late Archaic), found that the record from 160-5600 cal. BP is absent and represents a hiatus in sedimentation, being plausibly eroded or oxidized (Driese et al. 2017: 88, 91; Horn et al. 2019: 519). Although the hiatus for most of the Late Archaic period is unfortunate, especially when we consider the paucity of lake sediment data in the southern United States, we still get a glimpse of the early Late Archaic and preceding climate of the Middle Archaic. More importantly, this revelation of this missing data in the sedimentary record of Anderson Pond, which has been central to climate models in the region, helps us recalibrate our models. That said, additional cave and lake sediment data are still greatly needed to improve the resolution of climate models for the Late Archaic.

Late Archaic Subsistence

Significant harvesting of freshwater shellfish across the region dates back to 8000 cal. BP and persisted well into the Late Archaic (Anderson 2001:159; Anderson et al. 2007: 460; Claassen 1992: 1, 1996: 240; 2010). The preceding Hypsithermal event of the mid-Holocene is argued to have enhanced riverine

habitats for aquatic species due to rivers becoming stabilized and aggraded and creating a bounty of riverine shellfish to be exploited (Claassen 1996: 240; Lapham 2011: 409). The spatial distribution of the shell and earthen mounds of the Late Archaic were aggregated unevenly and clustered along many of the major river networks across the Midsouth and lower Midwest including the Tennessee, Green, and Ohio river valleys in a manner that settlement patterns and population concentrations may have been influenced by regional social and political conditions (Anderson 2001: 159; Claassen 1992: 1, 1996: 240).

Settlement and population size seem to be linked to the reliance on mollusks which provided not only subsistence but also ritual use in ceremonialism, and as a potential building material for the shell mounds subsequently influencing the social, cultural, and political systems of foraging peoples for an impressively extensive time (Claassen 1991, 1992, 1996, 2010, 2015). White-tailed deer were also a staple in the diet of Late Holocene populations (Chapman et al. 1982: 118-120; Lapham 2011: 409; Styles and Klippel 1996), but appear to have made up greater amounts of the faunal assemblages during the previous early and middle Holocene with deer procurement declining relative to other resources after 6000 cal yr BP (Anderson and Sassaman 2012: 105). The Hypsithermal is suggested to have affected the body size of deer causing them to decrease but does not appear to have significantly altered their exploitation by Late Archaic populations (Lapham 2011: 409). Other animals targeted during this time included squirrels, rabbits, raccoons, wild turkeys, eastern box turtles, and channel catfish (Lapham 2011: 409).

The terminal Late Archaic (4500-3200 cal. BP) also witnesses the selection of a variety of local plant species that led to their domestication such as sunflower, squash, sumpweed, goosefoot, maygrass, marshelder, chenopod, knotweed, and little barley and signal early independent domestication in what has been termed the "Eastern Agricultural Complex" (Anderson 2001: 161; Anderson et al. 2007: 460, 463-464; Anderson 2002: 254; Chapman et al. 1982: 118; Delcourt et al. 1998: 266-268; Anderson and Sassaman 2012: 101; Lapham 2011: 410; Smith

1990). At least four native species including sunflower, marshelder, squash, and chenopod are considered to have been domesticated sometime between 5000 and 3800 cal yr BP (Anderson and Sassaman 2012: 104). It has also been suggested that with the domestication of these species came a decline in the use of shellfish in some areas of the SMA (Anderson et al. 2007: 464).

Nutshells including hickory, acorn, black walnut, butternut, and chestnut along with various fruits from trees and shrubs also complemented the diets of Late Archaic peoples throughout the region and have likely served as an important staple in the diets of peoples throughout much of the Holocene (Abrams and Nowacki 2008: 1123-1124; Anderson 2001: 162; Anderson and Sassaman 2012: 102-103; Delcourt et al. 1998: 266; Hollenbach and Carmody 2018: 56; Jefferies et al. 2005: 7). Some researchers (see Springer et al. 2010: 276 for a summary) have suggested that indigenous populations were significantly altering the landscape and managing their resources intentionally via fire regimes and other land management practices that significantly impacted vegetation biomes beginning in the Late Archaic (Abrams and Nowacki 2008: 1123-1124; Delcourt et al. 1998: 276; Springer et al. 2010: 276). Such observations demonstrate that it behooves archaeologists to stay ecologically mindful and privy to areas on the landscape that boast larger densities of nut and fruit-producing trees than normal as they may indicate past locations of habitation or gathering or intentional propagation of these species (Anderson 2004: 276). In other words, the agency and resiliency of past peoples may be subtly embedded not just in the material record, but in the landscape as well.

Furthermore, the use of mast resources increased during the Late Archaic and are associated with a range of artifacts including groundstone mortars and pestles, nutting stones, fire-cracked rock, and storage vessels and pits (Anderson and Sassaman 2012: 102). Such land management practices associated with mast-producing trees such as the use of controlled burns, girdling, and felling or culling non-mast trees have been argued, with caution, to have potentially contributed to early domestication and development of agricultural systems (Abrams and Nowacki 2008: 1124; Anderson and Sassaman 2012: 70, 102-104). As

is commonly known, increased reliance on such food items also likely increased risk as many of these early cultigens and wild nuts were susceptible to climate shifts (Anderson 2001: 162). Diversification in diets such as those seen with fish, shellfish, nuts, and seeds is argued to have changed and improved as a result of changes in environment, demography, and technology (Anderson and Sassaman 2012: 101).

The Shell Mound Archaic

The southeastern United States contains thousands of earthen and shell mounds constructed over a 6,000-year history and demonstrating considerable variability and evolution in their physical sizes, designs, construction phases, and functions as well as in their political, economic, and sociocultural value and meanings (Anderson 2012; Anderson and Sassaman 2012: 76-86; Bissett 2014: 50; Claassen 1991: 294, 1996: 236-240, 2015: xii; Jefferies et al. 2005: 9; Kassabaum 2021; Kidder and Sassaman 2009: 672, 675; Saunders 2017: 4-8; Saunders et al. 1997; Sherwood and Kidder 2011: 69, 71, 83). What is referred to as the Shell Mound Archaic (SMA) represents a cultural manifestation occurring sometime after 8900 cal yr BP and coinciding with the end of the Younger Dryas which witnessed warming conditions in the early Holocene. The characteristic feature of the shell mounds is the abundance of shells derived from local riverine mollusk populations which comprises large amounts of the SMA mounds but do also demonstrate strata of shell-free deposits (Bissett 2014). Human burials are another of the distinctive and ubiquitous features of SMA mounds with an estimated 18,000 interred over 5,000 years from the Middle to Late Archaic (Claassen 1991: 289, 2010, 2015: 1, 20-21, 43; Sassaman 2010: 92) with over 3,000 being exclusively concentrated among the Green River sites in western Kentucky and comprising one of the world's largest and most significant concentration of hunter-gatherer skeletal remains (Anderson and Sassaman 2012: 96-97; Claassen 2010: 106; Haskin and Herrmann 1996: 107, 110-111).

Debate on what the shell mounds represent have ranged from the traditional argument that the mounds are simply long-accumulated refuse heaps or middens on the one hand (Milner and Jefferies 1998) to being

deliberate mortuary complexes and/or territorial markers (Claassen 1991, 1992, 1996, 2010, 2015; Sassaman 2010, 2011). Regionally, the SMA sustained an estimated four millennia of historical and cultural continuity along selected major rivers and their tributaries in the lower Midwest and Midsouth until the end of the Late Archaic ca. 3200 cal yr BP (Anderson and Sassaman 2012: 109; Bisset 2014: 50-70; Claassen 1991; 287; 1992: 1, 1996: 236, 2010; Marquardt and Watson 1983; Sassaman 2001: 230-232, 2010: 42-3, 50-59, 2011: 189-197; Saunders 2017: 4-8) (**Figure 1**). Using the chronology of the entire Archaic existing from 11,500-3200 cal yr BP, the SMA comprises the Middle Archaic (8900-5800 cal yr BP) and Late Archaic (5800-3200 cal yr BP) subperiods within this region of the continent (Anderson 2001: 156-163; Anderson and Sassaman 2012: 66; Kidder and Sassaman 2009: 668; Sassaman 2010: 20-21). It's worth emphasizing here that makes the shell-bearing mortuary sites of the Shell Mound Archaic so interesting is that they are only located along a few select rivers in clusters even though many other river systems also had an abundance of shellfish that were exploitable (Claassen 2010: 35-36). Indeed the water systems of Eastern North America contain nearly one-half the world's freshwater bivalve species (Claassen 2010: 51) and so the question that remains open to debate is why only a select number of rivers were chosen for the shell mound mortuaries?

The tentative formation of tribal societies during the Middle and Late Archaic coincided with the development of long-distance interaction and exchange throughout much of the southeast with group affiliation and distribution being inferred from utilitarian and ritual/ceremonial diagnostic artifacts such as hypertrophic bifaces, stone effigy beads, and bone bins found in caches and burials (Anderson and Sassaman 2012: 87-91; Deter-Wolf 2004: 18, 29; Johnson and Brooks 1989; Jefferies 1995b: 133, 1997, 2004; Kidder 2012: 467-468; Kidder and Sassaman 2009: 671). These foraging groups are argued to have been increasingly interconnected via expansive social and economic exchange networks and were not just subject to larger climatic or demographic alterations as causal explanations for cultural changes (Sassaman 2010). Much current anthropological theory maintains that people possess a level of agency that allows them

to culturally buffer themselves against varying environmental and social risks and are equipped to respond to these challenges in ways that promote resilience/adaptation and cultural persistence (Temple and Stojanowski 2019).



Figure 1. Shell Mound Archaic (SMA) with dotted line noting Benton Interaction Zone and shell ring sites of the Carolinas and Florida/Gulf coasts (after Kidder and Sassaman 2009).

The outcomes of these interactions mean that a variety of interconnected historical trajectories were unfolding throughout the Archaic. Adopting Wolf's (1982) historic approach to thinking about ancient processes of interaction, Sassaman (2010, 2011: 206-7) argues that the Archaic was a period of interrelated complexity and interaction with cultural changes amongst various populations and communities likely reverberating across the landscape over the ensuing millennia. As Sassaman (2011: 206-207) states:

Everyday Archaic life experiences were punctuated with intercultural encounters, displacements, emplacements, ethnogenesis, resistance movements, diasporas, and coalescences. We ought not to assume that these ancient populations were more isolated and self-contained than modern ones, or that the conditions of encounters and history-making in ancient

times were so radically different than those of modernity.

We can therefore expect an archaeological record to reflect many aspects of these phenomena. Increased evidence and interpretations for greater complexity over the past quarter-century suggest that that is indeed the case (Anderson 2004; Jefferies 1995; Sassaman 2010, 2011; Saunders 2017). Concluding a review of Midwestern Archaic research of the then previous twenty years, Jefferies (1995b: 136) stated that, “[i]t is now clear that Late Archaic groups were well along the road to cultural complexity and that traits once thought to be diagnostic of later, more complex societies, such as sedentism, population aggregation, plant domestication, social differentiation, and long-distance exchange, were already developing.” Such traits of complexity, therefore, lend themselves to changes and continuity in cultural responses/buffering mechanisms to risk, i.e., mobility, subsistence practices, storage of resources, and establishing exchange networks (Halstead and O’Shea 1989: 3-4).

The sustained continuity of the Shell Mound Archaic foraging lifeways throughout 2600 years of the Late Archaic in this region may therefore be argued to constitute cultural persistence and an active case study in human resilience. The central idea here is that Archaic peoples were not only cognizant of a large swath of the southeastern North American continent but possessed an intricate knowledge of the social relations and resource structure that existed over such an expansive landscape which contributed to mitigating risks and promoting resilience in times of social and environmental uncertainties, e.g. during times of conflict or increased precipitation causing floods that may have inhibited settlement, travel, and exchange. Having a working knowledge of the surrounding territory and who occupies it is vitally important for hunter-gatherers and has been well-documented ethnographically with many foragers being knowledgeable of vast areas on the landscape (Kelly 2016: 106) and also creating social networks to alleviate risk living in precarious environments (Wiessner 1982). Thus, we may be able to parse out three general prerequisites to resilience evidenced from the archaeological record for long-distance trade and interaction during the Late Archaic which includes

1) knowing the landscape, 2) knowing the resource structure, and 3) knowing your neighbors. These prerequisites greatly influence how a given group will buffer against the unpredictable changes of climate and the subsequent effects of the environment. Additionally, such factors also facilitate social practices that create exchange networks for such things as information, goods, and mates which helps to enhance cooperation and reduce risk and uncertainty (Jefferies 1995: 78-79; Kidder and Sassaman 2009: 677). This examination and outline of the resilience of the Shell Mound Archaic peoples are only meant to be provisional and a much greater synthesis of human resilience and cultural persistence of the Shell Mound Archaic is warranted.

Conclusion

In general, the climate, environment, and subsistence base of the lower Midwest and Midsouth region during the Late Archaic was comparable, albeit not entirely synonymous, to modern conditions. Temperatures appeared to be cooler and precipitation greater on average. Local flora and fauna boasted a diversity of exploitable species. The climatic conditions and resource structure thus served as the backdrop in which Late Archaic populations grew, continuing cultural trends of exchange and interaction and mortuary mound designation that began in the Middle Archaic and increased in scale and organization over the ensuing 2600 years of the Late Archaic (Anderson et al. 2007: 459; Claassen 2010). Additional climate studies, particularly local analyses of cave and lake sediment data, are required to refine the resolution of climate and vegetation models for many localities within the Shell Mound Archaic boundary (**Figure 1**).

An explanation as to why the Shell Mound Archaic hunter-gatherer lifeways persisted for 2600 years in the lower Midwest and Midsouth region of the Eastern United States for over four millennia may turn out to be quite simple: because it worked. Although there is still a great deal of information to be learned about the Archaic period, it is argued that the hunter-gatherer lifeway itself is a low-risk, resilient strategy that enables cultures that have adopted it to persist. In the case of the Shell Mound Archaic peoples who lived a mobile and/or semi-sedentary lifestyle, what allowed

them to be resilient had much to do with the knowledge they possessed of an extensive landscape, the bountiful resource structure to exploit, and distant neighboring groups to form lasting relationships with and buffer their environmental and social risks in times of stress or uncertainty. How, when, and where SMA peoples moved, settled, ate, constructed monuments, developed technologies, modified and managed the landscape, and navigated long-distance trade networks to exchange information, goods, and mates with others were all-important decision-making processes that worked to promote and sustain resilience over an incredibly long period of the Late Archaic. Many important questions remain to be answered. For instance, how were communities of the Shell Mound Archaic that were situated along the Green, Tennessee, and Ohio river valleys connected? Do the Shell Mound Archaic inhabitants represent a distinct ancestral population (*sensu* Sassaman 2010, 2011)? How frequently were such communities in contact with one another and how often were they exchanging and interacting throughout the Late Archaic? Lastly, how do we refine theory and test hypotheses on resilience and cultural persistence?

Unpredictable climate changes have occurred many times in the past and human responses have been highly varied across time and space. One of the uncanny features of humans is the capacity and depth of their adaptability. Learning how to tap into that capacity and understanding human strategies that promote human resilience and cultural persistence appears vitally important and timely given the many challenges confronting us in our own time.

References

- ABRAMS, MARC D., AND GREGORY J. NOWACKI. 2008. NATIVE AMERICANS AS ACTIVE AND PASSIVE PROMOTERS OF MAST AND FRUIT TREES IN THE EASTERN USA. *THE HOLOCENE* 18:1123–1137.
- ANDERSON, DAVID G. 1996. APPROACHES TO MODELING REGIONAL SETTLEMENT IN THE ARCHAIC PERIOD SOUTHEAST. IN *ARCHAEOLOGY OF THE MID-HOLOCENE SOUTHEAST*, EDITED BY K. SASSAMAN AND D. ANDERSON, PP. 157–176. UNIVERSITY PRESS OF FLORIDA, GAINESVILLE.
- ANDERSON, DAVID G. 2001. CLIMATE AND CULTURE CHANGE IN PREHISTORIC AND EARLY HISTORIC EASTERN NORTH AMERICA. *ARCHAEOLOGY OF EASTERN NORTH AMERICA* 29: 143–186.
- ANDERSON, DAVID G. 2002. THE EVOLUTION OF TRIBAL ORGANIZATION IN THE SOUTHEASTERN UNITED STATES. IN *THE ARCHAEOLOGY OF TRIBAL SOCIETIES*, EDITED BY WILLIAM A. PARKINSON, PP. 246–77. BERGHAHN BOOKS, ANN ARBOR.
- ANDERSON, DAVID G. 2004. ARCHAIC MOUNDS AND THE ARCHAEOLOGY OF SOUTHEASTERN TRIBAL SOCIETIES. IN *SIGNS OF POWER: THE RISE OF CULTURAL COMPLEXITY IN THE SOUTHEAST*, EDITED BY J.L. GIBSON AND P.J. CARR, PP. 270–299. UNIVERSITY OF ALABAMA PRESS, TUSCALOOSA.
- ANDERSON, DAVID G. 2013. PALEOINDIAN AND ARCHAIC PERIODS IN NORTH AMERICA. *THE PALEOINDIAN DATABASE OF THE AMERICAS* 2(15): 913–932.
- ANDERSON, DAVID G., RUSSO M., AND SASSAMAN, K. E. 2007. MID-HOLOCENE CULTURAL DYNAMICS IN SOUTHEASTERN NORTH AMERICA. IN ANDERSON, D. G., MAASCH K. A., AND SANDWEISS, D. H. (EDS.), PP. 457–490. *CLIMATE CHANGE AND CULTURE DYNAMICS: A GLOBAL PERSPECTIVE ON MID-HOLOCENE TRANSITIONS*, ACADEMIC PRESS, OXFORD.
- ANDERSON, DAVID G., AND SASSAMAN, KENNETH E. 2012. *RECENT DEVELOPMENTS IN SOUTHEASTERN ARCHAEOLOGY: FROM COLONIZATION TO COMPLEXITY*. SOCIETY FOR AMERICAN ARCHAEOLOGY PRESS.
- BISSETT, THAD G. 2014. THE WESTERN TENNESSEE SHELL MOUND ARCHAIC: PREHISTORIC OCCUPATION IN THE LOWER TENNESSEE RIVER VALLEY BETWEEN 9000 AND 2500 CALENDAR YEAR BP." PH.D. DISSERTATION, UNIVERSITY OF TENNESSEE.
- BUIKSTRA, JANE E. 2019. MODELS, METAPHORS, AND MEASURES. IN *HUNTER-GATHERER ADAPTATION AND RESILIENCE: A BIOARCHAEOLOGICAL PERSPECTIVE*, EDITED BY D.H. TEMPLE AND C.M. STOJANOWSKI, PP. 354–383. CAMBRIDGE UNIVERSITY PRESS.
- CHAPMAN, J., DELCOURT, P.A., CRIDLEBAUGH, P.A., SHEA, A.B., AND DELCOURT, H.R. 1982. MAN-LAND INTERACTION: 10,000 YEARS OF AMERICAN INDIAN IMPACT ON NATIVE ECOSYSTEMS IN THE LOWER LITTLE TENNESSEE RIVER VALLEY, EASTERN TENNESSEE. *SOUTHEASTERN ARCHAEOLOGY*, 1(2), 115–121.
- CHARLES DOUGLAS K., AND BUIKSTRA JANE E. 1983. ARCHAIC MORTUARY SITES IN THE CENTRAL MISSISSIPPI DRAINAGE: DISTRIBUTION, STRUCTURE, AND BEHAVIORAL IMPLICATIONS. IN *ARCHAIC HUNTERS AND GATHERERS IN THE AMERICAN MIDWEST* EDITED BY J. PHILLIPS AND J. BROWN, PP. 117–145. NEW YORK: ACADEMIC PRESS.
- CLAASSEN, CHERYL. 1991. GENDER, SHELLFISHING, AND THE SHELL MOUND ARCHAIC. IN *ENGENDERING ARCHAEOLOGY: WOMEN AND PREHISTORY*, EDITED BY J. GERO AND M. CONKEY, PP. 276–

300. BLACKWELL, LONDON.

CLAASSEN, CHERYL. 1992. SHELL MOUNDS AS BURIAL MOUNDS: A REVISION OF THE SHELL MOUND ARCHAIC. IN *CURRENT ARCHAEOLOGICAL RESEARCH IN KENTUCKY*, VOL. 2. EDITED BY D. POLLACK AND A.G. HENDERSON, PP 1-12. KENTUCKY HERITAGE COUNCIL, FRANKFORT.

CLAASSEN, CHERYL. 1996. A CONSIDERATION OF THE SOCIAL ORGANIZATION OF THE SHELL MOUND ARCHAIC. IN *ARCHAEOLOGY OF THE MID-HOLOCENE SOUTHEAST*, EDITED BY K. E. SASSAMAN AND D. G. ANDERSON, PP. 235-258. UNIVERSITY PRESS OF FLORIDA, GAINESVILLE.

CLAASSEN, CHERYL. 2010. *FEASTING WITH SHELLFISH IN THE SOUTHERN OHIO VALLEY: ARCHAIC SACRED SITES AND RITUALS*. KNOXVILLE: UNIVERSITY OF TENNESSEE PRESS.

CLAASSEN, CHERYL. 2015. *BELIEFS AND RITUALS IN ARCHAIC EASTERN NORTH AMERICA: AN INTERPRETIVE GUIDE*. TUSCALOOSA: UNIVERSITY OF ALABAMA PRESS.

DELCOURT, P.A., DELCOURT, H.R., ISON, C.R., SHARP, W.E. AND GREMILLION, K.J. 1998: PREHISTORIC HUMAN USE OF FIRE, THE EASTERN AGRICULTURAL COMPLEX, AND APPALACHIAN OAK-CHESTNUT FORESTS: PALEOECOLOGY OF CLIFF PALACE POND, KENTUCKY. *AMERICAN ANTIQUITY* 63(2), 263–78.

DETER-WOLF, AARON. 2004. THE ENSWORTH SCHOOL SITE (40DV184): A MIDDLE ARCHAIC BENTON OCCUPATION ALONG THE HARPETH RIVER DRAINAGE IN MIDDLE TENNESSEE. *TENNESSEE ARCHAEOLOGY* 1(1):18–35.

DRIESE, S.G., LI, Z.-H., CHENG, H., HARVILL, J.L., SIMS, J., 2015. HIGH-RESOLUTION RAINFALL RECORDS FOR MIDDLE AND LATE HOLOCENE BASED ON SPELEOTHEM ANNUAL UV FLUORESCENT LAYERS INTEGRATED WITH STABLE ISOTOPES AND U/TH DATING, RACCOON MOUNTAIN CAVE, TN, USA. IN: FEINBERG, J., GAO, Y., ALEXANDER, E.C., JR. (EDS.), *CAVES AND KARST ACROSS TIME*, PP. 231–246. GEOLOGICAL SOCIETY OF AMERICA, SPECIAL PAPERS 516. GEOLOGICAL SOCIETY OF AMERICA, BOULDER, CO.

DRIESE SG, HORN SP, BALLARD JP, BOEHM MS, LI Z. 2017. MICROMORPHOLOGY OF LATE PLEISTOCENE SEDIMENTS AND A NEW INTERPRETATION OF THE HOLOCENE CHRONOLOGY AT ANDERSON POND, TENNESSEE, U.S.A. *QUATERNARY RESEARCH* 87(1):82–95.

FAULSEIT, RONALD K. 2016. *BEYOND COLLAPSE: ARCHAEOLOGICAL PERSPECTIVES ON RESILIENCE, REVITALIZATION, AND TRANSFORMATION IN COMPLEX SOCIETIES*. SOUTHERN ILLINOIS UNIVERSITY PRESS.

HALSTEAD, PAUL., AND O'SHEA, JOHN. 1989. *BAD YEAR ECONOMICS: CULTURAL RESPONSES TO RISK AND UNCERTAINTY*. CAMBRIDGE UNIVERSITY PRESS.

HOLLENBACH, KANDACE D., AND STEPHEN B. CARMODY. 2018. A TASTE OF THE SEASONS, OR THE DAILY LIVES OF EARLY ARCHAIC FORAGERS IN THE MIDSOUTH. IN *THE ARCHAEOLOGY OF EVERYDAY MATTERS*, EDITED BY SARAH PRICE AND PHILLIP CARR, PP. 53-66. GAINESVILLE: UNIVERSITY PRESS OF FLORIDA.

HORN, S.P., BOEHM, M.S., AND BALLARD, J.P. 2019. AN IMPROVED CHRONOLOGY FOR THE MICROSCOPIC CHARCOAL AND POLLEN RECORDS FROM ANDERSON POND, TENNESSEE, USA. *PALYNOLOGY* 43.3: 517-22.

JEFFERIES, RICHARD W. 1995. LATE MIDDLE ARCHAIC EXCHANGE AND INTERACTION IN THE NORTH AMERICAN MIDCONTINENT. IN *NATIVE AMERICAN INTERACTIONS: MULTISCALAR ANALYSES AND INTERPRETATIONS IN THE EASTERN WOODLANDS*, EDITED BY MICHAEL S. NASSANEY AND KENNETH E. SASSAMAN, PP. 73-99. UNIVERSITY OF TENNESSEE PRESS, KNOXVILLE.

JEFFERIES, RICHARD W. 1995. THE STATUS OF ARCHAIC PERIOD RESEARCH IN THE MIDWESTERN UNITED STATES. *ARCHAEOLOGY OF EASTERN NORTH AMERICA* 23:119-144.

JEFFERIES, RICHARD W. 1997. MIDDLE ARCHAIC BONE PINS: EVIDENCE OF MID-HOLOCENE REGIONAL-SCALE SOCIAL GROUPS IN THE SOUTHERN MIDWEST. *AMERICAN ANTIQUITY* 62(3):464-487.

JEFFERIES, RICHARD W. 2004. REGIONAL-SCALE INTERACTION NETWORKS AND THE EMERGENCE OF CULTURAL COMPLEXITY ALONG THE NORTHERN MARGINS OF THE SOUTHEAST. IN *SIGNS OF POWER: THE RISE OF CULTURAL COMPLEXITY IN THE SOUTHEAST*, EDITED BY J.L. GIBSON AND P.J. CARR, PP. 71-85. UNIVERSITY OF ALABAMA PRESS, TUSCALOOSA.

JEFFERIES, RICHARD W. 2009. ARCHAIC CULTURES OF WESTERN KENTUCKY. IN *ARCHAIC SOCIETIES: DIVERSITY AND COMPLEXITY ACROSS THE MIDCONTINENT*, EDITED BY THOMAS E. EMERSON, DALE L. McELRATH, AND ANDREW C. FORTIER, PP. 635-666. STATE UNIVERSITY OF NEW YORK PRESS, ALBANY.

JEFFERIES, RICHARD W., THOMPSON, VICTOR D., AND MILNER, GEORGE R. 2005. ARCHAIC HUNTER-GATHERER LANDSCAPE USE IN WEST-CENTRAL KENTUCKY. *JOURNAL OF FIELD ARCHAEOLOGY*, 30, (1): 3–23.

JOHNSON, J. K., AND BROOKES, S. O. 1989. BENTON POINTS, TURKEY TAILS AND CACHE BLADES: MIDDLE ARCHAIC EXCHANGE IN THE SOUTHEAST. *SOUTHEASTERN ARCHAEOLOGY* 8: 134–45.

KASSABAUM, MEGAN. 2021. *A HISTORY OF PLATFORM MOUND CEREMONIALISM: FINDING MEANING IN ELEVATED GROUND*. UNIVERSITY PRESS OF FLORIDA. EXPECTED PUBLICATION DATE APRIL 2021.

KIDDER, T.R. 2006. CLIMATE CHANGE AND THE ARCHAIC TO WOODLAND TRANSITION (3000-2500 CAL BP) IN THE MISSISSIPPI

RIVER BASIN. *AMERICAN ANTIQUITY* 195–231.

KIDDER, T. R., AND K. E. SASSAMAN. 2009. THE VIEW FROM THE SOUTHEAST. IN *ARCHAIC SOCIETIES: DIVERSITY AND COMPLEXITY ACROSS THE MIDCONTINENT*, EDITED BY T. E. EMERSON, D. L. McELRATH, AND A. C. FORTIER, PP. 667–694. ALBANY, NY: SUNY PRESS.

KINTIGH K.W., ET AL. 2014. GRAND CHALLENGES FOR ARCHAEOLOGY. *AMERICAN ANTIQUITY* 79(1):5–24.

LAPHAM, HEATHER A. 2011. ANIMALS IN SOUTHEASTERN NATIVE AMERICAN SUBSISTENCE ECONOMIES. IN *SUBSISTENCE ECONOMIES OF INDIGENOUS NORTH AMERICAN SOCIETIES*, EDITED BY BRUCE D. SMITH, PP. 401–429. SMITHSONIAN INSTITUTION SCHOLARLY PRESS, WASHINGTON, D.C.

MARQUARDT, WILLIAM H., AND PATTY JO WATSON. 1983. THE SHELL MOUND ARCHAIC OF WESTERN KENTUCKY. IN *ARCHAIC HUNTERS AND GATHERERS IN THE AMERICAN MIDWEST*, EDITED BY JAMES L. PHILLIPS AND JAMES A. BROWN, PP. 323–339. ACADEMIC PRESS, ORLANDO, FLORIDA.

MILNER, GEORGE, AND RICHARD JEFFERIES. 1998. THE READ ARCHAIC SHELL MIDDEN IN KENTUCKY. *SOUTHEASTERN ARCHAEOLOGY* 17(2):119–132.

RASHIDIAN, ELNAZ. 2021. THE RESILIENCE CONCEPT IN ARCHAEOLOGY; A CRITICAL CONSIDERATION. IN *ACADEMIA LETTERS*, ARTICLE 362. [HTTPS://DOI.ORG/10.20935/AL362](https://doi.org/10.20935/AL362).

REDMAN, CHARLES L. 2005. RESILIENCE THEORY IN ARCHAEOLOGY. *AMERICAN ANTHROPOLOGIST* 107.1: 70–77.

SASSAMAN, KENNETH E. 2001. HUNTER–GATHERERS AND TRADITIONS OF RESISTANCE. IN *THE ARCHAEOLOGY OF TRADITION: AGENCY AND HISTORY BEFORE AND AFTER COLUMBUS*, EDITED BY TIMOTHY PAUKETAT, PP. 218–236. UNIVERSITY PRESS OF FLORIDA, GAINESVILLE.

SASSAMAN, KENNETH E. 2010. *THE EASTERN ARCHAIC, HISTORICIZED*. ALTA MIRA PRESS: LANHAM, MD.

SASSAMAN, KENNETH E. 2011. HISTORY AND ALTERITY IN THE EASTERN ARCHAIC. IN *HUNTER-GATHERER ARCHAEOLOGY AS HISTORICAL PROCESS*, EDITED BY KENNETH E. SASSAMAN AND DONALD H. HOLLY, JR., PP. 187–208. UNIVERSITY OF ARIZONA PRESS, TUCSON.

SAUNDERS, REBECCA. 2017. ARCHAIC SHELL MOUNDS IN THE AMERICAN SOUTHEAST. *OXFORD HANDBOOKS ONLINE*. OXFORD UNIVERSITY PRESS.

SAUNDERS, M., ROLFE D., MANDEL, ROGER T., SAUCIER, E., THURMAN ALLEN, C. T., HALLMARK, JAY K. JOHNSON, EDWIN H.,

JACKSON, CHARLES M., ALLEN, GARY L., STRINGER, DOUGLAS S., FRINK, JAMES K., FEATHERS, STEPHEN, WILLIAMS, KRISTEN J., GREMILLION, MALCOLM F., VIDRINE, RECA JONES. 1997. A MOUND COMPLEX IN LOUISIANA AT 5400-5000 YEARS BEFORE THE PRESENT. *SCIENCE* 277 (5333), 1796–1799.

SCHMIDT C.W., SHARKEY R.L., NEWMAN C., SERRANO, A., ZOLNIERZ, M., PLUNKETT, J.A., BADDER, A. 2010. SKELETAL EVIDENCE OF CULTURAL VARIATION: MUTILATION RELATED TO WARFARE. IN *HUMAN VARIATION IN THE AMERICAS: THE INTEGRATION OF ARCHAEOLOGY AND BIOLOGICAL ANTHROPOLOGY*. EDITED BY BENJAMIN M. AUERBACH, PP. 215-237. CENTER FOR ARCHAEOLOGICAL INVESTIGATIONS: SOUTHERN ILLINOIS UNIVERSITY CARBONDALE, OCCASIONAL PAPER No. 38 CARBONDALE, ILLINOIS

SHERWOOD, SARAH C., AND TRISTRAM R. KIDDER. 2011. THE DA VINCI'S OF DIRT: GEOARCHAEOLOGICAL PERSPECTIVES ON NATIVE AMERICAN MOUND BUILDING IN THE MISSISSIPPI RIVER BASIN. *JOURNAL OF ANTHROPOLOGICAL ARCHAEOLOGY* 30:69–87.

SMITH, MARIA O. 1995. SCALPING IN THE ARCHAIC PERIOD. *SOUTHEASTERN ARCHAEOLOGY* 14:60-68.

SMITH, MARIA O. 1996. BIOARCHAEOLOGICAL INQUIRY INTO THE ARCHAIC PERIOD POPULATIONS OF THE SOUTHEAST: TRAUMA AND OCCUPATIONAL STRESS. IN *ARCHAEOLOGY OF THE MID-HOLOCENE SOUTHEAST*, EDITED BY KENNETH E. SASSAMAN, DAVID G. ANDERSON, PP. 134-154. UNIVERSITY PRESS OF FLORIDA, GAINESVILLE.

SMITH, MARIA O. 1996. "PARRY" FRACTURES AND FEMALE-DIRECTED INTERPERSONAL VIOLENCE: IMPLICATIONS FROM THE LATE ARCHAIC PERIOD OF WEST TENNESSEE. *INTERNATIONAL JOURNAL OF OSTEOARCHAEOLOGY*, 6(1), 84–91.

SMITH, MARIA O. 1997. OSTEOLOGICAL INDICATIONS OF WARFARE IN THE ARCHAIC PERIOD OF WESTERN TENNESSEE VALLEY. IN *TROUBLED TIMES: VIOLENCE AND WARFARE IN THE PAST*, EDITED BY DEBRA L. MARTIN, DAVID W. FRAYER, PP. 241-265. GORDON AND BREACH, AMSTERDAM.

SPRINGER, G.S., WHITE, D.M., ROWE, H.D., HARDT, B., MIHIMDUKULASOORIYA, L.N., CHENG, H., AND EDWARDS, R.L. 2010. MULTIPROXY EVIDENCE FROM CAVES OF NATIVE AMERICANS ALTERING THE OVERLYING LANDSCAPE DURING THE LATE HOLOCENE OF EAST-CENTRAL NORTH AMERICA. *THE HOLOCENE* 20: 275–283.

STYLES, BONNE, AND WALTER KLIPPEL. 1996. MID-HOLOCENE FAUNAL EXPLOITATION IN THE SOUTHEASTERN UNITED STATES. IN *ARCHAEOLOGY OF THE MID-HOLOCENE SOUTHEAST*, EDITED BY KENNETH E. SASSAMAN AND DAVID G. ANDERSON, PP. 115–133. UNIVERSITY PRESS OF FLORIDA, GAINESVILLE.

TEMPLE, DANIEL H., AND CHRISTOPHER M. STOJANOWSKI. 2019. *HUNTER-GATHERER ADAPTATION AND RESILIENCE: A*

BIOARCHAEOLOGICAL PERSPECTIVE. CAMBRIDGE UNIVERSITY PRESS.

THOMAS, D. H., AND SANGER, M.C. 2010. *TREND, TRADITION, AND TURMOIL: WHAT HAPPENED TO THE SOUTHEASTERN ARCHAIC?* PROCEEDINGS OF THE THIRD CALDWELL CONFERENCE, ST. CATHERINES ISLAND, GA, 9–11 MAY 2008. ANTHROPOLOGICAL PAPERS OF THE AMERICAN MUSEUM OF NATURAL HISTORY: NEW YORK.

THOMPSON, VICTOR D. 2010. THE RHYTHMS OF SPACE-TIME AND THE MAKING OF MONUMENTS AND PLACES DURING THE ARCHAIC. IN *TREND, TRADITION, AND TURMOIL: WHAT HAPPENED TO THE SOUTHEASTERN ARCHAIC?*, EDITED BY DAVID H. THOMAS AND MATTHEW C. SANGER, PP. 217-228. ANTHROPOLOGICAL PAPERS OF THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK.

WIESSNER, POLLY. 1982. RISK, RECIPROCITY AND SOCIAL INFLUENCES ON !KUNG SAN ECONOMICS. IN *POLITICS AND HISTORY IN BAND SOCIETIES*, EDITED BY E. LEACOCK AND R. LEE, PP. 61–84. CAMBRIDGE UNIVERSITY PRESS.

WILLIAMS, J.W., SHUMAN, B.N., WEBB, T., III, BARTLEIN, P.J. AND LEDUC, P.L. 2004. LATE-QUATERNARY VEGETATION DYNAMICS IN NORTH AMERICA: SCALING FROM TAXA TO BIOMES. *ECOLOGICAL MONOGRAPHS*, 74: 309-334.

WOLF, ERIC R. 1982. *EUROPE AND THE PEOPLE WITHOUT HISTORY*. UNIVERSITY OF CALIFORNIA PRESS.

CHAPTER 2

Climate Change: Myth or Reality

Jessica Antley

Keywords: Hurricane, climate change, natural disaster, crime rate

Abstract. The fictional story takes place in the near future of 2022. On the coast of Georgia, a devastating category 5 hurricane hits land and destroys property. One particular property is Dr. Steve Rivers who is an anthropologist and a criminologist. After the destruction of his beautiful summer home, he grows an interest in why natural disasters are becoming more devastating than ever before. Is it due to climate change? Not only is Dr. Rivers is interested in how climate change is affecting natural disasters, but he is also interested in why the crime rate appears to increase once natural disasters occur. Is climate change a myth created to scare people or is it reality that is quickly setting in that needs to be taken more seriously? Dr. Rivers is determined to find out.

Story

The year is 2022 and a category 5 has recently hit the coast of Georgia. Amidst the disaster, Dr. Steve Rivers has fallen to devastation of his beautiful and beloved summer home. Dr. Rivers had worked several years to finally be able to pay off his dream home and only a few months later, it was completely destroyed by a raging hurricane. As Dr. Rivers arrives in Georgia by plane to see just how destroyed his home is, he wonders, why are these natural disasters becoming more and more dangerous and damaging. Over the past decade, he has noticed that storms, not just hurricanes, are becoming more and more common and more dangerous and destructive. This kind of study is in the field of research that Dr. Rivers is currently in. Dr. Rivers has a doctorate in anthropology and a masters in criminology. He received his bachelors, masters, and doctorate in anthropology from the University of Tennessee. He then received his bachelors and master in criminology from Lewis University. Over the past decade he has worked on

obtaining these degrees and is currently working towards a doctorate in criminology through Lewis University. He has taken part in several research projects throughout this past decade that have been considered very successful. He has been looking for a research project lately and has decided to look into what is causing these major disasters more regularly. He has also noticed that climate change has a hand in these changes because the U.S government has not taken deep concern in science and has ignored ways to help heal the planet. Dr. Rivers believes that he should begin his research with the idea of climate change causing all the devastation. Is it climate change or is it a mere coincidence that natural disasters are becoming more common, deadly, and dangerous? Dr. Rivers is determined to figure out the truth behind this question.

Dr. Rivers began to process the loss of his vacation home. He left the site of the rubble that was once his dream summer home. He had managed to scrape up a few photos and personal artifacts to bring back home with him. With nothing else left to his beloved home, he headed back to his hotel. Once there, he figured a week here was enough and he began to pack to head home to his lovely family. He was able to catch a flight at eleven at night. He had a few hours since it was only six. He decided to have dinner before heading to the airport. A few hours later, Dr. Rivers finished his dinner, grabbed his bags and made it to the gate his flight was located at. Once on the plane, all Dr. Rivers could wonder why natural disasters are worsening across the globe? He focused on his theory of climate change and scribbled down some notes in his notebook to refer to once he could get to his lab to begin his research.

The plane finally landed after what seemed to be

several long hours, and Dr. Rivers stepped off the plane. He returned home for some sleep and to see his family. The next morning, he had breakfast and took off to his lab to begin his research.

Dr. Rivers entered his lab and began to crack open books and research online for answers to his multitude of questions. Dr. Rivers discovered that over a little more than a decade, the ten warmest years on record occurred since 1998 (Lindsey, 2020). He dug into the context more to understand the possible effect these warm years did have on Earth. Dr. Rivers felt that learning the basics to climate change would be crucial to his research. Through his research, he discovered that surface temperature completely flipped from cooler to warmer beginning in the 1970s and 1980s (Lindsey, 2020). He joked to himself by saying “probably all that hairspray haha”. The overall temperature of Earth, in terms of land and ocean temperatures, has increased .07 °C (.13°F) every decade since 1880 (Lindsey, 2020). Dr. Rivers decided to put into perspective what that meant, so he looked further and found that in 1900 the temperature was -.5 and had increased to 1.0 by 2020 (Lindsey, 2020). He wondered if the increase in surface, ocean, and overall temperature continually increased while natural disasters worsened, does it mean correlation? Thus, he figured he should look into how this increase in temperature is making natural disasters worse, more specifically hurricanes.

Dr. Rivers knew that sea levels were slowly rising and the surface temperatures across the globe were increasing as well. He hears about it on the television almost every day. He found very interesting, however, that greenhouse-gases have increased the number of category 5 hurricanes (Global Warming, 2020). Obviously, Dr. Rivers knew the stronger the hurricane the more destructive it is. He learned though, a category 4 hurricane has a wind speed of 130 to 156 miles per hour and a category 5 hurricane has a wind speed of 157 or more miles per hour (Denchak, 2018). He also discovered that a storm that has wind speeds of 150 mile per hour has 256 times more damage potential than a 75 mile per hour storm (Berardelli, 2019). That is a category 1 hurricane compared to at least a category 4 hurricane. So, Dr. Rivers realized that if a category 4 hurricane can produce that much

more damage than a category 1, he could only imagine how much more damage a category 5 produces. He never realized just how fast hurricanes can become nor how much damage potential it can have either. Now, he understood why his house was completely destroyed. He also never noticed how recently hurricanes have been growing stronger in less time than a few decades ago. For instance, Hurricane Dorian only took five days to strengthen from a mere category 1 to a category 5 hurricane (NASA, 2020). This blew Dr. Rivers' mind because that is a very short timeframe to increase speeds and power that much (Albaladejo, 2017). This intrigued him to continue digging deeper into his research.

While researching why Hurricane Dorian increased so fast, Dr. Rivers found that intensification of storms have increased by roughly 4.4 miles per hour faster per decade since 1986 (Berardelli, 2019). Suddenly, Dr. Rivers had an epiphany. Warmer temperatures cause more heat energy in the oceans thus causing the creation of a higher possibility for development of tropical cyclones that eventually strengthen to potentially damaging hurricanes (Berardelli, 2019). With the oceanic temperature increasing, it has caused category 4 and category 5 hurricane occurrence to increase 25 to 30% per degree Celsius increase caused by global warming (Berardelli, 2019). With that said, Dr. Rivers wanted to see which states are affected most by hurricanes, just to see if its certain states on the east coast or that it is random. He found that 90% of hurricanes hit either Florida or Texas (Denchak, 2018). He knew Florida had to be in the top states because there always seems to be a hurricane that hits at least southern Florida, but Texas surprised him. He believed that it would be states like Louisiana, Georgia, North Carolina, and South Carolina.

Dr. Rivers became fascinated with the fact that as climate change became worse over the years, natural disasters, specifically hurricanes, grew more powerful and disastrous than ever. He had discovered quite a bit already, but Dr. Rivers was just beginning his research and still had several aspects to look into to confirm his theory that climate change increases natural disasters, specifically hurricanes, power and damage that it causes. With only a few days of research, Dr. Rivers discovered that another hurricane

was forming and that it was quickly picking up speed and heading towards the same area that had just been devastated with the most recent hurricane. He was not worried about his home because it had already been torn to pieces from the previous storm, but the storm that was heading in the same direction appeared to be just as powerful. Although he had already discovered that hurricanes were becoming more frequent, he wanted to be able to add this hurricane to his study to make his evidence to his theory stronger and more concrete. For now though, Dr. Rivers knew it was time to put the notebook down, shut his laptop, and spend some time with his family and eat dinner. So, he called it for the night and went home.

As a new day began, Dr. Rivers walked into his office at his lab and opened his laptop and notes to continue his research. His plan was to continue his research, but he wanted to add another factor into his study. He possessed a better understanding of why hurricanes are becoming stronger and more disastrous and dangerous. So, he believed that adding this second factor would make a stronger argument that climate change is something that should not be taken lightly.

While he was back in Georgia to find the remains of his summer home, he discovered that many people were now homeless and had nowhere to go, especially the lower class families. With the skyrocketed increase in homeless and nowhere for these hurricane victims to go, Dr. Rivers believed that the crime rate probably also increased. So, he decided to see if all three factors correlated or if just two factors do or if it is just mere coincidence.

Now, before Dr. Rivers even began his extended study, he knew correlation did not mean causation. So first, he looked at the average crime rates for the particular town his home was in. The first thing he discovered was that after hurricanes hit, security is temporarily shut down due to the mass disaster that is caused (Albaladejo, 2017). Which made sense to him. In his own thoughts, Dr. Rivers figured out that with security being down, even only temporarily, would make people less worried about getting caught stealing than they normally would which would cause petty crimes to increase gradually. Whilst digging deeper into his research, Dr. Rivers discovered that

towns were not particularly concerned with looters causing petty crimes, but instead worried more about saving lives; which made more sense since it was more important and morally correct.

Another issue that Dr. Rivers came across as hurricane victims sometimes had no other choice but to result in looting and committing petty crimes in means of their own survival. What also leads to the crime rate to increase is the shortages that occur. Food and water shortages cause people to become frantic and fear that they could eventually starve or become dehydrated thus begin to loot stores that are damaged from the storm and steal food and water for themselves and their loved ones. Which obviously causes the crime rate to increase as well for areas such as robbery and burglary (Albaladejo, 2017).

Dr. Rivers understood this, but could see why other homeowners would not. Everyone affected by the hurricane faced troubles, but lower class individuals were hit the hardest. They sometimes have no other option. Looting and causing petty crimes could be the result of life or death. An individual will do anything they possibly can to survive devastating circumstances to prevent the death of themselves or loved ones. When hurricanes hit, they have damaging winds, heavy rainfall, and can even contain a tornado. Hurricanes cause massive flooding and homelessness. This means that sometimes victims of the hurricane have no place to go so they break into empty houses and either steal food, squat there, and/or steal items to be able to sell for some money. Dr. Rivers found that this occurred in countries that have poor communities that are often hit with hurricanes that they cannot afford to clean up and rebuild (Albaladejo, 2017). The looting is not always the result of the hurricane, sometimes there are just terrible people who create petty crimes for the adrenaline rush. Not all types of crime can be blamed on natural disasters, but during this particular time of need, it happens more often than not (Albaladejo, 2017). Dr. Rivers knew this, but needed to include it in his research to show that not every downfall was from the effects of the hurricane or natural disaster.

With this evidence, Dr. Rivers was able to connect that increased natural disasters caused more damage and

thus makes security throughout towns to be down longer causing looting and petty theft to increase after hurricanes or any other type of disaster hits. So, natural disasters, hurricanes in this case, cause crime rate to increase due to the lack of concern on security while the town is rescuing people from the disasters that have just caused havoc in the town. Which coincidentally causes the correlation to occur between increased crime rate and climate change.

With the evidence that Dr. Rivers compiled, he felt strong about his results that showed that as climate change takes more effect on global temperatures the power and destruction of natural disasters, specifically hurricanes, increases thus leading to crime rate to increase due to the lack of concern of security since the town is more focused on saving lives and cleaning up the rubble that was left behind from the path of the storm. The increased oceanic temperature is what causes the hurricanes to develop more frequently, stronger, and faster than ever before (Lindsey, 2020). Thus, causing hurricanes to cause more destruction that causes security measures to be shut down longer, causing crime rate (mainly petty crimes, such as looting) to increase. So, Dr. Rivers concluded in his research that the correlation between climate change, hurricanes, and crime rate do in fact mean causation.

Dr. Rivers will forever miss his beautiful summer home, but he will never be more proud than he is right now in his research of climate change, hurricanes, and crime rate. This study and knowledge will forever stay with Dr. Rivers and hopes that his knowledge can be spread to future scholars and students to be able to conduct their own research and make the argument greatly stronger. He also hopes there will be counter arguments that will allow him to discover other possible ways that climate change affects the strength of natural disasters.

For now though, it is time for Dr. Rivers to close his notes and laptop, go home, and spend time with his beautiful family and be thankful everyone is safe and sound. As he goes to bed tonight, he says a little prayer for those who are affected by natural disaster and prays that we, as a global aspect, can reverse the dramatic effects of climate change and begin to heal Earth before it truly is too late. If it is not too late

already. Dr. Rivers has officially found another calling in his field and will continue to look at new data over the next few years to keep his research and concerns up to date and fully aware of what is going on in this world.

References

- ALBALADEJO, ANGELIKA AND LASUSA, MIKE. "THE PERFECT STORM: HOW CLIMATE CHANGE EXACERBATES CRIME AND INSECURITY IN LATAM." *INSIGHT CRIME*, 25 SEPT 2017, [INSIGHTCRIME.ORG/NEWS/ANALYSIS/PERFECT-STORM-CLIMATE-CHANGE-EXACERBATES-INSECURITY-LATIN-AMERICA-CARIBBEAN/](https://insightcrime.org/news/analysis/perfect-storm-climate-change-exacerbates-insecurity-latin-america-caribbean/).
- BERARDELLI, JEFF. "HOW CLIMATE CHANGE IS MAKING HURRICANES MORE DANGEROUS." "YALE CLIMATE CONNECTIONS." *YALE CLIMATE CONNECTIONS*, 21 JULY 2020, [YALECLIMATECONNECTIONS.ORG/2019/HOW-CLIMATE-CHANGE-IS-MAKING-HURRICANES-MORE-DANGEROUS/](https://climateconnections.org/2019/how-climate-change-is-making-hurricanes-more-dangerous/).
- BUIS, ALAN. "HOW CLIMATE CHANGE MAY BE IMPACTING STORMS OVER EARTH'S TROPICAL OCEANS." "NASA GLOBAL CLIMATE CHANGE." *NASA*, 10 MAR 2020, [CLIMATE.NASA.GOV/BLOG/2956/HOW-CLIMATE-CHANGE-MAY-BE-IMPACTING-STORMS-OVER-EARTHS-TROPICAL-OCEANS/](https://climate.nasa.gov/blog/2956/how-climate-change-may-be-impacting-storms-over-earths-tropical-oceans/).
- DENCHAK, MELISSA. "HURRICANES AND CLIMATE CHANGE: EVERYTHING YOU NEED TO KNOW." *NRDC*, 3 DEC 2018, [NRDC.ORG/STORIES/HURRICANES-AND-CLIMATE-CHANGE-EVERTHING-YOU-NEED-KNOW/](https://nrdc.org/stories/hurricanes-and-climate-change-everything-you-need-know/).
- "GLOBAL WARMING AND HURRICANES." *GFDL*, 23 SEPT 2020, [WWW.GFDL.NOAA.GOV/GLOBAL-WARMING-AND-HURRICANES/](https://www.gfdl.noaa.gov/global-warming-and-hurricanes/).
- LINDSEY, REBECCA AND DAHLMAN, LUANN. "CLIMATE CHANGE: GLOBAL TEMPERATURE." *NOAA*, 14 AUG 2020, [CLIMATE.GOV/NEWS-FEATURES/UNDERSTANDING-CLIMATE/CLIMATE-CHANGE-GLOBAL-TEMPERATURE/](https://climate.gov/news-features/understanding-climate/climate-change-global-temperature/).

CHAPTER 3

Article Adaptive Agricultural Responses to Climatic Variability and Change: A Case Study from Peru

Keri Burge and Navit Nachmias

Keywords: Climate change, Peru, Inca Empire, El Niño, Agriculture

Abstract. Peru has had a long history of climate variability, especially in its coastal regions. El Niño events in particular result in droughts, loss of aquatic life, and flooding. This current variability combined with climate change is especially detrimental to indigenous groups due to their high-altitude environments and biodiversity-reliant livelihoods, making there a need for sustainable agricultural adaptations today. Archaeological evidence from the Wari, Tiwanaku, and Inca empires showcase past irrigational adaptations to changing environmental conditions. Specifically, Wari and Tiwanaku-inspired raised-field techniques and the Inca practice of water sowing, which are starting to be successfully reimplemented by indigenous groups in Peru today, demonstrates the value of archaeological evidence and indigenous knowledge in current climate change mitigation.

Introduction

According to the Intergovernmental Panel on Climate Change (IPCC), published scientific evidence proves that anthropogenic climate change currently has global effects, including loss of sea ice, rising sea levels, and more intense heat waves (IPCC 2014: 2-16). The net cost of these effects is damaging and will continue to significantly increase over time unless efforts are taken to mitigate this problem (Shafitel et al. 2020). In order to understand how climate change functions today and how humans might respond to it, it is important to

understand the past climate and environment and how we as humans have adapted to those changes in climate over time. Looking to the past can provide guidance for future environmental responses. Due to the fact that Peru not only faces climate change but also known climate variability (i.e. El Niño), it is a unique case study to examine the impacts of past climate change and how archaeological evidence can be applied to current efforts to adapt to these changing conditions; this paper will specifically establish a timeline of climate variation in Peru through a discussion of El Niño, and then explore how indigenous groups responded and continue to respond, especially in their agricultural practices.

History of El Niño in Peru

Past Evidence of El Niño

One of the biggest processes that impacts Peruvian climate, especially coastal climate, is El Niño. El Niño is a disruption of the normal cold-water conditions with an increase in sea surface temperature. During normal years, the Peruvian coasts have “cool, deep, nutrient-rich water;” however, during El Niño the coastal waters are significantly impacted (Sandweiss et al. 2020: 8272). There are four different types, or flavors, of El Niño that function in the present as well as in the past. These are eastern Pacific El Niño (EP), coastal El Niño (COA), central Pacific El Niño (CP), and La Niña (LN)

(Sandweiss et al. 2020: 8272). EP is characterized by weaker trade winds and abnormal warming in the central Pacific. This results in warmer sea surface temperatures, diminishing nutrients, and a decrease in the marine biomass food chain. Warmer water often leads to destructive storms and flooding that causes damage to infrastructure and irrigation systems (Sandweiss et al. 2020: 8272). COA is very similar to EP events in that there is a dramatic increase in water temperature and more rainfall. During these two El Niño events “fishing is diminished, coastal infrastructure is damaged or destroyed, insect-borne diseases are rampant, and sediment transport drives coastal progradation” (Sandweiss et al. 2020: 8273). CP events do not cause an increase in water temperature, but instead, there is a decrease in precipitation leading to drier conditions. Sandweiss et al. (2020) postulate that since CP events currently have adverse effects on current irrigation-based agriculture they likely had similar impacts in the past. La Niña, on the other hand, is a reverse of El Niño. During LN there is “an exaggeration of normal conditions” (Sandweiss et al. 2020: 8273). The water cools and conditions get drier. LN events result in less destruction than El Niño events.

Sandweiss and Kelley (2012) argue that “El Niño is one of the most important drivers of interannual climate change, particularly in the Pacific Basin, and it has significant consequences for humans as well as for other species” (373). For example, fish that are used to colder water temperatures either die or have to migrate south to cooler waters. This disturbs the whole food chain. For other marine animals and mammals that depend on these fish they either have to migrate or they die. Another change that has consequences for humans are heavy storms that lead to flooding. Flooding destroys infrastructure and standing water facilitates insect breeding which leads to diseases (Sandweiss and Kelley 2012: 373). With increased frequency of El Niño, using archaeological proxies to reconstruct past conditions may help gain a better understanding of future projections.

During the Holocene, especially the mid-Holocene, the climate on Earth was more variable compared to the previous and following millennia (Sandweiss et al. 1999: 499; Sandweiss et al. 2001: 63).

Geoarchaeological evidence indicates that between 8900- and 5800-years BP, El Niño did not occur. Other evidence, such as faunal records from shells and fish, ice cores, and coral records, supports the conclusion that water off the northern coast of Peru had a warmer mean temperature than today (Sandweiss et al. 1999: 499). A shift took place around 5000 years ago, during the late middle Holocene, and El Niño frequencies started to increase (Sandweiss et al. 2001: 604). Based on analysis of mollusks found at archaeological sites, from 5800 to 2900 years ago, EP events were present but not as frequent, and after 2900 years ago, they became more frequent. During those years, there was a shift in the mollusk species that correlated with habitat and water temperature (Sandweiss et al. 2001: 603). By tracking the shift in species, researchers could use that as a proxy for tracing variable climatic conditions. With the increased climate fluctuation, one response was migration. People and communities would migrate to different areas that were not as impacted by these climate changing events (Sandweiss et al. 2020: 8272). The shifting climate also led to a growing dependence on leaders and institutions. Sandweiss et al. (2020) also found that:

“leadership and institutional quality (e.g., levels of corruption, political competence, and political turmoil) were critical to the ability of human systems to effectively respond to climate and other environmental perturbations, especially for groups dependent on irrigation systems supporting monocrop subsistence and demanding high levels of management, hierarchy, capital, or labor to maintain and rebuild” (8272).

Current Trends

El Niño is still impacting climate and society today. In 1982-1983, El Niño events caused around 8.11 billion dollars' worth of damage globally (Sandweiss and Kelley 2012: 373). In 1997-1998, there were 34 billion dollars in damage plus thousands of people dead, sick, or dispersed from their home (Sandweiss and Kelley 2012: 373). In Peru in 2017, there were hundreds of flood-related deaths, millions of people displaced, and around 3 billion dollars in damage (Sandweiss et al. 2020: 8273).

Glacier recession in the tropical Peruvian Andes is also a result of climate change that has significant

impacts on the global population. Normally people are dependent on the glacier melts during the seasons of dryer climate in the Andes (Mark et al. 2010: 795). However, the recession impacts the water availability on which many people are dependent and affects the livelihood of families living in these communities. The glacier recession led to “shifting water availability, increasing weather extremes and threats to tourism” (Mark et al. 2010: 801). Families living in communities impacted by glacier recession have indicated that there has been a decrease in water supply during the dry seasons. This creates a significant impact on the productivity of agriculture and livestock because they depend on water for growth and nourishment. Cool season crops grow in the rainy season, so water is abundant. Warm season crops, on the other hand, require water from other sources; however, with increasing water scarcity crops are under more stress. (Mark et al. 2010: 801). As previously noted, climate change has led to more severe weather. People living near the central Andes have experienced “intense precipitation events, freezing events, strong winds, shifting rainfall patterns, and intense heat spells [that] have all negatively affected household health, agricultural productivity, and livestock health” (Mark et al. 2010: 802). With an unpredictable climate, families who rely on agriculture struggle. Another important revenue provider that has been affected by local climate change is tourism. With the high glacier peaks being the primary tourist destination in the area, the receding peaks are leading to a decrease in tourism and threatening “tourism-related income for households” (Mark et al. 2010: 802).

Adaptations in Agricultural Practices

Indigenous peoples in Peru are especially vulnerable to the dangerous effects associated with events of climatic variability, such as El Niño, as well as current climate change. There is no doubt that less developed countries and communities will suffer disproportionately even though their lifestyles contribute the least to the actions causing anthropogenic climate change. Mountainous indigenous people deserve particular attention because they currently experience, and will continue to experience, severe impacts directly due to the

environment they live in and their mode of sustenance. This is because both environments in high altitude zones and biodiversity-reliant livelihoods are especially fragile and sensitive to changes in climate (Walshe and Argumedo 2016:166, 172). In addition, these groups typically have low incomes, a reliance on agriculture, and a limited capacity to seek alternative lifestyles, which overall intensifies hazard events (Altieri and Nicholls 2013:34-6).

With this in mind, there is a need for sustainable and effective adaptation today, especially when it comes to protecting agricultural practices, on which many indigenous groups rely on (Walshe and Argumedo 2016:166, 169-70). Crop production could be severely affected by changing climatic variables such as rainfall and temperature, which has the potential to compromise food security, especially in areas, like in Peru, that rely on irrigation from the wet-season, which is now decreasing due to the combination and interplay of both overall climate change as well as El Niño effects (Altieri and Nicholls 2013:34-6). Overall, knowledge surrounding climate change is very much science-driven and expert-orientated. Scientific knowledge is the primary framework for political discourse surrounding climate change (Moser 2010, Bäckstrand 2004) This puts the, “...responsibility for mitigating climate change onto individuals through the consumption of techno-scientific solutions...” (Bee et al. 2015:339).

However, rather than focusing solely on new technology, it is crucial to analyze the techniques incorporated into traditional practices which not only consider the cultural values of indigenous groups but have also combated climate change in the past; though not the only techniques implemented by indigenous groups today, certain aspects of past agricultural practices have shown success in a modern setting, indicating that continued archaeological research into past societies and their agricultural practices has the potential for positive benefits in terms of current mitigation efforts (Kendall 2005:211).

Archaeological evidence of farming and irrigation techniques

Archaeological evidence shows how Andean agrarian civilizations used canal construction and irrigation to support complex societies throughout time. Despite obstacles presented by climate and hazards associated with El Niño events, pre-Columbian societies were able to manipulate their environment through extensive irrigation networks, canal construction, and terracing in order to support social complexity (Goldstein 2011:155). Archaeological evidence of human irrigation systems is seen as the “material form of social structures and relations” (Ertsen and van der Spek 2009:178), and, when coupled with cultural variables, can reveal past adaptations and responses to hazard situations (Goldstein 2011:156). In this section, the agricultural practices of three distinct yet overlapping archaeological cultures—Huaracane (2000 BC-AD 800), Wari (AD 600-1000), and Tiwanaku (AD 600-1100)—will be evaluated in terms of their irrigation systems. Lastly, agricultural adaptations of the Inca empire (1400-1532 AD) will be introduced in order to transition into modern indigenous practices.

First, excavations of a group of raised fields near Huatta, which lies on the Peruvian side of Lake Titicaca on the Peru-Bolivia border revealed evidence of parallel canals attributed to the Huaracane (Bray 1990:385). These canals, known as Waru-Warus were built between 1000 BC and AD 400, and mounds around one meter high, four to ten meters wide, and ten to one hundred meters long were piled between the parallel canals. Pollen analysis performed on field soils shows that potatoes and quinoa, which are high-altitude grains rich in protein, were the main crops grown (Bray 1990:385). These canals were beneficial in terms of both droughts and floods. During droughts, moisture from the canals would slowly ascend to the roots through capillary action while during floods, excess run-off would drain away. Waru-Warus also reduced the impact of low temperatures; water from the canals would absorb the sun’s heat during the day and then radiate it back at night, helping protect the crops against frost (Altieri and Nicholls 2013:36-7). However, these techniques were altered at the site after AD 400 which coincides with the growth of the Tiwanaku and Wari empires as well as increased temperatures (Bray 1990:385).

As stated, Waru-Warus and raised-field techniques evolved during the Tiwanaku and Wari periods (AD 500-1100) at the Huatta site. These two distinct archaeological cultures overlapped in time during the Middle Horizon period (AD 500-1000). The Middle Horizon was a geological time period characterized by climatic and environmental changes—brought about by droughts and El Niño events—in which there were multiple political centers (Goldstein 2011:156). The Middle Horizon is characterized by two main periods of drought: a long drought from AD 562 to 594 and a centuries-long drought beginning around AD 1100 (Williams 2002:361-2). Archaeologists at Huatta discovered terraces on the hill slopes and systems of raised fields. Various aspects of the landscape and technology came together to form a functioning integrated system that allowed wet-season rainfall to be collected in natural lagoons in the hills and then transported by aqueducts across the plain and into the lake. This system is beneficial for areas that rely on wet-season precipitation throughout the dry season (Bray 1990:385).

However, though co-existing at the same time during the Middle Horizon and indistinguishable at the Huatta site in particular, both the Wari and Tiwanaku had culturally distinct agrarian adaptations to the arid environment and found their own economic niche. Looking specifically at Peru’s Osmore drainage, also known as the Moquegua Valley, systematic surveying has revealed the unique agricultural systems that the Wari and Tiwanaku employed (Goldstein 2011:156-8). The Wari civilization of Ayacucho, Peru, considered the southernmost expansion of one the first empires of the Andes’, introduced agricultural terracing, specifically “extensive flights of mountainside bench terraces on a scale that would be unmatched until the Inca occupation”, to the upper valley (Goldstein 2011:160). This significantly enhanced the upper valley’s agricultural potential (Williams and Nash 2002:249) despite limitations (i.e. rocky poorly watered soils, steep slope, cooler climate, and high labor investment) that upper valley terraced agriculture typically faces (Goodman-Elgar 2008:3085). There is certainly a striking contrast between the Wari’s upland terracing and the practices of the Tiwanaku, which involved mid-elevation desert reclamation. Overall, the Tiwanaku employed agricultural strategies that

required less labor in areas with better water access (i.e. easily irrigable valley bottom lands). Specifically, they occupied flat planting areas that could be watered by springs and river-fed canals, which formed a large array of spring-fed systems (Goldstein 2011:162).

While these systems may seem beneficial in terms of filling a distinct niche, many researchers have explored their true effectiveness in terms of changing environmental conditions because many scholars credit the decline of both empires in part to environmental issues (Ortloff and Kolata 1993:195-221). After AD 880, there was increasing drought in the region (Diamond 2009:480). However, to put it simply, raised-fields and the use of aqueducts to shuttle water from the highlands to the lowlands is an adequate practice to combat drought. Though the Wari's irrigation systems were slightly more efficient, both empires were capable of providing enough irrigation to sustain agricultural systems and provide for their populations (Williams 2002:362-5). Nonetheless, eventually, these irrigation systems failed the Tiwanaku. Therefore, the role of drought in the collapse of both empires is not a simple, clean-cut cause; social elements rather than just disaster agents must be considered. One argument supports the idea that the Wari reduced water to lowland Tiwanaku settlements by developing high sierra agrarian technology; those in the high elevations had the hydraulic superiority, which made Tiwanaku settlements in the lower and middle valleys more prone and vulnerable to the water shortages associated with droughts (Williams 2002:371-2). Therefore, while droughts, or environmental effects, may have played a role in collapse, it is important to note the interplay with other important social factors as well, which shows that these agricultural techniques themselves were not a sole cause of collapse and could still be confidently implemented today without the fear of detrimental effects.

While drought may have contributed to the Wari and Tiwanaku collapses, the Inca empire, which rose in the early 15th century and existed until Spanish colonization in the 1530s, has a different story. This could be due to the fact that they did not face the same social and economic pressures as the Wari and

Tiwanaku. During the Northern Hemisphere's Medieval Warm Period (ca. A.D. 950-1250), temperatures rose. This increase in temperature allowed the Inca predecessors and then the Inca themselves to move their agriculture to higher elevations and exploit glacial meltwater for irrigation, allowing them to use the changing environmental conditions to their advantage (Diamond 2009:480).

Similar to the irrigation systems of the Wari and Tiwanaku, the Inca utilized a technique known as water sowing that was advantageous for their specific environmental conditions. This method employs the use of raised fields as well as *qochas*, or small artificial lagoons, at the top of hills in order to capture rainwater that can then be directed to mountain aquifers, which will then provide water for irrigation to streams and bogs, preventing them from drying up before the next rain (Morris 199:289). The geologic properties and evolution of *qochas* have been studied in great detail throughout sites along the northern Lake Titicaca Basin in Peru, for example (Craig et al. 2011: 2897). This technique was incredibly beneficial for the Inca in times of drought and played a major role in the expansion of the empire (Morris 199:289).

Current indigenous response

Today, with increasing global temperatures, some Peruvian villages are reincorporating ancient techniques into existing agricultural practices. Looking specifically at the practice of water sowing implemented by the Inca, in some areas of Peru, it is becoming more popular and necessary to make *qochas*. The idea to do this came from the Climate Change Adaptation Program (PACC), a Swiss international cooperation project that was active in Peru from 2009 to 2016 and provided guidance to several Andean villages (Alvarez 2017). However, PACC is not the only organization supporting more traditional forms of knowledge. In fact, an organization called the Cusichaca Trust initiated an agricultural rehabilitation project with the goal of alleviating poverty experienced by present-day Andean communities in areas that were known to have had the adequate infrastructure capable of sustainable agriculture in pre-Columbian times (Kendall 2005:207). In addition to

qochas, the Cusichaca Trust has helped construct terrace structures that implement Waru-Warus and raised-field techniques seen in the Middle Horizon during the time of the Wari and Tiwanaku (Kendall 2005: 209-11). The Cusichaca Trust has successfully supported local, indigenous communities in both Peru and Bolivia for the past four decades, leading to increased crop yields—that have even doubled in some cases—and the implementation of sustainable agriculture (Kaptijn 2018:7).

Viewing the success of incorporating traditional practices in Peru shows the overall importance of ancient techniques in global efforts to alleviate effects of climate change. Today, many biotechnology companies, in order to sell their products and promote new technology to poor farmers, say that their technologies are crucial and the only way to successfully combat climate change (Tester and Langridge 2010:818-22). This is not to say that science should be completely ignored. There have certainly been amazing technological advances in recent years, which have successfully been implemented in Western countries where these technologies are more easily affordable.

Nevertheless, promoting only technology-driven approaches invalidates and completely ignores the use of traditional practices, which have the potential to be incredibly useful, especially since ancient techniques are often particular to the specific environment they are implemented in rather than a generalized environmental setting (Altieri and Nicholls 2013:40-3). In addition, in regard to irrigation in particular, ancient water management systems often require relatively simple technology and can be relatively easily implemented and adopted, making them beneficial in less developed areas (Kaptijn 2018:7). Another factor to consider is that resilience to climate disasters is closely linked to a high level of on-farm biodiversity, which is a typical feature of many traditional practices and a feature that many biotechnical solutions lack. For this reason, it has been suggested to instigate efforts to rescue traditional management systems in order to increase the sustainability and resilience of agricultural production under predicted climatic changes (Altieri and Nicholls 2013:40-3). While some may argue that traditional

practices used by past populations no longer apply to the dense, urban populations that exist today, they can certainly still be applied to the local level on a case-by-case basis.

It is important to note that while archaeological research can provide insight into past evidence of adaptation to changing climatic variables, archaeology does have its limitations, a major limitation being that the material evidence left behind does not always paint a completely accurate picture of the socio-cultural and ideological conditions at the time (Kaptijn 2018:7). Due to this reason, modern indigenous groups must be included in all development projects because they hold valuable knowledge of the land and the culture of their communities. Even though mitigation measures are often determined at the international and national levels, their implementation still needs to occur across different levels—the local level being one that is often forgotten when thinking of the big picture. Many indigenous groups are excluded from discussions surrounding climate change even though local specificity and situational aspects need to be considered (Brugnach et al. 2017:19-21). Certainly, it is clear that indigenous voices need to be included in these conversations (Roosvall and Tegelberg 2015:50-1).

Conclusion

For millennia Peru has faced climate change and climatic variability (i.e. El Niño), and indigenous groups have implemented different agricultural practices to combat these changing conditions. Current indigenous groups have successfully utilized Wari and Tiwanakua-inspired raised-field techniques as well as the ancient Inca farming practice of water sowing in their communities, proving that new technologies are not the only way to effectively counter climatic fluctuations. Indeed, ancient techniques should not be valued less than new technology when it comes to mitigating the effects of climate change today. Through archaeology, we can better understand how humans and the environment interacted, especially during times of great variability. Further research investigating the history of climate change in other regions of the world would be useful. Understanding how different past cultures responded and thrived

under variable conditions can be applied not only to current global mitigation efforts but to local and community efforts as well. There is a long record of interactions between humans and the environment and taking a closer look at archaeological examples can reintroduce successful past strategies that can be combined with new technology in order to provide guidance and context for future environmental scenarios.

References

- ALTIERI, M., & NICHOLLS, C. 2013. "THE ADAPTATION AND MITIGATION POTENTIAL OF TRADITIONAL AGRICULTURE IN A CHANGING CLIMATE." *CLIMATIC CHANGE* 140(1):33–45.
[HTTPS://DOI.ORG/10.1007/S10584-013-0909-Y](https://doi.org/10.1007/s10584-013-0909-y)
- ALVAREZ, PABLO PEREZ. 2017. "AN INCAS TRICK AGAINST THE EFFECTS OF CLIMATE CHANGE. FAIR PLANET." AVAILABLE AT [HTTPS://WWW.FAIRPLANET.ORG/STORY/AN-INCAS-TRICK-AGAINST-THE-EFFECTS-OF-CLIMATE-CHANGE/](https://www.fairplanet.org/story/an-incas-trick-against-the-effects-of-climate-change/) (ACCESSED 14 NOVEMBER 2020)
- BÄCKSTRAND, K. (2004). SCIENTISATION VS. CIVIC EXPERTISE IN ENVIRONMENTAL GOVERNANCE: ECO-FEMINIST, ECO MODERN AND POST-MODERN RESPONSES. *ENVIRONMENTAL POLITICS*, 13(4), 695–714.
- BEE, B. A., RICE, J., & TRAUGER, A. 2015. "A FEMINIST APPROACH TO CLIMATE CHANGE GOVERNANCE: EVERYDAY AND INTIMATE POLITICS." *GEOGRAPHY COMPASS*, 9(6): 339–350.
- BRAY, W. 1990. "AGRICULTURAL RENASCENCE IN THE HIGH ANDES." *NATURE* (LONDON), 345(6274):385–385.
[HTTPS://DOI.ORG/10.1038/345385A0](https://doi.org/10.1038/345385a0)
- BRUGNACH, M., CRAPS, M., & DEWULF, A. 2017. "INCLUDING INDIGENOUS PEOPLES IN CLIMATE CHANGE MITIGATION: ADDRESSING ISSUES OF SCALE, KNOWLEDGE AND POWER." *CLIMATIC CHANGE* 140(1):19–32. [HTTPS://DOI.ORG/10.1007/S10584-014-1280-3](https://doi.org/10.1007/s10584-014-1280-3)
- CRAIG, NATHAN, ET AL. 2011. "GEOLOGIC CONSTRAINTS ON RAIN-FED QOCHA RESERVOIR AGRICULTURAL INFRASTRUCTURE, NORTHERN LAKE TITICACA BASIN, PERU." *JOURNAL OF ARCHAEOLOGICAL SCIENCE* 38.11: 2897–2907.
- DIAMOND, J. 2009. "ARCHAEOLOGY MAYA, KHMER AND INCA." *NATURE* (LONDON) 461(7263):479–480.
[HTTPS://DOI.ORG/10.1038/461479A](https://doi.org/10.1038/461479a)
- ERTSEN, M.W., VAN DER SPEK, J., 2009. "MODELING AN IRRIGATION DITCH OPENS UP THE WORLD. HYDROLOGY AND HYDRAULICS OF AN ANCIENT IRRIGATION SYSTEM IN PERU." *PHYSICS AND CHEMISTRY OF THE EARTH, PARTS A/B/C WATER HISTORY* 34 (3): 176–191.
- GOLDSTEIN, PAUL S., AND FRANCIS J. MAGILLIGAN. 2011 "HAZARD, RISK AND AGRARIAN ADAPTATIONS IN A HYPERARID WATERSHED: EL NIÑO FLOODS, STREAMBANK EROSION, AND THE CULTURAL BOUNDS OF VULNERABILITY IN THE ANDEAN MIDDLE HORIZON." *CATENA* 85.2: 155–167.
- GOODMAN-ELGAR, M., 2008. "EVALUATING SOIL RESILIENCE IN LONG-TERM CULTIVATION: A STUDY OF PRE-COLUMBIAN TERRACES FROM THE PACA VALLEY, PERU." *JOURNAL OF ARCHAEOLOGICAL SCIENCE* 35 (12): 3072–3086.
- IPCC. 2014. "CLIMATE CHANGE 2014 SYNTHESIS REPORT. SUMMARY FOR POLICY MAKERS." AVAILABLE AT [HTTPS://WWW.IPCC.CH/SITE/ASSETS/UPLOADS/2018/02/AR5_SYR_FINAL_SPM.PDF](https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_SPM.PDF) (ACCESSED 29 NOVEMBER 2020).
- KAPTIJN, EVA. 2018. "LEARNING FROM ANCIENT WATER MANAGEMENT: ARCHEOLOGY'S ROLE IN MODERN-DAY CLIMATE CHANGE ADAPTATIONS." *WILEY INTERDISCIPLINARY REVIEWS: WATER* 5.1: E1256.
- KENDALL, ANN. 2005. "APPLIED ARCHAEOLOGY: REVITALIZING INDIGENOUS AGRICULTURAL TECHNOLOGY WITHIN AN ANDEAN COMMUNITY." *PUBLIC ARCHAEOLOGY* 4.2-3: 205–221.
- MARK, BRYAN G., [JEFFREY BURY](#), [JEFFREY M. MCKENZIE](#), [ADAM FRENCH](#) & [MICHEL BARAER](#). 2010. "CLIMATE CHANGE AND TROPICAL ANDEAN GLACIER RECESSION: EVALUATING HYDROLOGIC CHANGES AND LIVELIHOOD VULNERABILITY IN THE CORDILLERA BLANCA, PERU." *ANNALS OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS* 100(4):794–805.,
 DOI:10.1080/00045608.2010.497369.
- MORRIS, ARTHUR. 1999. "THE AGRICULTURAL BASE OF THE PRE-INCAN ANDEAN CIVILIZATIONS." *GEOGRAPHICAL JOURNAL*: 286–295.
- MOSER, S. C. (2010). COMMUNICATING CLIMATE CHANGE: HISTORY, CHALLENGES, PROCESS AND FUTURE DIRECTIONS. *WILEY INTERDISCIPLINARY REVIEWS: CLIMATE CHANGE*, 1(1), 31–53.
- ORTLOFF, CHARLES R., AND ALAN L. KOLATA. 1993 "CLIMATE AND COLLAPSE: AGRO-ECOLOGICAL PERSPECTIVES ON THE DECLINE OF THE TIWANAKU STATE." *JOURNAL OF ARCHAEOLOGICAL SCIENCE* 20.2: 195–221.

ROOSVALL, A., & TEGELBERG, M. 2015. "MEDIA AND THE GEOGRAPHIES OF CLIMATE JUSTICE: INDIGENOUS PEOPLES, NATURE AND THE GEOPOLITICS OF CLIMATE CHANGE." *TRIPLEC*, 13(1), 39–54–39–54.
[HTTPS://DOI.ORG/10.31269/TRIPLEC.V13I1.654](https://doi.org/10.31269/TRIPLEC.V13I1.654)

SANDWEISS, DANIEL H., AND ALICE R. KELLEY. "ARCHAEOLOGICAL CONTRIBUTIONS TO CLIMATE CHANGE RESEARCH: THE ARCHAEOLOGICAL RECORD AS A PALEOCLIMATIC AND PALEOENVIRONMENTAL ARCHIVE." *ANNUAL REVIEW OF ANTHROPOLOGY* 41(1): 371–391., doi:10.1146/ANNUREV-ANTHRO-092611-145941.

SANDWEISS, DANIEL H., C. FRED T. ANDRUS, ALICE R. KELLEY, KIRK A. MAASCH, ELIZABETH J. REITZ & PAUL B. ROSCOE. 2020. "ARCHAEOLOGICAL CLIMATE PROXIES AND THE COMPLEXITIES OF RECONSTRUCTING HOLOCENE EL NIÑO IN COASTAL PERU." *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES* 117(15): 8271–8279., doi:10.1073/PNAS.1912242117.

SANDWEISS, DANIEL H., KIRK A. MAASCH, RICHARD L. BURGER, JAMES B. RICHARDSON III, HAROLD B. ROLLINS & AMY CLEMENT. 2001. "VARIATION IN HOLOCENE EL NIÑO FREQUENCIES: CLIMATE RECORDS AND CULTURAL CONSEQUENCES IN ANCIENT PERU." *GEOLOGY* 29(7): 603-606., [HTTPS://DOI.ORG/10.1130/0091-7613\(2001\)029<0603:VIHENO>2.0.CO;2](https://doi.org/10.1130/0091-7613(2001)029<0603:VIHENO>2.0.CO;2)

SANDWEISS, DANIEL H., KIRK A. MAASCH & DAVID G. ANDERSON. 1999. "CLIMATE AND CULTURE: TRANSITIONS IN THE MID-HOLOCENE." *SCIENCE* 283(5401): 499–500., doi:10.1126/SCIENCE.283.5401.499.

SHAFTTEL, HOLLY, RANDAL JACKSON, SUSAN CALLERY & DANIEL BAILEY. 2020. "CLIMATE CHANGE: HOW DO WE KNOW?" NASA: GLOBAL CLIMATE CHANGE. AVAILABLE AT [HTTPS://CLIMATE.NASA.GOV/EVIDENCE/](https://climate.nasa.gov/evidence/) (ACCESSED 29 NOVEMBER 2020).

TESTER, M., & LANGRIDGE, P. 2010. "BREEDING TECHNOLOGIES TO INCREASE CROP PRODUCTION IN A CHANGING WORLD." *SCIENCE* (AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE), 327(5967):818–822.
[HTTPS://DOI.ORG/10.1126/SCIENCE.1183700](https://doi.org/10.1126/SCIENCE.1183700)

WALSHE, R., & ARGUMEDO, A. 2016. "AYNI, AYLLU, YANANTIN AND CHANINCHA: THE CULTURAL VALUES ENABLING ADAPTATION TO CLIMATE CHANGE IN COMMUNITIES OF THE POTATO PARK, IN THE PERUVIAN ANDES." *GAIA* (HEIDELBERG, GERMANY) 25(3):166–173.
[HTTPS://DOI.ORG/10.14512/GAIA.25.3.7](https://doi.org/10.14512/GAIA.25.3.7)

WILLIAMS, P. 2002. "RETHINKING DISASTER-INDUCED COLLAPSE IN THE DEMISE OF THE ANDEAN HIGHLAND STATES: WARI AND TIWANAKU." *WORLD ARCHAEOLOGY* 33(3):361–374.
[HTTPS://DOI.ORG/10.1080/00438240120107422](https://doi.org/10.1080/00438240120107422).

WILLIAMS, P.R., NASH, D.J., 2002. "IMPERIAL INTERACTION IN THE ANDES: HUARI AND TIWANAKU AT CERRO BAÚL, ANDEAN ARCHAEOLOGY I. VARIATIONS IN SOCIOPOLITICAL ORGANIZATION." KLUWER ACADEMIC/PLENUM, NEW YORK: 243–265.

CHAPTER 4

Climate Change Impacts on Louisiana's Wetlands

Sierra Neugent



Climate Change Impacts on Louisiana's Wetlands

Sierra Neugent

Climate Change Impacts on Louisiana's Wetlands

- Louisiana is home to a vast arrangement of wetlands that provide food sources and protection for a diverse ecosystem
- Without Louisiana's wetlands not only will wildlife suffer but so will humans if there is no source of action to help slow climate change
- Climate Change has affected Louisiana in multiple ways that has resulted in many impacts such as the coastal erosion of Louisiana's wetlands, rising sea shores, warming temperatures, flooding, and increase in tropical storms that not only impacts humans and wildlife but the wetlands they depend on



Marshes

"Marshes are defined as wetlands frequently or continually inundated with water, characterized by emergent soft-stemmed vegetation adapted to saturated soil conditions. There are many different kinds of marshes, ranging from the prairie potholes to the Everglades, coastal to inland, freshwater to saltwater. All types receive most of their water from surface water, and many marshes are also fed by groundwater. Nutrients are plentiful and the pH is usually neutral leading to an abundance of plant and animal life. We have divided marshes into two primary categories: non-tidal and tidal."

Importance of Louisiana Marshes

- Marshes are responsible for moderating water flow to streams and help reduce damage from flooding by storing water and as the water flows through the marsh the pollutants are being swallowed into the floor allowing microorganisms to thrive off excess nutrients
- "Due to their high levels of nutrients, freshwater marshes are one of the most productive ecosystems on earth. They can sustain a vast array of plant communities that in turn support a wide variety of wildlife within this vital wetland ecosystem. As a result, marshes sustain a diversity of life that is disproportionate with their size. In addition to their considerable habitat value, non-tidal marshes serve to mitigate flood damage and filter excess nutrients from surface runoff."
- Tidal marshes act as a buffer against volatile weather and slow coastal erosion but most importantly provide habitat and food source for diverse life such as crustaceans and waterfowl



Freshwater Marsh

- Can be located in lakes, streams, rivers, and ponds as they are usually associated with poorly drained or shallow water
- Marsh with the highest plant life with common names such as duckweed or cattails
- Contains freshwater and has the largest diversity of life with a salinity level of 0-2 ppt

Intermediate Marsh



- Similar to Freshwater Marsh they can be located in lakes, streams, rivers, and ponds
- This type of Marsh is only located in Louisiana with a salinity range of 2 ppt - 10 ppt

"Intermediate marsh can be easily diagnosed (even from high in an airplane) by its tell-tale combination of freshwater plant species (especially cattails, cut grass, and water lilies) with Wire Grass."

Brackish Marsh



- Can be located in rivers, lakes, ponds, and coastal areas with a salinity level of 10 ppt - 20 ppt
- Easily recognized by the abundance of Wire Grass with little plant diversity



Salt Marsh

- Located near coastal areas and flooded daily from saltwater tides with the highest salinity of greater than 20 ppt

"Specialized plants have adapted to live in this habitat because of the high amount of salt in the water. The plant most seen in this marsh is oyster grass (Spartina alterniflora). One tree that can take the high amount of salt water is black mangrove. Fiddler crabs and oysters are common animals that live in a salt marsh."



Biodiversity of Marshes



Smooth Cordgrass

Spartina Paten

- Found in all marsh but dominant in intermediate and brackish
- Dark green, wirelike, hollow, stiff stems
- Leaves are dark green and droopy
- Long slender plate whitish to reddish rhizomes



Saltwort

Batis Maritima

- Found in highly saline tidal marshes
- Trailing stems that roots at the nodes form open mats that grow from flowering stems
- Leaves are small smooth and yellow to bright green
- Flowers are small and white
- Fruits are yellow



Seashore Paspalum

Paspalum Vaginatum

- Found in fresh to brackish marshes on wet soil
- Salinities ranging from 0 to 3.5 ppt
- Stems are erect with creeping stolons that show purplish flattened internodes
- Leaf blades are short and narrow flat along the midrib



Roseau Cane

Phragmites Australis

- Found in marshes
- Leaf blade is flat and smooth
- Seed head is open panicle with purplish or tawny and flag like
- Tallest grass in southern marshes



Cattail

Typha domingensis

- Found in marshes
- Looks like a hot dog on a leaf
- Small flowers with no petals
- Contain hairs that can fly away and reproduce their seeds to a new location leaving the current hot dog in a mangy state



Blue Crab

Callinectes sapidus

- Females are found in higher salinity waters while males are located in lower salinities
- The males and females are distinguished by their aprons and claw color
- They take refuge in shallow saltwater marshes and are opportunist when feeding



Fiddler Crab

Uca

- Found near saltwater marshes or sandy beaches
- Easily detected by their plentiful small holes in the substrate and males who have one large claw that represents a fiddle

"This species is an industrious and hardworking breed of detritivore and a prime indicator of the overall health of a wetlands system. The crabs obtain nutrients by consuming detritus (decomposing plant or animal matter) and help to enrich water quality by removing excess particles."



King Rail (Marsh Hen)

Rallus elegans

- Prefers the freshwater marsh but can be located in brackish marsh
- Uses plants such as cattails and grasses as it's habitat coverage
- Feeds mainly in the water on crustaceans



Swamps

"A swamp is an area permanently saturated with freshwater or saltwater, and it's one with nutrient-rich soil that supports a high level of biodiversity. Trees thrive in wetlands, and a swamp is often defined by the types of trees that grow there."

Importance of Louisiana Swamps

- Swamps act as a reservoir for water as they sponge up excess water from flooding from heavy rains
- Protect the current fragile coastline from being washed completely away
- The ecosystem in swamps act as a filtration system and purify the water naturally
- The Bald Cypress and Black Gum trees found in swamps allow for growth as they anchor sediments and helps the accumulation of soil as the roots grow and die
- Contribute to the capturing and storing of carbon < very important
- Act as a nursery for fish as they reproduce and use the tree roots as protection and food sources
- Provide food sources and protection for diverse ecosystem with it's overabundance of plants and nutrients
- Waterfowl are dependent and plentiful on the swamps

Important trees in Louisiana Swamps

Bald Cypress

- Transport air to drowned roots underground
- Soak up floodwaters
- Prevent erosion
- Trap and prevent pollutants
- Breeding ground/home for animals

Black Gum

- Roots allow it to live in inundated environment that provide stability in heavy winds
- Used by artistic wood carvers especially carving ducks



Bald Cypress

Taxodium distichum

"Bald cypresses have very important roles in the wild. Since they tend to grow along rivers and in wetlands, they are excellent at soaking up floodwaters and preventing erosion. They also trap pollutants and prevent them from spreading. Frogs, toads, and salamanders use bald cypress swamps as breeding grounds. Wood ducks nest in hollow trunks, catfish spawn in the submerged hollow logs, and raptors like bald eagles nest in the treetops."



Black Gum

Nyssa sylvatica

"Large aquatic tree with swollen base, long, straight trunk, narrow, open crown of spreading branches, and large, shiny leaves. Water tupelo is a narrow-crowned, flood-tolerant, deciduous tree, 50-100 ft. tall, with a buttressed base. It is very symmetrical and pyramid-shaped in its early years, but develops an irregular form with age. Large, glossy, dark-green leaves turn yellow in fall. Fruit ripens to black."



Biodiversity of Swamps



Great Egret

Ardea alba

- Protected bird commonly seen in wetlands
- Males and females typically appear similar even in breeding season
- Feeds mainly on fish and crustaceans but will eat insects and rodents
- Catches prey by wading in the water



Catfish

Siluriformes

- Distinguished by their feelers which resembles a cats whiskers
- Bottom dwellers and are notorious scavengers that will eat literally anything
- Overabundance in Louisiana and typically the flathead or blue catfish are the most common
- Abundant in Louisiana and flathead and blue catfish are common table fare



Alligator

Alligator mississippiensis

- Typically found in swamps in Louisiana
- Largest North American reptile
- Considered apex predators and will feed on fish, insects, small mammals, pets, and even humans
- Rely on external heat to regulate their body temperature
- Hatchlings will stay with their mother for 1-2 years before becoming independent



Spanish Moss

Tillandsia usneoides

- Long tendrils of moss that appear green or dark grey depending on the season hanging from trees
- House many animals specifically snakes and insects
- Considered a epiphytic bromeliad which means it grows on another plant but does not retain nutrients from that plant and is not considered moss at all



Duckweed

Lemnoideae

- Green semi-star shaped plant that float on top of freshwater and wetlands
- Green to yellowish color
- Used to shelter aquatic life for protection but the con is that if they completely cover the surface the result is oxygen depletion and sunlight blocking



The Atchafalaya Basin

"The Atchafalaya Basin is the nation's largest river swamp, containing almost one million acres of America's most significant bottomland hardwoods, swamps, bayous and backwater lakes. The basin begins near Simmesport, La., and stretches 140 miles southward to the Gulf of Mexico. Currently, the Atchafalaya Basin is bound by levee building along active and abandoned courses of the Mississippi River."



Atchafalaya Basin Importance

"Besides providing critical habitat, the Atchafalaya Basin functions as a flood relief outlet for the Mississippi River Basin by taking some its water. Another of the basin's crucial functions is its filtration power. The Atchafalaya contains an especially high variety of plants and wildlife that is not only important for nature's sake, but also to the people who make their living from the Atchafalaya's lands and waters. In fact, the value of the Basin's natural services (flood control, carbon storage, navigation, oil and gas resources, forest, fish and wildlife resources, and nutrient reduction) is valued at billions of dollars annually."



Impact of Climate Change on Wetlands

"In the coming decades, Louisiana will become warmer, and both floods and droughts may become more severe. Unlike most of the nation, Louisiana did not become warmer during the last century. But soils have become drier, annual rainfall has increased, more rain arrives in heavy downpours, and sea level is rising. Our changing climate is likely to increase damages from floods, reduce crop yields and harm fisheries, increase the number of unpleasantly hot days, and increase the risk of heat stroke and other heat-related illnesses."

Impact of Climate Change on Wetlands

- Louisiana will become warmer in temperature with severe precipitation and flooding due to climate change
- Sea levels will continually rise from climate change resulting in faster coastal erosion
- Wetlands that are responsible for containing greenhouse gases will be completely wiped out in a few centuries that result in the release of these trapped gasses contributing to warming temperatures in Louisiana
- Tropical storms will become more intense
- Diverse ecosystems will be impacted
- Increase in mosquito population due to warmer temperatures



Temperature in Louisiana

"Hot days can be unhealthy, even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems. Warmer air can also increase the formation of groundlevel ozone, a key component of smog. Ozone has a variety of health effects, aggravates lung diseases such as asthma, and increases the risk of premature death from heart or lung disease."



Although mosquitos are a issue for humans and livestock in Louisiana, they play a vital role in wetlands as they are kept in check by natural predators who rely on this food source

What does hotter temperatures mean for Louisiana?

Increase in mosquito seasons!

"Mosquitoes can leave behind more than just an itchy welt. The insects transmit a number of diseases — including malaria, dengue and West Nile — making them the world's deadliest animal. Climate change is expected to further spread mosquito-borne diseases and make them more prevalent in some areas. Warmer temperatures are projected to expand the ranges of disease carrying mosquitoes north and south to places where they weren't previously present, said Dr. Dawn Wesson with Tulane's School of Public Health and Tropical Medicine."



Increased flooding from Climate Change

- Rising sea levels makes lower lying areas susceptible to flooding
- The majority of Louisiana is below sea level and protected by levees and without this protection Louisiana is at stake for fatal flooding as seen in Hurricane Katrina
- Excessive flooding increases insurance rates
- Flooding decreases farmers crop yields
- Increased flooding will drive out diverse wildlife along with plants that normally are unaccustomed to that sudden environmental change



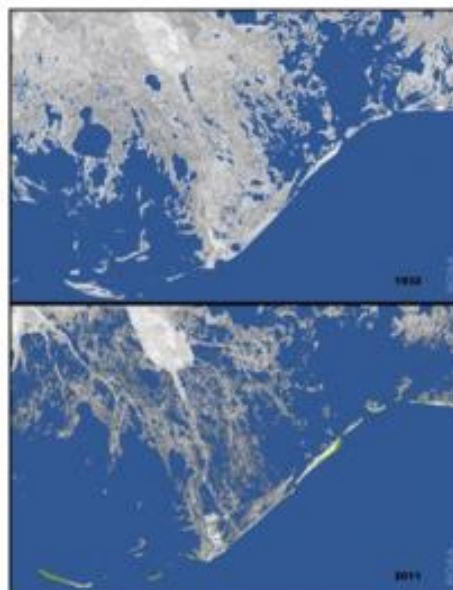
Sea Level Rising in Louisiana

"If temperatures continue to warm, sea level is likely to rise one to three feet during the next century. Rising sea level has the same effect as sinking land, so changing climate is likely to accelerate coastal erosion and land loss. Federal, state, and local governments have ongoing projects to slow land loss in Louisiana, but if the sea rises more rapidly in the future, these efforts will become increasingly difficult."

"Louisiana's barrier islands are eroding, however, at a rate of up to 20 meters per year; so fast that, according to recent USGS estimates, several will disappear by the end of the century. As the barrier islands disintegrate, the vast system of sheltered wetlands along Louisiana's delta plains are exposed to the full force and effects of open marine processes such as wave action, salinity intrusion, storm surge, tidal currents, and sediment transport that combine to accelerate wetlands deterioration."

- Subsidence occurs naturally but with the increase in sea levels and human intervention this both poses a huge problem for the wetlands
- Louisiana loses a football field of land every hour due
- Salinity intrusion kills wetlands like freshwater marshes that cannot survive in salt water leading to the loss of diverse ecosystem of plants and animals
- Louisiana is one of the largest oil industry leaders that produces nearly 18% of oil in the U.S. and because of the production of oil it contributes to subsidence as they pull from the ground it decreases the reservoir that allows for land loss

The issue with subsidence and wetlands in Louisiana





Wetlands and Greenhouse Gases

When salt marshes are subjected to coastal erosion or other damage they release the blue carbon into the atmosphere that influences climate change

"When we protect the carbon in coastal systems, we protect healthy coastal environments that provide many other benefits to people, such as recreational opportunities, storm protection, and nursery habitat for commercial and recreational fisheries."



Tropical Storm Increase

With the warming of waters in the Gulf of Mexico, tropical storms are likely to increase in category because of Climate Change

Hurricanes will increase in wind speed and precipitation that can destroy anything in its path including fragile wetland infrastructure

This photo was taken of the aftermath of Hurricane Laura 2020, which was the most deadliest storm to hit Southwest Louisiana in a long time, and it's important to have the realization how devastating these natural disasters are and if they can obliterate cities this easily the damage to sensitive ecosystems in wetlands will be near nonexistent in the future as they intensify

Louisiana birds and Climate Change



"Birds are under threat by Louisiana's land loss crisis. Unfortunately, these birds are under tremendous threat, as they live in a collapsing river delta. Over 2,000 square miles (about the size of Delaware) have been lost to open water in the last 80 years, and land loss continues to be one of the greatest threats to bird habitat. Nesting islands are eroding away, marsh-dwelling species are seeing habitat fragmentation as it sinks and becomes water, and beach-nesting species are seeing their nests washed away as seas rise."

Louisiana wetlands holds the key in supporting endangered bird species such as the Wilson Plover to the left and without protection against predators or natural disasters that the wetlands provide these diverse birds will eventually become extinct.

Louisiana birds and Climate Change



"Birds are under threat by Louisiana's land loss crisis. Unfortunately, these birds are under tremendous threat, as they live in a collapsing river delta. Over 2,000 square miles (about the size of Delaware) have been lost to open water in the last 80 years, and land loss continues to be one of the greatest threats to bird habitat. Nesting islands are eroding away, marsh-dwelling species are seeing habitat fragmentation as it sinks and becomes water, and beach-nesting species are seeing their nests washed away as seas rise."

Louisiana wetlands holds the key in supporting endangered bird species such as the Wilson Plover to the left and without protection against predators or natural disasters that the wetlands provide these diverse birds will eventually become extinct.



Anthropogenic Impacts



Mary Giger 2020 ©

Invasive Species in Louisiana

The apple snail is an invasive snail from South America that cannot be destroyed with pesticides in Louisiana

This snail threatens native species as it steals food and will overpopulate

They destroy natural habitats for fish and wildlife and disrupt the natural ecological process

The apple snail on the left was found in crawfish traps as it was destroying rice fields and unfortunately passing on diseases to the crawfish making them unable for human consumption and loss in harvest from farmers

Other invasive species that plague Louisiana land and waters include the Asian Carp, Lionfish, and tiger prawn as seen on the left



Farming in Louisiana

"Changing climate will have both harmful and beneficial effects on farming. Seventy years from now, Louisiana is likely to have 35 to 70 days with temperatures above 95°F, compared with about 15 days today. Even during the next few decades, hotter summers are likely to reduce yields of corn and rice. But higher concentrations of atmospheric carbon dioxide increase crop yields, and that fertilizing effect is likely to offset the harmful effects of heat on soybeans and cotton—if adequate water is available. On farms without irrigation, however, increasingly severe droughts could cause more crop failures. Higher temperatures are also likely to reduce livestock productivity, because heat stress disrupts the animals' metabolism."



Fisheries in Louisiana

- Rising sea levels and heated temperatures threaten the fisheries as the land that supports crawfish, crabs, fish, oysters, shrimp, and other catch are 75 percent of the total states commercial fisheries
- The fishing industry brings in 1.1 billion pounds of fish and shellfish annually
- Wetland deterioration results in the decline of fishery production and the loss of jobs and food sources that many Louisiana natives depend on



Altered Hydrology in Louisiana

- Reduced sediment flow is one of the main contributions to land loss in Louisiana
- Levees are created to prevent flooding in areas like New Orleans but realistically they do more harm than good as they prevent the sediment from reaching the wetland floodplains which causes the land to sink
- Human manipulation of natural river flow has altered sediment depositing and land replenishment

"The U.S. Geological Survey (USGS) maintains that, without the deposition of sediment to offset lost elevation, subsidence has accounted for 53% of land loss in Louisiana's deltaic plain over the past century."



Coastal Excavation in Louisiana

"Coastal Excavation is a most destructive process that results in the rapid degradation of wetlands to open water. Land is directly removed through the construction of navigation channels, waterfront property with finger canals and marinas. Extensive dredging of canals—over 10,000 miles—also occurred with oil and gas exploration, which peaked in the 1960s to 1980s. The channels serve as conduits through which salt water enters interior marshes and weakens and eventually destroys freshwater vegetation. Marsh soil disintegrates without plants to hold it in place, thus hastening the conversion of wetlands to open water."

The extractions of excavations increases land loss in Louisiana as it increases the water depths and decreases the sediments and with Louisiana's cargo shipping the waterways will likely be exposed to open water in future generations

Climate Change Impacts on Louisiana's Wetlands

- Louisiana's wetlands are in peril due to many anthropogenic factors such as altered hydrology, invasive species introduction, and coastal excavation
- Louisiana stands to lose its cultural heritage, animal and plant diversity, unique habitats and many economic assets such as tourism and fisheries without its wetlands
- In order to save current wetlands and possibly restore lost habitat there are several potential solutions; better public education and outreach, funding for research and remediation projects and hydrological structures that more closely mimic natural sediment deposition would be an excellent state

Work Cited pg. 1

Atchafalaya National Heritage Area. "The Atchafalaya Basin." *The Atchafalaya Basin | Atchafalaya National Heritage Area*, www.atchafalaya.org/atchafalaya-basin.

"Classification and Types of Wetlands." EPA, Environmental Protection Agency, 5 July 2018, www.epa.gov/wetlands/classification-and-types-wetlands.

Deziel, Chris. "Types of Trees in Swamps." Sciencing, 13 Mar. 2018, sciencing.com/types-trees-swamps-8480721.html.

EPA. "What Climate Change Means for Louisiana ." *United States Environmental Protection Agency*, Aug. 2016, 19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-la.pdf.

Johnson, Erik L. "Coastal Louisiana – A Bird Paradise to Be Saved, or Lost Forever?" *Audubon Louisiana*, 19 July 2019, la.audubon.org/news/coastal-louisiana-%E2%80%93-bird-paradise-be-saved-or-lost-forever.

Kelly, Jack. "Fiddler Crabs Are Vital to Salt Marshes." *Newport This Week*, 18 July 2015, www.newportthisweek.com/articles/fiddler-crabs-are-vital-to-salt-marshes/.

Lady bird Johnson Wildflower Center. "Plant Database." *Lady Bird Johnson Wildflower Center - The University of Texas at Austin*, www.wildflower.org/plants/result.php?id_plant=nyaq2.

Louisiana's Oil. "Louisiana's Oil." *Wetlands and Coastal Erosion*, www2.southeastern.edu/orgs/oilspill/wetlands.html.

LSU Ag Center. *Wetland Habitats*, www.lsuagcenter.com/MCMS/RelatedFiles/%7B89611EF1-C5E8-431E-9D3D-51923D794CA9%7D/Wetland-Habitats.pdf.

Work Cited pg. 2

The National Wildlife Federation. "Bald Cypress." *National Wildlife Federation*, www.nwf.org/Educational-Resources/Wildlife-Guide/Plants-and-Fungi/Bald-Cypress.

The Nature Conservancy. "The Atchafalaya River Basin." *The Nature Conservancy*, www.nature.org/en-us/about-us/where-we-work/united-states/louisiana/stories-in-louisiana/the-atchafalaya-river-basin/.

Pooler, Harriett. "The Great Egret." *Country Roads Magazine*, 28 Mar. 2013, countryroadsmagazine.com/outdoors/knowning-nature/the-great-egret/.

Sara Sneath, Louisiana Illuminator. October 20. "Climate Change Leads to More Intense Hurricanes - and More Mosquitoes." *Louisiana Illuminator*, 20 Oct. 2020, lailuminator.com/2020/10/20/climate-change-leads-to-more-hurricanes-and-more-mosquitoes/.

Shirley, Jolene S. "Louisiana Coastal Wetlands: A Resource At Risk." *Louisiana Coastal Wetlands: A Resource At Risk - USGS Fact Sheet*, pubs.usgs.gov/fs/la-wetlands/.

Types of Wetlands, www.americanwetlandresources.com/wildlife_ecology/plants_animals_ecology/wetlands/TypesofWetlands.html.

U.S. Fish and Wildlife Service. "Classification and Types of Wetlands." EPA, Environmental Protection Agency, 5 July 2018, www.epa.gov/wetlands/classification-and-types-wetlands.

US Department of Commerce, National Oceanic and Atmospheric Administration. "What Is Blue Carbon?" NOAA's National Ocean Service, 1 June 2013, oceanservice.noaa.gov/facts/bluecarbon.html.

Wallen, Dayle. "Sentinels of the Swamp: Cypress and Tupelo Trees." *National Forest Foundation*, 7 Oct. 2015, www.nationalforests.org/blog/cypress-and-tupelo-trees.

Creative Commons Photo Citing

"Tall Trees and Duckweed" by mikemac29 is licensed under CC BY-NC 2.0

"Louisiana Marsh" by bgautrea is licensed under CC BY-SA 2.0

"ME-16 Freshwater Introduction South of Highway 82" by CWPPRA is licensed under CC BY-NC-ND 2.0

"Egret, Cleaned of Oil, Released" by lagohsep is licensed under CC BY-SA 2.0

"Bridging Nature" by Ray Devlin is licensed under CC BY 2.0

"salt dome" by leidio is licensed under CC BY-ND 2.0

"Newly Released Whooping Cranes" by USFWS Headquarters is licensed under CC BY 2.0

"Spartina alterniflora, smooth cordgrass, Sengekontacket Pond, Old Farm Road, Felix Neck" by Iggpotterfield is licensed under CC BY-NC-SA 2.0

"Saltwort, *Batis maritima*" by Anita363 is licensed under CC BY-NC 2.0

"Paspalum vaginatum plant9" by Macleay Grass Man is licensed under CC BY 2.0

"Phragmites australis" by paulschulze photo is licensed under CC BY 2.0

Image by Beau B is licensed under CC BY 2.0

Creative Commons Photo Citing

"Callinectes sapidus (blue crab) (Cayo Costa Island, Florida, USA) 5" by James St. John is licensed under CC BY 2.0

"File:Fiddler Crab Gulf Coast.jpg" by Junglecat is licensed under CC BY-SA 3.0

"2018-05-19 Montrose Point 3" by JanetandPhil is licensed under CC BY-NC-ND 2.0

"Louisiana Swamp" by MSMcCarthy Photography is licensed under CC BY-ND 2.0

"bald cypress swamps with spanish moss (Tillandsia)" by Vilseskogen is licensed under CC BY-NC-SA 2.0

"Nyssa sylvatica (black tupelo or black gum)" by tgpotterfield is licensed under CC BY-NC-SA 2.0

"Clear Lake 9104" by MSMcCarthy Photography is licensed under CC BY-ND 2.0

"Lake Martin 9627" by MSMcCarthy Photography is licensed under CC BY-ND 2.0

Louisiana Wildlife and Fisheries. "Get out and Fish! Community Fishing Program". WLF Louisiana. 2021.

"20120106-OC-AMW-0707" by USDAgov is marked with CC PDM 1.0

"Spanish Moss on Trees" by Steve Snodgrass is licensed under CC BY 2.0

Creative Commons Photo Citing

"Duckweed" by Remember To Breathe is licensed under CC BY 2.0

"Atchafalaya-Basin---RM1_2520" by Roberto Marchegiani is licensed under CC BY-NC-ND 2.0

"Atchafalaya Basin" by Matthew Levine is licensed under CC BY 2.0

"Sabine Wetlands Walk, Hackberry, La" by louisianatravel is licensed under CC BY-ND 2.0

"Aedes aegypti mosquito" by Sanofi Pasteur is licensed under CC BY-NC-ND 2.0

"New Orleans, Aug. 31, 2005" by djwudi is licensed under CC BY-NC-SA 2.0

"Coastal Wetlands Restoration After Katrina" by NOAA Images is marked with CC PDM 1.0

Kennedy, Caitlyn. "Underwater: Land loss in coastal Louisiana since 1932". Climate. 5 April. 2013.

Creative Commons Photo Citing

"DSC_0742b" by JaumoJen is licensed under CC BY-NC-ND 2.0

"Hurricane Laura" by Josiah Pugh is marked with CC PDM 1.0

"Wilson's Plovers" by MyFWC Florida Fish and Wildlife is licensed under CC BY-ND 2.0

"shrimp stew" by Billy Metcalf Photography is licensed under CC BY-NC-ND 2.0

Grigor, Mary. "Invasive Species". Watercolor painting on paper, 2021.

"20130820-OC-RBN-2648" by USDAgov is licensed under CC BY 2.0

"Step this way" by bbcworldservice is licensed under CC BY-NC 2.0

"TE-72 Lost Lake Marsh Creation and Hydrologic Restoration" by CWPPRA is licensed under CC BY-NC-ND 2.0

"Dredging, Sand Berm Construction Continue in Coastal Louisiana" by lagohsep is licensed under CC BY-SA 2.0

"Newly Released Whooping Cranes" by USFWS Headquarters is licensed under CC BY 2.0

"A Satellite View of a Back-door Cold Front" by NASA Goddard Photo and Video is licensed under CC BY 2.0

Part II

Climate Change Induced Migration and Relocation

CHAPTER 5

The Atlantis of the North and What We Can Learn from the Rising Sea Levels of the Past

Logan Ostrom

Keywords: Doggerland, Post-Glacial Period, Adaptation, Holocene, Sea Level

Abstract. The effects of climate change can be seen in various ways. One of these ways is the rising sea levels and how they have begun to cause increasing flood concerns on coastal cities. For this paper I am investigating how not only the rising sea levels but also how the ending of the glacial period would have brought about seasonal and meteorological changes on a vast scale. One area that was affected by rising sea levels in the past was Doggerland or what is now Dogger Bank and the North Sea. The focus of this paper is how the memory and material culture of the people of Doggerland in understanding and realizing the changes is also something I shall be trying to understand based off how others in the world are adapting to sea level rise as well as with their material culture. By looking into how people of the past in places such as Doggerland dealt with and adapted to sea level rising and ecological changes, we can perhaps better understand what would be best for overcoming these challenges for our generation and beyond.

Introduction

What is now the North Sea was, during the last glacial period, part of the continent of Europe connecting as far as England to mainland Denmark. This land has become known as Doggerland which takes its name from the modern term of the area of Dogger Bank. (Sturt et al.2013:3971). Doggerland had vast ice sheets extending into sea ice in the north as well as vast glacial ice sheets in the mountain ranges in adjoining areas such as what is today Scotland (Bjerck

2019:2).

Doggerland had vast ice sheets extending into sea ice in the north as well as vast glacial ice sheets in the mountain ranges in adjoining areas such as what is today Scotland. (Bjerck 2019:2) The period in which Doggerland was most heavily affected by sea level change was 13,000 BP and 8,000 BP during the end of the last glacial period (Peeters 2014:56-57) As Doggerland slowly went under the waves the people living there had to find ways to adapt to the changing environment and loss of land.

The sea level rise during this timeframe gradually modified the environment of Doggerland over time, until the entire area was underwater. Some areas were affected far quicker than others which had a more gradual rate of sea level rise (Sturt et al.2013:3968). Part of the sea level rise was due to global warming following the Ice Age. This warming caused the ice caps to melt and the sea water to expand as it warmed. The coast line in the Doggerland area also was affected by the increased runoff from the melting ice sheets of the European continent flowing out to the North Sea via the various major rivers of the areas and the Baltic Sea. The end result is that the area is currently under sixty meters of seawater (Ward et al. 2006:212).

Doggerland Environment

One contributor towards the sea level rise in what would become the North Sea occurred around 8,000

BP when the Storegga Slide caused a massive tsunami over Doggerland and northern central Europe (Gaffney et al. 2020). This large underwater landslide that occurred over an area of roughly three thousand cubic kilometers (Hill et al. 2014:11; Gaffney et al. 2020). This tsunami would have caused waves up to ten meters high in some area with an average height around three meters (Weninger et al. 2008:15). However, while the tsunami would have hit and subsided back into the ocean from rockier and cliffy beaches such as in Scotland and Norway, areas such as Doggerland which was low lying instead would have dealt with long term extensive inland flooding. This flooding would have been especially pronounced around coastal and river bodies where Doggerland peoples would have mainly inhabited this would have had a major impact upon their population (Weninger et al. 2008:14).

One concern that would have been arising during this time would have been a steady reduction in fresh water as it flowed into and stayed in the ocean. The amount of fresh water available would also be reduced as groundwater levels decreased (Crombé 2018:354). Another issue at the time was given the growth of forests over what had been steppe with meandering rivers caused peat to fill the rivers and streambeds (Crombé 2018:353). Many forces and actions may have led to a reduced amount of fresh water being available for the Doggerland peoples and their environment.

Another concern these people would have faced is the occurrence of wildfires (Crombé 2018:359). Pines, especially dead ones, burn well and can cause forest fires to occur much more commonly than they would have in the colder plains and marshes. The rising and more varied temperature would have also caused a higher mortality among the pines in the conifer forests contributing to the wildfire risks (Crombé 2018:359). These forest fires would have posed another environmental concern as the climate degradation that was accompanying it also brought about elements of drought (Crombé 2018:359).

Migration and Adaptation

From contemporary sites in the Netherlands there is

also some indication that the Doggerland people began to change how they created their tools, likely in response to dietary preferences as different prey animals became available. The microliths from the sites begun to change around the same time frame as the sinking of Doggerland (Crombé 2018:356-357). One shift was in how the arrows were produced. The arrows were given barbs of microliths around the end of the points. This may be due to the shift to hunting wild boar as prey instead of red deer and aurochs. The extra barbs on the weapons may have been an adaption to be more lethal and harder to dislodge than the non-barbed points of earlier arrows. Wild boar likely proved to be a far more dangerous game species than red deer or even aurochs, requiring more careful hunting practices and better weapons. There is evidence that they were primary focusing on females and younger adults for prey (Crombé 2018:356). The focusing on females and young adults would have reduced the danger of attempting to hunt full grown adult males, which were bigger more aggressive, and would have had larger tusks.

In evidence from the time period in the Netherlands there was a shift in diet from the earlier diet mainly of deer and aurochs to a diet mainly consisting of boar as the climate and environment shifted from plains and marshy wetlands to more that of pine rich boreal forests (Crombé 2018:356). The deer and aurochs flourished in the grass lands prior to the warming but the new forests seem to have favored wild boar. This is seen somewhat as well from some of the human remains found in the same regions as bones from both aurochs and boar in the seawaters of Dogger bank (Peeters 2014:62). This shift in game animals would have made survival more challenging for the people of Doggerland as wild boar are both more difficult to find in the forest than large herds of deer and aurochs but also more aggressive and dangerous game. During the time as Doggerland was flooding nearby areas such as the Netherlands witnessed an increase in pines and hazels trees (Crombé 2018:356). This is of great significance as it is likely that the people of Doggerland would have shifted their diets to including hazelnut and other nuts as the climate allowed more nut bearing deciduous trees to flourish. There is also indication for site preference along rivers and streams as opposed to other areas.

Another direction of looking where the Doggerland peoples could have adapted while their environment was changing is looking towards the sea for resources instead of further inland (Bjerk 1019:1-2). By looking at how they would use the marine resources as a means of survival is also an important part of the discussion. By looking at sites dated to around the same time and slightly after the flooding of Doggerland in Norway, we can see other ways of adapting towards the sea. By using these archaeological sites as well geographical understanding of how the ice sheets would have looked like at the end of the Holocene ice age, we can see another way the people of Doggerland would have overcome the adversity of climate change. The lifestyle of the Doggerland people appears to have depended on hunting and gathering. However, the Doggerland peoples were highly adaptable and may have also fished, whaled, or sealed to obtain prey (Bjerk 1019:1-2).

The various sites in Norway point towards a concept of fishermen and possible boat usage in this timeframe. These sites that are spread throughout Norway occur on sometimes what would have been rocky islands around the icy ocean and thus would have been impossible to reach by foot, or even by swimming (Bjerk 1019:3). There is a likelihood that the Doggerland peoples may have turned to more marine food sources to replace the lost food sources of the aurochs herds and deer. It is possible that the Doggerland peoples may have practiced fisheries exploitation and boating prior to the melting of the ice sheets given the age of some of the sites in Norway being before the flooding of Doggerland (Bjerk 1019:4). Support for this hypothesis would be the fact that some of the sites found after the Doggerland peoples dispersal into Scandinavia are in regions, that would have been rugged rocky islands at the time of occupation. The inference would be that the Doggerland peoples must have reached these areas by boat and relied on fisheries for their protein. One example to point to of this is the site on Vega Island (Bjerk 2019:4). This island in Norway is a bit off the current coast line and also would have been impossible to get to by foot since it appears to have been an island before the sea level rise.

The ice sheets that covered most of Scandinavia

would have been thawing at the time of Dogger Land flooding and would have contributed to the flooding. However, the melting of the ice sheets would have provided the Doggerland peoples a new area of habitable land as their previous homelands were submerged. The migration to this newly exposed area forced the Doggerland peoples to adapt a new mode of life or to locate regions more similar to their previous homelands, such as going to the Netherlands or Britain. The Doggerland peoples would have the option to push into newly exposed areas without settlements or into the growing forests farther inland, which would likely have already been settled (Crombé 2018:356). In southern Sweden, which would have been connected to Denmark and Doggerland at the time via a land bridge there is human and reindeer remains found in the same sites (Magnell 1999:9). Migration via a land bridge into southern Sweden is another possible way people could have fled the rising sea levels of Doggerland.

One final area of possible relocation for Doggerland peoples is Britain. Given its connection geographically it is logically to see how with the rising sea level the migration of people from Doggerland to what is now Britain occurred as well. Shortly after the complete submerging of Doggerland there is also a population surge within Britain and a rise of farming (Collard 2010). This also seems to correlate with the expansion of agriculture throughout the rest of Central and Northern Europe. As the temperature rose new methods of foods would have become available. There is also a rise in cattle raising throughout Europe at this time (Collard 2010).

Discussion

All of these different areas, the Netherlands, Scandinavia, and Britain, show how varied adaptation to changing situations can be. By adapting to and overcoming the changing climate, rising sea levels, and retreating ice sheets the Doggerland peoples displayed remarkable resilience. The Doggerland peoples must have acquired new skills, practices, and habits to survive in the changing environment at the end of the Holocene. The Doggerland people would also have needed to show remarkable fortitude in exploring new lands and changing their diets and food

sources. These changes for a hunting and gathering to fishing and farming would have been a great challenge. Many years of tradition and hunting tactics would have to be adapted to new game in order to survive. The changing climate and ecosystem meant that gathering vegetable matter for food would be more difficult as well.

How the rising sea levels effected the people of Doggerland shows us people who gradually shifted their eating habits as well as begun to change how they made their tools. While most of the current world does not rely upon hunting and gathering to survive, we too, will have to adapt in some way to the changes that are happening around us. One example is how fishermen experiencing the collapse of cod fisheries in the Newfoundland's Grand Banks turned to the harvesting lobsters and snow crab. (Schrang 2016:406). Much of the present population of the planet lives close to the coastlines of the world and will be inundated if the seas level rise significantly. (Martínez 2007:265) Should the sea level rise be as great as that experienced on Doggerland, sixty meters, then most major cities would be underwater (Martínez 2007:266) Despite the fanciful ideas of skyscrapers sticking out the water marking the location of a major city, it more likely that the force of the waves, tides, and currents would quickly overcome the structural integrity of most buildings. Recognizing the changing climate and ecological concerns is the first step to understanding how to address them as they vary across the world. Though with an understanding that unlike the Doggerland people we do not have many areas of the globe without already existing significant populations.

Conclusion

Overall, what we can learn from Doggerland is how adaptive our species can be at overcoming environmental changes. The dietary change from hunting grazing animals, like red deer and aurochs, to forest living and hunting wild boar is just one example. The different possible locations that they travelled to also show possibilities, as the Doggerland peoples would have been forced to move away to higher ground in what is now the Netherlands, Germany, England, and Scandinavia. Unlike the Dogger Bank

people climate change current industrialization is largely to blame for the present climate change and as we continue to fear what climate change and ecological damage will do to the Earth we live on. we must continue to adapt and find ways to better survive in the changing landscape and world. New climate patterns and sea level rise are problems that current societies must face in the near future. The resilience, adaptability, and perseverance of the Doggerland peoples may be an example of the traits that current societies might need to follow in order to survive and thrive in a challenging new situation. While our seas may not rise sixty feet as the Doggerland people faced, a rise of ten feet or more will also force us to abandon many of our larger cities and seek new lives, lifestyles, and livelihoods farther inland and perhaps farther North and South than we have lived before. Just as the Doggerland peoples had to migrate to new areas exposed by ice sheets, we to may have to relocate to areas of Greenland, Antarctica, and other areas now covered by ice sheets. Just as the Doggerland people before us, societies around the world must face the challenges and opportunities of a changing climate and rising sea levels. Many of the challenges are the same from sea level rise, salt water intrusion and forced migration, and we need to face these challenges with resilience and adaptability. Regardless of what path we choose we must face the challenges and opportunities presented to us by the currently changing climate.

References Cited

- BANG-ANDERSEN, S. 2012 "COLONIZING CONTRASTING LANDSCAPES. THE PIONEER COAST SETTLEMENT AND INLAND UTILIZATION IN SOUTHERN NORWAY 10.000-9500 YEARS BEFORE PRESENT" *OXFORD JOURNAL OF ARCHAEOLOGY*, 31 (2):103-120
- BJERCK, HEIN B. 2019 "WHAT COULD THE 'SEA ICE MACHINE' DO TO ITS PEOPLE? ON LATEGLACIAL DOGGERLAND, MARINE FORAGING, AND THE COLONISATION OF SCANDINAVIAN SEASCAPES." *ENVIRONMENTAL ARCHAEOLOGY: THE JOURNAL OF HUMAN PALAEOECOLOGY*: 1-13.
- COLLARD, MARK, EDINBOROUGH, KEVAN, SHENNAN, STEPHEN MARK G. THOMAS, 2010 "RADIOCARBON EVIDENCE INDICATES THAT MIGRANTS INTRODUCED FARMING TO BRITAIN," *JOURNAL OF ARCHAEOLOGICAL SCIENCE*, VOLUME 37(4): 866-870
- CROMBÉ, PHILIPPE. 2018 "ABRUPT COOLING EVENTS DURING THE EARLY HOLOCENE AND THEIR POTENTIAL IMPACT ON THE

ENVIRONMENT AND HUMAN BEHAVIOUR ALONG THE SOUTHERN NORTH SEA BASIN (NW EUROPE): EARLY HOLOCENE COOLING IN THE SOUTHERN NORTH SEA BASIN." *JOURNAL OF QUATERNARY SCIENCE* 33(3): 353–367.

GAFFNEY V, FITCH S, BATES M, WARE RL, KINNAIRD T, GEAREY B, HILL T, TELFORD R, BATT C, STERN B, WHITTAKER J, DAVIES S, SHARADA MB, EVERETT R, CRIBDON R, KISTLER L, HARRIS S, KEARNEY K, WALKER J, MURU M, HAMILTON D, LAW M, FINLAY A, BATES R, ALLABY RG. 2020 "MULTI-PROXY CHARACTERISATION OF THE STOREGGA TSUNAMI AND ITS IMPACT ON THE EARLY HOLOCENE LANDSCAPES OF THE SOUTHERN NORTH SEA." *GEOSCIENCES* 10 (7):270.

HUGHES, A. L. C., GYLLENCREUTZ, R., LOHNE, Ø. S., MANGERUD, J., SVENDSEN, J. I. 2016 (JANUARY): THE LAST EURASIAN ICE SHEETS – A CHRONOLOGICAL DATABASE AND TIME-SLICE RECONSTRUCTION, DATED-1. *BOREAS* 45: 1–45.

HILL, JON, S. COLLINS, GARETH, AVDIS, ALEXANDROS, C. KRAMER, STEPHAN, D. PIGGOTT, MATTHEW. 2014 "HOW DOES MULTISCALE MODELLING AND INCLUSION OF REALISTIC PALAEOBATHYMETRY AFFECT NUMERICAL SIMULATION OF THE STOREGGA SLIDE TSUNAMI?" *OCEAN MODELLING* 83, PP. 11-25

MAGNELL, OLA, LILJEGREN, RONNIE, EKSTRÖM, JONAS 1999 "HÄSSLEBERGA – A LATE PALAEOLITHIC KILL SITE IN SCANIA, SWEDEN, CONFIRMED BY ANALYSIS OF BONE MODIFICATIONS" *LUND ARCHAEOLOGICAL REVIEW* 5:5-19

MARTÍNEZ, M.L ET AL. 2007 "THE COASTS OF OUR WORLD: ECOLOGICAL, ECONOMIC AND SOCIAL IMPORTANCE." *ECOLOGICAL ECONOMICS* 63.2 254–272.

PEETERS, J.H.M, AND G. MOMBER. 2014. "THE SOUTHERN NORTH SEA AND THE HUMAN OCCUPATION OF NORTHWEST EUROPE AFTER THE LAST GLACIAL MAXIMUM." *GEOLOGIE EN MIJNBOUW* 93(1-2): 55–70.

SCHRANK, WILLIAM E, AND NOEL ROY. 2013. "THE NEWFOUNDLAND FISHERY AND ECONOMY TWENTY YEARS AFTER THE NORTHERN COD MORATORIUM." *MARINE RESOURCE ECONOMICS* 28.4 397–413.

STURT, FRASER, DUNCAN GARROW, AND SARAH BRADLEY. 2013. "NEW MODELS OF NORTH WEST EUROPEAN HOLOCENE PALAEOGEOGRAPHY AND INUNDATION." *JOURNAL OF ARCHAEOLOGICAL SCIENCE* 40(11): 3963–3976.

WARD, INGRID, PIERS LARCOMBE, AND MALCOLM LILLIE. 2006. "THE DATING OF DOGGERLAND - POST-GLACIAL GEOCHRONOLOGY OF THE SOUTHERN NORTH SEA." *ENVIRONMENTAL ARCHAEOLOGY* 11(2): 207–218.

WENINGER, B., R. SCHULTING, M. BRADTMÖLLER, L. CLARE, M. COLLARD, K. EDINBOROUGH, J. HILPERT, O. JÖRIS, M. NIEKUS, E.J. ROHLING, B. WAGNER 2008 "THE CATASTROPHIC FINAL FLOODING OF DOGGERLAND BY THE STOREGGA SLIDE TSUNAMI" *DOCUMENTA PREHISTORICA* XXXV: 1-24.

CHAPTER 6

Climate Influenced Migration and Resulting Necroviolence at the U.S.—Mexico Border

Sarah T. Schwing

Keywords: migration, environmental refugees, U.S.-Mexico border, necroviolence

Abstract. Environmental refugees are increasing in number as the effects of climate change are increasingly felt across the globe. Although climate change is a global phenomenon, its damaging effects are local and multifaceted, ranging from environmental degradation to poor water quality, air pollution, to harmful impacts on human health. A small body of literature has focused on the impacts of changing climatic conditions in various regions of Mexico and the associated impacts on immigration into the United States. Researchers have found that deleterious environmental effects in Mexico, particularly inadequate or excess rainfall, are frequently linked to spikes in emigration from Mexico to the U.S. Recent scholarship suggests that such environmentally spurred migration consistently lags behind environmental events by approximately 2-4 years, a finding which several scholars attribute to (in)availability of resources. As climate changes are projected to become more severe in the coming decades, scholars predict significant increases in migration at the U.S-Mexico border, a phenomenon compounding current migration issues at an already highly politicized and militarized border zone, likely resulting in increased migrant deaths, unidentified migrant remains, and necroviolence met by the dead and the survived in this region.

Introduction

Over the past several decades, undocumented migration across the world has risen dramatically. Movement of undocumented migrants has taken on many forms, from navigating the bowels of the

Sonoran Desert at the height of summer, to traversing the Mediterranean Sea in makeshift rubber dinghies during its perilous winter months, as migrants increasingly sign over their lives and family savings to human smugglers (coyotes), seeking life and the right to live in European and North American countries.

Among undocumented migrants are those seeking economic opportunities to support families left behind, political and religious refugees seeking asylum from oppression, genocide, and persecution, as well as environmental refugees, populations leaving their homelands due to an inability to secure a sustainable livelihood (Myers 2001, 609). Myers specifically describes environmental refugees as those displaced by such environmental conditions as drought, soil erosion, desertification, deforestation, lack of agricultural land, and other environmental issues, either within or outside of their homecountry (2001, 609). In the case of environmental refugees, environmental push factors of one's homecountry tend to surpass economic pull factors in destination countries, though the two often coincide (Myers 2001). Social capital in the form of migrant networks, or strong histories of migration, have been found to be influential in the movement of migrants facing environmental challenges due to climate change, specifically between Mexico and the U.S. Further, migration at this border has risen for myriad reasons, as have migrant deaths and enforcement strategies meant to preclude such undocumented border crossings.

Over the course of the past thirty years, alongside increases in undocumented migration at the U.S-

Mexico border, border control regimes have become increasingly militarized (De Leon 2015; Spijkerboer 2013). These strategical shifts refer to the onset of policy shifts inaugurated in 1993 by border patrol agent Silvestre Reyes' "Operation Blockade," implemented at the southern U.S border between El Paso and Ciudad Juarez (De Leon 2015, 30). These tactical shifts, termed deterrence displacement, sought to combat illegal undocumented migration from Mexico by making the process of crossing the border more challenging, and intentionally funneling migrants into the destitute lands of the Sonoran Desert, increasing the chances of migrant death (De Leon 2015; Rubio-Goldsmith et al. 2016). Operation Blockade and similar border control policies implemented shortly thereafter, increased the violence met by migrants - in the form of externalized borders, which force migrants to travel more perilous routes, internalized borders, which encompass the violence used to manage migrants after capture and during detainment and return processes, and violence that ensues even in migrant death.

The process of undocumented migration often results in individuals being left behind. Many enter the Sonoran Desert but not as many make it out. The remains of undocumented crossers left behind have become greater in number through time but are infrequently recovered by border patrol. Rather, the remains of those left behind are left to the agents of the desert, left to be minimized, scattered, and ultimately dissipated by what Jason De Leon terms the "hybrid collectif" (2015, 39). The sun and heat, the flies and dermestid beetles, mammalian and avian scavengers, rodents, and wind comprise the agents acting upon human remains left in the desert and De Leon's *hybrid collectif*, a collective of non-human agents acting to disappear the undocumented under the will of U.S border policies (2015). In his book, *The Land of Open Graves: Living and Dying on the Migrant Trail*, De Leon coins this complex system of violence – that performed knowingly by border patrol and U.S policy makers, met by deceased migrants, and that felt by families left to guess the fate of their loved ones - "necroviolence," and describes it as a corporeal mistreatment, "a violence performed and produced through specific treatment of [migrant] corpses that is perceived to be offensive" (2015, 69).

With increases in migration and increasingly militarized border zones, migrant deaths have significantly increased (De Leon 2015; Spijkerboer 2013). The Binational Migration Institute (BMI) at the University of Arizona's Mexican American Studies and Research Center (MASRC) reported, in a study looking at undocumented migration at the U.S-Mexico border between 1990 and 2005, that undocumented border crosser deaths increased 20-fold, from an annual case load of nine prior to 1990 to a case load of 201 by year 2005 (Rubio-Goldsmith et al. 2016). This, however, is a gross underestimate of the true number of deaths occurring in the region, as this number only refers to those found and recovered. As undocumented border crossers are not, as yet, citizens of their destination countries, innumerable bodies go unidentified and unrecovered in crossing zones. Swallowed by the unrelenting waters of the Mediterranean Sea or dissipated by the collective agents of the Sonoran Desert (e.g. sun, insects, scavengers, wind) (De Leon 2015), these individuals are frequently ignored and forgotten by the countries so ardently working to lock them out. Unauthorized migration, as Conley (2020) notes, is not an autonomous process, however, it does not exist in a vacuum free of external influences. Rather, causal factors are political, socioeconomic, and environmental in nature and act to push migrants out of their home countries, while the prospects of increased wages and economic opportunities pull them into the U.S., Canada, and European countries.

In recent decades, increasing numbers of migrants have been impacted by the environmental effects of climate change and its broad ranging impacts, and are turning to undocumented migration as both temporary and permanent adaptations to support their families (Hunter et al. 2014). Myers (2001) reports that Sub-Saharan Africa accounts for the largest proportion of the world's environmental refugees, although China, Mexico, and India also account for large quantities of this population.

Recent, though limited, scholarship demonstrates that environmental degradation is playing an increasing role in the movement of undocumented migrants from Mexico - a trend that is predicted to continue in the coming decades as climate change is predicted to

become more negatively impactful (Feng et al. 2010). Feng et al. look specifically at the relationship between climate change, (reduction in) crop yield, and migration patterns at the U.S-Mexico border (2010). Mexico, like numerous 'developing countries,' relies heavily upon agricultural production and may experience long-term population shifts as a result of broad geographical climatic changes (Feng et al. 2010). Looking specifically at corn and wheat production, two of the most cultivated crops in Mexico, Feng et al. indicate that for every 10 percent reduction in crop yield, emigration is expected to increase by 2 percent, and predict an increase of 1.4-6.7 million Mexican migrant adults by the year 2080 (2010).

Puente et al. (2015) write similarly of the correlation between rainfall and migration at the U.S-Mexico border, focusing on periods of drought and excess rain. Using monthly rainfall data at the *municipio* level from the Mexican Migration Project (MMP), they report that periods of drought, periods characterized by rainfall averages one to two standard deviations below historical averages, correlate with increases in emigration from Mexico to the U.S, though this migration consistently lags by a period of two to four years (Puente et al. 2015). This pattern of increased emigration, however, is largely constrained to regions with strong histories of migration to the U.S, thus strong migrant networks, as those without may be unable to mobilize the resources necessary to send a relative even two to four years later. Puente et al. (2015) also report that excessive rainfall, rainfall one or two standard deviations greater than historical averages, correlates with decreased migration. This suggests that increased rainfall mitigates the need to migrate to the U.S for economic opportunities, as the increased harvest produced allows for increased self-consumption, as well as income from selling portions of the harvest.

Pugatch and Yang (2010) also investigate the impact of rainfall on migration, proposing a model that estimates the impact of below average rainfall on emigration to the U.S for various Mexican states. Their findings suggest heightened migration from Mexico to the U.S approximately two to four years after significant state-wide below-average rainfall in a given Mexican state. As similarly discussed by Puente et al.

(2015), this pattern may emerge from the unavailability of fiscal resources needed to make such a trip. Puente et al. (2015) also found a greater likelihood for emigration following periods of drought from *municipios* with greater histories of migration and stronger migrant networks. This notion is also supported by Hunter et al. (2014), who found that emigration from Mexican households with recent drought histories is much less likely than emigration from households in areas with less recent drought histories (e.g. two or more years). Both Pugatch and Yang (2010) and Hunter et al. (2014) write that such environmentally spurred migration most frequently increases for migrants associated with solidified migrant networks in the U.S and increases especially for those from rural regions, as they rely more heavily on agricultural production. The same pattern is not observed for migrants lacking social capital in the form of migration networks, however, a phenomenon Hunter et al. (2014) attribute to weaker migration histories and, thus, a lack of transnational and social capital from the U.S.

Looking at correlations between rainfall and U.S-bound emigration, Hunter et al. (2014) found that, following periods of drought, emigration from Mexico lagged by approximately 2 years, followed by significant increases in migration. This finding, however, was restricted to regions with strong histories of migration to the U.S (Hunter et al. 2014). For regions without pre-existing migration ties, rainfall deficits were seen to constrain migration by more than 2 years, due to greater insecurity and risk associated with these regions (Hunter et al. 2014). Additionally, correlations were found between periods of excess rainfall and decreased emigration for regions with migration ties, as this increased natural capital and mitigated the need for individuals to migrate. For regions lacking strong migration histories, periods of excess rainfall were, conversely, found to increase the likelihood of migration, as this increased 'environmental' or 'natural capital' allowed families to mobilize greater resources to facilitate emigration to the U.S (Hunter et al. 2014, 896). Furthermore, Hunter et al. (2014) describe that projected atmospheric warming for Latin America is in the range of 1 to 6 °C and is likely to result in increased experiences of "water stress," an occurrence that may be particularly challenging for regions that rely on

agriculture production (e.g. rural regions) (2014, 897). They suggest large implications of these climate changes, specifically a hindrance in coffee production in Veracruz, Mexico's most valuable export, by up to 34 percent, resulting in complete loss of rural Mexico's economic reliance on this crop (Hunter et al. 2014) and contributing to continued economic instability and migration among rural Mexican households.

Research on changing climatic conditions and correlations between decreased rainfall, crop-failure, and emigration from Mexico to the U.S is not extensive (Hunter et al. 2014; Puente et al. 2015), suggesting that patterns of environmental refugees at this border have not been thoroughly explored. Hunter et al. (2014) note that migration networks and sending regions may change as climate stress is felt in different regions across Mexico, both in regions with strong historical migration ties and in those without. Further, they note that emerging scholarship is incorporating migration theory to better inform future predictions of emigration from Mexico and to better understand whether these patterns are merely temporary adaptation strategies and how this will impact economic opportunities for immigrants in the U.S (Hunter et al. 2014, 898).

It is apparent that climate alone does not predict migration, but that numerous factors are at play including available resources (natural and environmental capital), opportunities in desired destinations, and social and transnational capital in the form of existing migrant networks (Hunter et al. 2014; Puente et al. 2015). Further contributing to facilitation or constraint of emigration, however, is the type of environmental vulnerability experienced (Hunter et al. 2014). Hunter et al. (2014) write that flooding and crop failure are among the environmental changes propelling migration, particularly amongst women and children, and will be brought on by increased frequency of severe, short-term weather conditions, like hurricanes, and less acute but prolonged periods of drought and excess rainfall.

In the face of changing and increasingly difficult environmental conditions, the perseverance of undocumented migrants and the cyclical nature of militant border control efforts remain in effect at this

border. Continued environmentally forced migration suggests continued crossing attempts over dangerous terrain, an increase in fatalities, and an increase in unidentified and unrecovered bodies of undocumented migrants. According to the BMI at the University of Arizona's MASRC, over one-fourth of the 927 migrant remains recovered between 1990 and 2005, went unidentified (Rubio-Goldsmith et al. 2016). Although identification and repatriation efforts through various agencies, non-profit organizations, and medical examiner's offices have increased since this time period, the same cannot be said of death and necroviolence mitigation efforts at this border. The BMI cited the primary cause of increased deaths found during this study as heat induced strokes, citing a statistically significant increase in the death toll due to heat stroke and a decrease in deaths caused by other factors (Rubio-Goldsmith et al. 2016). Further, it was found that women are far more likely to die of heat strokes than men, a factor compounding Hunter et al.'s (2014) findings that, in many instances, climate change mobilizes more women and children as environmental refugees due to inaccessibility of agricultural land for this population (877). The BMI also reported increased numbers of migrant remains of central and southern Mexican individuals recovered from the border between 1990 and 2005, while numbers of migrants from northern Mexico decreased (Rubio-Goldsmith et al. 2006); this finding suggests greater movement of environmental refugees from central and southern Mexico as these regions are characterized by more rural landscapes.

As migrant deaths at this border remain high and identification processes remain lengthy and costly, the process of necroviolence is likely to continue. As scholars predict increases in the flow of climate-induced migration, identification efforts will face further challenges and resource constraints, as remains cannot be identified without space, time, resources, and recovery efforts needed for positive identifications and repatriation.

Conclusion

Environmental refugees and migrants deserve basic human rights and access to opportunities to support their families. As poignantly conveyed by De Leon

(2015) and Villagran (2018), humans, even in death, retain the right to dignity, to not be treated degradingly or inhumanely, and, fundamentally, the right to identity. Efforts at recovery and identification must be improved and should be followed by an extensive and intensive scrutiny of immigration policies, and the inhumane conditions upheld by such policies. Governmental aid for those looking to maintain agricultural lifestyles in Mexico may also help to mitigate the necessity of international migration, by allowing farmers to maintain secure income and resources in Mexico (Oppenheimer 2020). The ultimate goal of slowing or reducing global climate change should also be considered when devising new policies, as such efforts may also help to mitigate the necessity of migration (Oppenheimer 2020).

References

- CONLEY, MEGAN. 2020. IMMIGRANT RIGHTS IN THE NUEVO SOUTH: ENFORCEMENT AND RESISTANCE AT THE BORDERLANDS OF ILLEGALITY. PHILADELPHIA: TEMPLE UNIVERSITY PRESS.
- DE LEÓN, JASON. 2015. THE LAND OF OPEN GRAVES: LIVING AND DYING ON THE MIGRANT TRAIL. OAKLAND, CA: UNIVERSITY OF CALIFORNIA PRESS.
- FENG, SHUAIZHANG, KRUEGER, ALAN, AND OPPENHEIMER, MICHAEL. 2010. LINKAGES AMONG CLIMATE CHANGE, CROP YIELDS AND MEXICO-US CROSS-BORDER MIGRATION. PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 107(32): 14257-14262. DOI:10.1073/PNAS.1002632107
- HUNTER, LORI, MURRAY, SHEENA, AND RIOSMENA, FERNANDO. 2013. RAINFALL PATTERNS AND U.S. MIGRATION FROM RURAL MEXICO. INTERNATIONAL MIGRATION REVIEW 47(4): 874-909. DOI:10.1111/IMRE.12051
- OPPENHEIMER, MICHAEL. 2020. THE YEARS PROJECT: REFUGEES ARE FLEEING CLIMATE CHANGE. YOUTUBE.
- PUNTE, GERONIMO, PEREZ, FRANCISCO, AND GITTER, ROBERT. 2016. THE EFFECT OF RAINFALL ON MIGRATION FROM MEXICO TO THE UNITED STATES. INTERNATIONAL MIGRATION REVIEW 50(4): 890-909. DOI:10.1111/IMRE.12116
- PUGACH, TODD, AND YANG, DEAN. 2010. THE IMPACT OF MEXICAN IMMIGRATION ON UNITED STATES NATIVES: EVIDENCE FROM MIGRATION FLOWS DRIVEN BY RAINFALL SHOCKS.
- RUBIO-GOLDSMITH, RAQUEL, MELISSA MCCORMICK, DANIEL MARTINEZ, AND INEZ DUARTE 2006. THE 'FUNNEL EFFECT' & RECOVERED BODIES OF UNAUTHORIZED MIGRANTS PROCESSED BY THE PIMA COUNTY OFFICE OF THE MEDICAL EXAMINER, 1990-2005. SSRN ELECTRONIC JOURNAL.
- SPIJKERBOER, THOMAS. 2013. MOVING MIGRANTS, STATES, AND
- RIGHTS HUMAN RIGHTS AND BORDER DEATHS. THE LAW & ETHICS OF HUMAN RIGHTS 7(2): 213-242. DOI:10.1515/LEHR-2013-0009
- VILLAGRAN, OTTAVIA. 2018. IDENTIFYING MIGRANT BODIES IN THE MEDITERRANEAN. MIGRATION, SOCIAL INCLUSION, AND PEACEFUL SOCIETIES (2): 5TH SER., 1-24.

CHAPTER 7

Katrina: Climate Change, Response, Displacement, and Forensics

Hadley Allison, Jarrett Burgess, Bryn Rose Dalrymple, Destiny Dismore, & Hannah Leso

Keywords: Hurricane Katrina, Forensic Science

Abstract. Hurricane Katrina was a natural disaster that struck New Orleans in 2005 and showed the increasing hazards of storms and natural phenomena in the context of global climate change. As climate changes, the patterns of weather and severity become exponentially more difficult to measure and prepare for. The storm showed how unprepared the city was to structurally withstand a disaster and divulged the inadequacy of government funded relief. Many private entities were contracted to help with the various issues of disaster relief, one of these being body identification in order to count victims, bring closure to families, and to replace bodies exhumed by the storm.

Natural Disaster Patterns and the Effects of Climate Change

A natural disaster is defined by the US Department of Homeland Security (DHS) as, “All types of severe weather, which have the potential to pose a significant threat to human health and safety, property, critical infrastructure, and homeland security” (DHS 2018). Natural disasters can include fires, earthquakes, hurricanes, mudslides, etc. We have evidence that shows the number of worldwide reported natural disasters has increased exponentially over the last half century where in 1947 there were 12 reported disasters and in 2019 there were 350 reported events. The year that had the highest number of natural disasters reported was 2005 (Ritchie and Roser 2014). This year is especially significant for the United States because this is the year that Hurricane Katrina impacted the Gulf Coast, killing over 1800 people,

causing roughly \$125 billion in damages, and displacing hundreds of thousands of people. Those of us that were alive to see the events unfold saw homes underwater, mausoleums and graves exhumed due to the flooding, as well as the Superdome (where the New Orleans Saints hold their football games) used as an emergency shelter for displaced people (Burnett 2015).

Looking at years after Katrina, we can see periods where there continued to be greater disasters that have caused more damage and killed more individuals in the US. For example, in 2017 the US was hit by 3 separate hurricanes (Maria, Irma, & Harvey) that combined killed hundreds of people and cost over \$200 billion (Fritz 2019).

There is current scientific evidence to support the fact that climate change is affecting natural disasters, for example a study performed in 2005 states, “The environmental changes that are under way favor enhanced convection and thus more thunderstorms.” (Trenberth 2005). Additionally, there has been a report showing the number of hurricanes reaching category 4 or 5 has increased from 1970 to 2004 as well as an increase in sea surface temperatures over the same time span (Webster et al. 2005)

However, it is important to note that it is not the only factor. For example, we can track the climate in a region where an event such as a wildfire or a hurricane occurred but other factors such as human preparedness & intervention are also going to play a

key role in the severity of the disaster. The data from the scientific community shows that the weather is in fact changing and the average global temperature is in fact rising. 19 of the 20 warmest years have all occurred since 2001 (NASA 2020) and 9 of the 10 warmest years have occurred since 2005 (NOAA 2020). A recent article published in the Proceedings of the National Academy of Sciences this year (Kossin et al. 2020) shows evidence that tropical cyclones are occurring more frequently and with greater severity as tropic temperatures are warming.

With the idea held for many years that climate change is affecting natural disasters, we are able to use new research and data to support this claim. Trenberth says, “once a tropical storm has formed, the changing environmental conditions provide more energy to fuel the storm, which suggests that it will be more intense than it would otherwise have been, and that it will be associated with heavier rainfalls” (Trenberth 2005). We can use this knowledge to look back on historic events such as Hurricane Katrina to see that the severity of this storm and others like it were due in part to climate change.

Local or State Response and Impacts of Hurricane Katrina

Hurricane Katrina expanded across three states, but in “Louisiana alone, approximately 1.7 million people were affected” (Institute of Medicine 2007:2). The effect the storm had on the state, as a whole, as well as the densely populated city of New Orleans was a traumatic experience for the citizens, the local government, and the environment in the city. The state of Louisiana evacuated approximately 1.5 million people before the hurricane made landfall; however, many remained during the storm for a variety of reasons with some staying on purpose and some staying due to not having the opportunity to evacuate as resource availability was low. The state worked to aid its citizens by setting up shelters for those with special needs as well as a general hotspot – the Superdome (Institute of Medicine, 2007; Gerhart 2005). While these actions were a positive aspect of the disaster response, the lack of resources and supplies was still a critical failure in planning for those unable to evacuate. In the Superdome alone, it

typically took days to receive supplies, and those that were received were sparse in amount. Due to supplies being infrequently received, it shows how little government workers and first responders were prepared for the true impact Hurricane Katrina had on residents (Edwards 2015; Institute of Medicine 2007). Many of the residents and reporters alike deemed the situation “hell” (Pao 2015), with the conditions being less than ideal – food was low or completely gone, water was limited, the bathroom situation had failed and no matter where you went you stepped in excrement – the situation ceased to get better and many questioned how they were supposed to go on as a community, or a people (Gerhart 2005).

The local government's actions and response were vital to the protection of their community, but even with their promises of continued evacuation, the government's response was lacking at all levels. State and local governments are much better in their responses to handle most natural disasters: “first responders and their assets are mainly owned and managed locally” (Edwards 2015), showing they can quickly and easily handle disasters, but with the federal government's hesitation in their involvement, response became delayed resulting in a lack of leadership by many state figures (Pao 2015). The Louisiana government announced plans to evacuate the Superdome and move the refugees elsewhere, to a safer area, but the plans never went through, showing how erratic communication had been across the board for government aid (Gerhart 2005). Communication had been inconsistent throughout New Orleans, but the continued lack of urgency seen by the citizens from the government showed how there was no real plan for what had occurred (Gerhart 2005)

The government's lack of response fueled situations in New Orleans that continued creating a bad environment to be in or go back to. Obvious concerns persisted for citizens to return to New Orleans too soon included:

The quality of municipal and community water, the quality of food establishments and whether food supply was contaminated or spoiled, the actions of waste disposal, wastewater treatment systems to be rebuilt and reconfigured, and just [having] regularly

living or recreational activities (Institute of Medicine 2007: 17-18).

Risk communication was vital for those who wanted to go back to their homes and rebuild what they could. People wanted to go back to a sense of normalcy, a chance to move on with their lives, but if the environment was not brought back to a livable standard there was no way for them to seize that opportunity.

Displaced Graves and Their Identification

During Hurricane Katrina, coffins, vaults, and tombs were uprooted from the ground and moved across the landscape due to the mass flooding and high winds. This, in turn, caused a mass of unidentified bodies from those who had been previously deceased to be exposed. The fact that coffins do not tend to display the name of the deceased only added to the difficulty of identification. Another issue that would be prevalent in cases that involve the long dead like this is that antemortem records may not be available to aid in the identification, whereas they more likely would be in mass fatality incidents that occur in modern days (Steadman 2009: 282). An official had stated that at least 137 sets of remains were disinterred from their graves, 80 of which were still in their coffins (Koppel 2005). In another article from a later date, the reporter states that more than 1,500 graves were uprooted, so it seems the number grew dramatically as time went on and more coffins or disinterred deceased were discovered. The article also states that, while on the way to recover one coffin, Councilman Mudge along with friends and coworkers would drive by many more, and there are plenty of pictures that show this fact (Elliott 2006). Coffins were found daily, even in trees. The Disaster Mortuary Operational Response Team, or DMORT for short, is a subsection of FEMA, the Federal Emergency Response Agency, and it works to identify the deceased after disasters, setting up temporary morgues and working to make sure the remains of the victims of the disaster go back to their families. A spokesman for the DMORT stated in reference to the coffins that, "Many are in extremely remote and inaccessible areas. They have been carried way downrange into muck and swamp and forest" (Koppel 2005). This leads to the thought that

there may be some remains still yet to be found even now and that the remains themselves have been separated and displaced into different areas, potentially to never be recovered. Although much of the identification was difficult, identifying some of the displaced remains was not, as some coffins were built so that they contained burial scrolls that included the name of the dead inside of the coffin. However, there were few that contained these scrolls. Coffins could also be traced by the manufacturer's serial numbers they contained, which aided in identifying the deceased. Other remains could be identified by the type of medical devices they had (the device's serial number was also a help in these cases), the evidence of fractures from X-rays, or evidence of medical procedures or medical conditions they were known to have (Koppel 2005). Things under these categories would include dental fillings, surgical implants, and old injuries visible on the bone or under X-ray. During all of this, forensic anthropologists would have to work with many other professions like dentists, pathologists, and fingerprint examiners to name a few, which is crucial for an identification (Steadman 2009: 281). Area maps of cemeteries were also used in order to try to identify the deceased. In cases of embalming, some could be identified visually. In other cases, DNA matching was vital in identifying the deceased (Koppel 2005). Steadman (2009) has argued that during disaster management, one should "speak with family members concerning methods of identification", in response to another case of flooded graveyards with disinterred bodies (281).

Government Response, and the Identification of Victims

Hurricane Katrina was a catastrophic event, and as such, the Government stepped in, sending out FEMA. FEMA helped by giving people \$2,500 to rebuild their homes, along with the infamous trailers for people to reside in while that was happening (Adams 2013: 25). They were infamous because in order to receive a trailer, one must have access to property to put it on, leading many to have to move to trailer lots, which Adams refers to as "the modern equivalent of relocation camps" (Adams 2013: 40) complete with National Guardsmen posted at the entrances. Beginning in 2009, however, FEMA started demanding

\$25,000 for the trailers or they would be taken away, which was money that many did not have, making the situation even worse for them. Those trailers, which FEMA had paid subcontractors around \$229,000 for each one, were some of the only places people had left, and most people that were affected felt that if they had received that much instead of a trailer that they would be back in their homes by that time (Adams 2013:32). The trailers were a symptom of FEMA merging with the Department of Homeland Security. This had just happened, which led to subcontracting, which led to companies such as ICF being put in charge of programs such as the Road Home Program, which was said to help people get funds to rebuild their homes. Unfortunately, the bureaucracy involved caused many to not be able to receive aid, and an estimated 870 families were still in their FEMA trailers even five years later (Adams 2013:25, 31). A DMORT, again one of the subsections of FEMA, made a base of operation in an abandoned school where the DMORT workers also had to live for two weeks (Needell and Kruse-Feldstein 2006). There, they worked to process the bodies of the victims being brought into both identify the cause of death and identify the victims themselves. The team used the usual techniques for identifying the recently deceased, which are similar to the methods used to identify the disinterred that were described above with fingerprint analysis added in. The autopsies were performed by the New Orleans medical examiner staff (Needell and Kruse-Feldstein 2006). A Family Assistance Center (FAC) was also established to help identify the dead as direct DNA identification could not work in some instances due to the flooding ruining reference samples (Dolan 2009). The FAC had 88 genetics professionals volunteer to help contact families with missing family members in order to try to gain family reference samples. This helped to do kinship analysis on the DNA recovered from the hurricane victims. This helped reduce the number of reported missing people related to the hurricane from approximately 13,000 to roughly 150 people in a little over a year when the FAC ended DNA operations (Dolan 2009)

Conclusion

The effects of Hurricane Katrina are still felt to this day as cities like New Orleans and others in the Gulf Coast

still show signs of damage fifteen years later. This reflects the lack of attention and aid these cities and areas received during and after the disaster. Not only was the initial response lacking and late, but support for post-disaster rebuilding also left many people homeless and without places to go to and cost many people their lives. The severity of disasters may be influenced directly from climate change, as the frequency for wildfires and hurricanes have increased in the last twenty years in tandem with the increased change in the global climate. But the lack of response and preparedness compounds the devastations of these events leading to an increase of avoidable destruction and loss of life if the proper systems were implemented. Not only did the physical damage take its toll but also families who lost members during Katrina leaves an emotional scar as loved ones were lost and the remains from past relatives lost in the flooding. However, with the aid of forensic science and DNA testing, members of the community were able to receive closure as their family members were properly identified. With the changing climate being the catalyst for such events, humans must recognize their role in the premature changing of the global climate and must reflect on the ways in which interactions and uses of the environment take place. Not only must humans rethink the way they interact with the environment in the context of a changing climate, but Katrina proved the necessity for having proper disaster relief systems in place and the importance of post disaster relief. With the increased frequency of natural disasters due to the changing climate, the importance of such systems is stressed in hopes that when disasters of this magnitude happen again, the people in charge of giving aid to those who need will be held to a higher standard and sense of urgency.

References

ADAMS, VINCANNE. 2013. *MARKETS OF SORROW, LABORS OF FAITH: NEW ORLEANS IN THE WAKE OF KATRINA*. DURHAM AND LONDON: DUKE UNIVERSITY PRESS, 2013.

BURNETT, JOHN. "AT A SHELTER OF LAST RESORT, DECENCY PREVAILED OVER DEPRAVITY." NPR. AUGUST 25, 2015. <https://www.npr.org/2015/08/25/431909047/at-a-shelter-of-last-resort-decency-prevalled-over-depravity>. (ACCESSED 25 NOVEMBER 2020)

DHS (DEPARTMENT OF HOMELAND SECURITY) 2020, WWW.DHS.GOV/NATURAL-DISASTERS. (ACCESSED 7 NOVEMBER 2020)

DOLAN, SARAIYA. 2009. "THE EMERGING ROLE OF GENETICS PROFESSIONALS IN FORENSIC KINSHIP DNA IDENTIFICATION AFTER A MASS FATALITY: LESSONS LEARNED FROM HURRICANE KATRINA VOLUNTEERS." *GENETICS IN MEDICINE* 11(6):414-417. SPRINGER SCIENCE AND BUSINESS MEDIA LLC, MAY 2009 DOI:10.1097/GIM.0b013e3181a16ccc.

EDWARDS, CHRIS. (2015, AUGUST 27). HURRICANE KATRINA: REMEMBERING THE FEDERAL FAILURES. CATO INSTITUTE. [HTTPS://WWW.CATO.ORG/BLOG/HURRICANE-KATRINA-REMEMBERING-FEDERAL-FAILURES](https://www.cato.org/blog/hurricane-katrina-remembering-federal-failures)

ELLIOTT, DEBBIE, AND AUDIE CORNISH. 2006. "FLOODS DIDN'T SPARE NEW ORLEANS GRAVEYARDS".

NATIONAL PUBLIC RADIO. 28 JAN. 2006.

FRITZ, ANGELA. "HURRICANES HARVEY, IRMA, MARIA AND NATE WERE SO DESTRUCTIVE, THEIR NAMES HAVE BEEN RETIRED." *THE WASHINGTON POST*. APRIL 24, 2019. [HTTPS://WWW.WASHINGTONPOST.COM/NEWS/CAPITAL-WEATHER-GANG/WP/2018/04/12/HURRICANES-HARVEY-IRMA-MARIA-AND-NATE-WERE-SO-DESTRUCTIVE-THEIR-NAMES-HAVE-BEEN-RETIRED/](https://www.washingtonpost.com/news/capital-weather-gang/wp/2018/04/12/hurricanes-harvey-irma-maria-and-nate-were-so-destructive-their-names-have-been-retired/). (ACCESSED 25 NOVEMBER 2020)

GERHART, ANN. (2005, AUGUST 31). 'AND NOW WE ARE IN HELL'. *THE WASHINGTON POST*. [HTTPS://WWW.WASHINGTONPOST.COM/WP-DYN/CONTENT/ARTICLE/2005/08/31/AR2005083102801_2.HTML](https://www.washingtonpost.com/wp-dyn/content/article/2005/08/31/AR2005083102801_2.html)

INSTITUTE OF MEDICINE. 2007. ENVIRONMENTAL PUBLIC HEALTH IMPACTS OF DISASTERS: HURRICANE KATRINA: WORKSHOP SUMMARY. WASHINGTON, DC: THE NATIONAL ACADEMIES PRESS. [HTTPS://DOI.ORG/10.17226/11840](https://doi.org/10.17226/11840). (ACCESSED 7 NOVEMBER 2020)

KOPPEL, LILY. 2005. "COFFINS AND BURIED REMAINS SET ADRIFT BY HURRICANES CREATE A GRISLY PUZZLE". *THE NEW YORK TIMES*, 25 OCT. 2005.

KOSSIN, JAMES P., KENNETH R. KNAPP, TIMOTHY L. OLANDER, AND CHRISTOPHER S. VELDEN. 2020. "GLOBAL INCREASE IN MAJOR TROPICAL CYCLONE EXCEEDANCE PROBABILITY OVER THE PAST FOUR DECADES." *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES*, 117 (22): 11975–11980., DOI:10.1073/PNAS.1920849117.

NASA (NATIONAL AERONAUTICS AND SPACE ADMINISTRATION), 2020. "GLOBAL SURFACE TEMPERATURE." 16 JULY 2020, CLIMATE.NASA.GOV/VITAL-SIGNS/GLOBAL-TEMPERATURE/.

NEEDELL, BARBARA L., AND CHRISTINE KRUSE-FELDSTEIN, 2016,

FALL. "HURRICANE KATRINA: MORGUE OPERATIONS: TWO FORENSIC PROFESSIONALS' PERSPECTIVES." *THE FORENSIC EXAMINER*, 15(3):16 [IS THIS THE FULL PAGE RANGE?] FALL 2006, GALE GENERAL ONEFILE, [HTTPS://LINK.GALE.COM/APPS/DOC/A150862793/ITOF?U=TEL_A_U_T1&SID=ITOF&XID=8CDA5939](https://link.gale.com/apps/doc/A150862793/ITOF?u=tel_a_u_t1&sid=ITOF&xid=8CDA5939).

NOAA (NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION) 2020. CLIMATE. WWW.NOAA.GOV/CLIMATE. (ACCESSED 7 NOVEMBER 2020)

PAO, MAUREEN. (2015, AUGUST 27). SWEEPED UP IN THE STORM: HURRICANE KATRINA'S KEY PLAYERS, THEN AND NOW. *NPR.ORG*. [HTTPS://WWW.NPR.ORG/2015/08/27/434385285/SWEPT-UP-IN-THE-STORM-HURRICANE-KATRINAS-KEY-PLAYERS-THEN-AND-NOW](https://www.npr.org/2015/08/27/434385285/swept-up-in-the-storm-hurricane-katrinas-key-players-then-and-now)

RITCHIE, HANNAH, AND MAX ROSER. 2014. "NATURAL DISASTERS." *OUR WORLD IN DATA*, 3 JUNE 2014, OURWORLDINDATA.ORG/NATURAL-DISASTERS.

STEADMAN, DAWNIE. 2016. "HARD EVIDENCE CASE STUDIES IN FORENSIC ANTHROPOLOGY". ROUTLEDGE, NEW YORK, PRENTICE HALL, 2009.

TRENBERTH, KEVIN. 2005. "UNCERTAINTY IN HURRICANES AND GLOBAL WARMING" *SCIENCE* (308) 5729: 1753-1754, DOI:10.1126/SCIENCE.1112551 (ACCESSED 25 NOVEMBER 2020)

WEBSTER, P., HOLLAND, G., CURRY, J., CHANG H. "CHANGES IN TROPICAL CYCLONE NUMBER, DURATION AND INTENSITY IN A WARMING ENVIRONMENT" *SCIENCE* 309(5742):1844-1846, DOI:10.1126/SCIENCE.1116448 (ACCESSED 25 NOVEMBER 2020)

Part III

Social Inequality, Structural Violence, and Policy

CHAPTER 8

"Environmentality," the Politics of Climate Change and Climate Justice: The Efficacy/Inefficacy of Institutional/Legal Frameworks, Apocalyptic Discourses, and Critical Education in Addressing Climate Change and Environmental Injustice

K. Raymond Da-boi

Keywords: Climate change, climate justice, biopolitics, biopower, politics, governance, sociopolitical, education

Abstract. Undoubtedly the worst threat to the continuity of humanity and other species on earth, the impact of climate change is pervasive, cutting across social and scientific spheres, having abysmal consequences on individuals, communities, and groups in untold ways in disparate locations across the globe. Climate change is not a static, isolated phenomenon, and thus cannot be understood from an apolitical and ahistorical context. The acceleration of climate change in recent years has been unprecedented and demands urgent attention. Addressing the challenge of climate change requires holistic mechanisms and approaches that foreground the role of politics, economics, cultural and other social factors that produce or contribute to the process of climate change.

This essay draws upon Michel Foucault's (1926-1984) original concepts of biopower and governmentality to explore the politics and intersections of climate change, climate governance, and climate justice. It applies notions of "environmentality," "green governmentality," and "ecogovernmentality" to a sociopolitical analysis of the natural environment. This work highlights the conjuncture of economic, social,

and political factors shaping the climate crisis, and the crucial interplay of legal and ecological considerations in addressing this challenge. The essay examines the role, efficacy/inefficacy of institutional and legal frameworks, apocalyptic discourses and critical education, and the importance of recognizing both the local/global dichotomy and connections in addressing climate change and environmental injustice.

Introduction

Invariably, climate change continues to permeate the lives of people daily everywhere across the globe, having exponential effects on individuals and communities in disparate social milieus. This process is occurring rapidly, shaping our everyday lives in many critical ways, and thus requires urgent attention. This essay assumes that climate change is shaped by entrenched sociopolitical practices and processes. It foregrounds the utility of contexts, discourses, and narratives in analyzing, understanding, and addressing climate change.

A multi-dynamic process, climate change is not a new phenomenon. However, like globalization processes,

climate change continues to escalate at an unprecedented pace, impacting and permeating many different spheres of the contemporary milieu including among many, social, political, cultural, economic, educational, and legal. Whereas globalization processes have created a dichotomous world of "haves" and "have nots," new studies underline the critical role of capitalism and climate change in deepening the gaps between and creating further inequalities between those two worlds. And thus, understanding climate change requires multidimensional approaches and perspectives that transcend ecology, integrate, and recognize the role of political and social factors and forces that contribute to and undermine effective solutions.

Given its multifaceted nature, the quest for a holistic approach to the climate question continues to attract scholars and experts from a wide spectrum of fields. This has also evoked wide-range of responses in recent years, most of which have highlighted the importance of the connections between local, regional, and global processes, intersecting ecology, politics, economics, law, and many other fields. The climate situation demonstrates both the convergence of, and tensions between, political goals and community needs, as well as conflicting economic priorities, social interests, and ecological concerns in the fight against climate change locally, regionally, internationally.

Unpacking "environmentality," "ecogovernmentality," or "green governmentality"

The notion of "environmentality or green governmentality is a neologism that offers an extension of Michel Foucault's concept of governmentality" (Foucault 1991; 1997; 2003; 2010; as cited in Rutherford 2017, p. 11), and is based largely on the assumptions and argument that nature/natural processes can be governed, controlled, or mediated by politics, or more specifically, by power. In other words, the concept of environmentality, ecogovernmentality or green governmentality assumes that power is at the core of the relations/associations between humans and the natural world. "This governmentality of nature" as Rutherford (2007) notes, "comes through in the

scientific discourse related to the carrying capacity and limits of the earth" (Rutherford 1999; 2002; Luke 1999 cited in Rutherford, 2007, p. 298). In this context, these terms highlight the centrality of governance in mediating and addressing [the impact] of climate change. Most precisely, environmentality or green governmentality is an approach that seeks to x-ray the management of nature from a Foucauldian perspective, and, as Rutherford (2007) suggests, "donning his particularly insightful lens to take up how the saving of nature as a profoundly political project" (p. 303). This concept raises different sets of question germane to and nudges us to examine the environmentalist critique a bit further in the attempt to generate new insights and perspectives, paying particular attention to how assertions about truth and governance rules are constructed. Governmentality, in Foucault's original conception broadly connotes "the art of government" (Foucault 1991), or "the conduct of conduct" (Gordon 1991; as cited in Rutherford, 2017, p. 1), it "takes aim at the modality of modern rule" (Rutherford, p. 1). Elsewhere, Rutherford (2007) emphasizes three important components of governmentality – its analytics of power, biopolitics, and technologies of the self – that are critical to the spread of green governmentality, suggesting that the concept "offers promising analytical terrain" for the interrogating the intersections between nature, power and society" (p. 292). She argues that this kind of interrogation enables us:

"to make different kinds of assertions about the ways in which modern rule operates: that power is exercised in multiple sites, through different discourses, and often outside the traditional boundaries of the state; [that] it forms nexuses of power/knowledge that shape how we come to understand things and truth, and that it is both constructed by and of certain subjectivities" (Rutherford 2007, p. 294).

Governmentality offers a powerful way of examining the productive functionality and generative capacity of power in production of knowledge systems and formation of subjectivities for achieving strategic ends. Rutherford (2017) delineates the utility of the governmentality studies and highlights the inseparability and mutually reinforcing connections between the governmentality and environmentality, as

follows:

"More specifically, studies in governmentality examine how power is not only repressive but also productive, eliciting and promoting particular knowledge systems, techniques for regulation, and subject positions that work to the best end of a governing authority... As an elaboration on governmentality, environmentality seeks to understand the ways in which this analytic of power can be applied to how we understand and act upon questions of environmental management, from global climate change negotiations (Bäckstrand and Lövbrand 2006) to individual habits of recycling (Darier 1999). It has become a useful concept to help think through the ways that the environment is not only a biophysical reality, but also a site of power, where truths are made, circulated, and remade" (p. 1).

Arguably, as Rutherford (2007) points out, governmentality can be applied in "analyzing the production" and spread of "discourses of nature if we extend the concept of biopower to include all life" (p. 297). For example, Darier (1999 as cited in Rutherford 2007) argues, "biopolitics can be reframed as 'ecopolitics' where concerns for conditions of the national population is subsumed under more intensified attempts to manage the planet's environment" (p. 297). One of the most powerful expressions or applications of biopolitics according to Rutherford (2007, 297) "is through the use of science to tell the truth of the environment – its characteristics, its usefulness and, eventually, its crisis." She concludes "...deploying notions around the circulation of power, biopolitics, and technologies of the self, [enables us to] show how these concepts can provide a strong basis on which to interrogate the self-evident virtuousness of environmentalism in particular, and the governing of nature more generally" (Rutherford 2007, pp. 302-305). However, she calls for a more critical perspective in exploring climate change through the lens of Foucault.

Environmentality, the politics and nexus of climate change and climate justice

The politics of climate change and climate justice on which this essay focuses occur at two levels and within

two mutually nonexclusive spaces or sites. The first level or site is the global, which consists of the lead actors and forces that essentially drive and finance the agenda for climate change and climate justice at both levels. The global level is an arena comprising the international fora, international institutions, and structures anchored on global climate discourses, debates, policies, laws, and frameworks. The second level or site is the local, which comprises communities, grassroot actors, local civil society organizations and groups, activists, among others. The politics of climate change and climate justice in these sites is intense and complex, characterized by overlapping and sometimes competing and conflicting interests, priorities, and concerns.

Environmentality or green governmentality is important in exploring the politics of climate change and the nexus between climate change and climate justice. Environmentality as an analytical framework can be applied in myriad of ways and across many different contexts. For example, deploying notions around the circulation of power, biopolitics, and technologies of self, Rutherford (2007, p. 305) demonstrates "how these concepts can provide a strong basis on which to interrogate the self-evident virtuousness of environmentalism in particular, and the governing of nature more generally."

As stated previously, environmentality and green governmentality highlight the centrality of power or political governance in mediating and addressing [the impact of] climate change and can go a long way in curtailing climate justice. Since its inception, "environmentality or green governmentality has been tested [across many different situations] – from protection of biodiversity and ecosystem, for example, and by the "American Museum of Natural History" (Rutherford 2011 as cited in Rutherford 2017, p. 2) – and in many disparate locations – from the rural Philippines (Dressler 2014 as cited in Rutherford 2017, p. 2) to Arizona (Cepek 2011 as cited in Rutherford, 2017, p. 2). Rutherford (2017) identifies three interrelated efforts or approaches to understand the workings of green governmentality, as follows: "the production of rationalities of rule, the question of strategies of intervention, and generation of specific kinds of self-governing subjects" (p. 2)

The climate justice (CJ) movement is a fusion of "variety of progressive political-economic and political-ecological currents to combat [climate change, which Bond (2011, p. 1) describes as] the most serious threat [facing] humanity and most other species in the 21st century." This represents the nexus of climate change and climate justice. The climate justice movement is a relatively young phenomenon, which emerged in the wake of the rapid acceleration of climate change and as a direct response to its numerous detrimental consequences on humans, enabled in part by "the inability of global elite actors to solve major environmental, geopolitical, social, and economic problems" (Bond 2011, p. 1). The CJ movement emerged only two decades ago "through a variety of interrelated and often overlapping (although sometimes conflicting) political traditions that seek primarily to consolidate a mass-based movement" that unites 'green' and 'red' (or in the US 'blue-green') politics" (Bond 2011, p. 55). These traditions range from the 1990s anti-racist environmentalism which initially conclusively linked social justice to ecological problems to the renewed direct-action initiatives that generated the Mobilization for Climate Justice in the US from 30 November and in 2010 drew in more mainstream groups like Greenpeace, Rainforest Action Network and 350.org" (Bond 2011, p. 3). The 1990s advocacy leading to the Kyoto Protocol negotiations to the 2000s global justice movement (which was birthed with the December 1999 Seattle World Trade Organization protest was a major effort in the regard (Bond 2011, pp. 2-3).

CJ underscores the growing interconnectedness and interwoven nature and inseparability of social justice and environmental protection. For example, as Pellow (2019, p. 2) notes, "The environmental justice movement is composed of people from communities of color, indigenous communities who are focused on combating environmental justice—the disproportionate burden of environmental harm facing these populations." Also, the scale of climate change is "deeply racialized, gendered, and classed" across the globe" (2007, 7) as Pellow argues:

"The impact of climate change offers a telling example of how environmental racism reflects this fact. While the conclusions of climate

change scientists are remarkably clear that anthropogenic climate change is occurring at a dramatic pace and with increasing intensity, this is also happening unevenly, with people of color, the poor, indigenous peoples, peoples of the global South, and women suffering the most" (Harlan et al. 2015, as cited in Pellow 2019, pp. 7-8).

Environmental or climate injustice is structural and systemic as Pellow (2019, 2) explains:

"studies have demonstrated that people of color, people of lower socioeconomic status, indigenous and immigrant populations, and marginalized communities are disproportionately affected by ecologically harmful infrastructures, such as landfills, mines, incinerators, polluting factories, and destructive transportation systems, as well as by negative consequences of ecologically harmful practices, such as climate change/disruption and pesticide" (Ringquist, 2005 as cited in Pellow, p. 2).

Similarly, the growing and exploitative nature of capitalism lies at the core of environmental injustice, which is by no means limited to humans but gravely affects nonhuman worlds as well as McLaren and Houston (2004) point out:

"Precisely what a dialectics of ecological and environmental justice illuminates [], is how the malign interaction between capitalism, imperialism, and ecology has created widespread environmental degradation and has developed coevally with the expansionist regimes of free markets into new territories of production and accumulation. Moreover, it reveals how such conditions require that the most economically exploited and socially vulnerable people and places on the planet bear the greatest burden of ecocide on their bodies, livelihoods, and communities. The present historical conditions of global capitalism also threaten nonhuman nature. To name but a few examples: the poisoning of ecosystems by industrial and military wastes; the fragmentation and destruction of habitats leading to the extinction of species as a result of the relentless quest for land and resources; and the super exploitation of animals for the

mass production of food, pharmaceuticals, and cosmetics" (McLaren and Houston (2004, p. 33)

The importance of climate justice in mitigating climate change cannot be overemphasized. The importance of climate justice lies in "articulating not only the urgency of reducing greenhouse gas emissions but also the need to transform our inherited systems of materials extraction, transportation and distribution, energy-generation, production of goods and services, consumption, disposal, and financing." (Bond 2011, p. 5).

Arguably, as Bond (2011, p. 9) insists, "The particular sites of struggle [which] illustrate the different strategies deployed with CJ make it unique "in comparison to other environmental traditions." However, Bond laments that most discourses of climate change and CJ project take place in ivory tower conferences primarily within UN negotiations at the exclusion of those who are most vulnerable and affected by the worst effects of climate change, and hence there is often a disconnect between CJ interventions and local contexts, priorities, and needs. Bullard (as cited in Bond, 2011, p. 17) sums the discourses and narratives on climate policy into three categories – "business as usual, catastrophic, and climate justice," and likens the international climate negotiations to those of the World Trade Organization (WTO): Citing the groundbreaking nature of the Cochabamba conference in Bolivia from April 19-22, 2010, for example, which accordingly "set in motion a much more serious transnational climate justice approach", Bond (2011, p. 11) calls for more serious, pragmatic strategies and approaches to addressing the climate crisis, which he asserts "can only come from much richer merging of social and ecological discourses," not based on lofty climate goals and targets of the UN and other international environmental agencies. The South African experience foregrounds the role and link of [global] economic factors and forces and global capitalism, the deleterious effects of which equate to those of climate change and defy geographical boundaries, which offers yet another useful context for analyzing the politics and nexus of climate justice and climate change. Drawing on the South African experience,

Bond (2011) "contextualizes ecofeminist insights into climate politics within a concrete case study [which reveals the intricate connections between] class, race, and environmental oppressions with gender" (p. 15). "As recession spreads," Bond (2011, p. 16) notes, global capitalism is becoming much more like apartheid: predatory against women and environment."

"By and large, countries are defending their narrow economic interests and the rich countries in particular are trying to grab the last slice of the atmospheric pie. Although the Kyoto Protocol is deeply flawed, especially the low targets and reliance on market mechanisms, ... attempts by the US to get rid of Kyoto are dangerous. It is critical to retain the rich countries legally binding commitment in any future agreement and any alternative that could emerge at this stage would be much worse" (Bond 2011, p. 17).

[The efficacy/inefficacy of] institutional/legal frameworks, apocalyptic discourses, and critical education

There has been a proliferation of initiatives (programs, policies, projects, frameworks and approaches) in the growing assemblage of human responses to climate change at the local, regional and global levels, most of which have been heavily supported, in some instances even initiated by the United Nations directly through the General Assembly, the World Bank, the World Trade Organization, and a host of international organizations (IOs) and international nongovernmental organizations (INGOs). Some of the key questions that arise are: have these initiatives been effective in mitigating climate change and ensuring climate justice? If not, why have they failed?

The UN Charter (1945) and the United Nations Declaration for Human Rights (UNHDR) (1948) provided the cornerstone for the inception of a development and human rights regime. For example, the United Nations Millennium Declaration launched the Millennium Development Goals (MDGs), a fifteen (15) year global commitment of world leaders to address extreme hunger, poverty, infant and mortality, environmental and other social issues, which ended in 2015, and in its wake, emerged another set of thirty

(30) year follow-up commitments known as the Sustainable Development Goals (SDGs). Three of these goals (13, 14, and 15), focus specifically on "Climate Change, Oceans, and Biodiversity," respectively and recognize the frameworks of the Kyoto Protocol and the 1992 United Nations Framework Convention on Climate Change (UNFCCC) as overarching frameworks in the effort to combat climate change. Another important international instrument is the Forest Carbon Partnership Facility (FCPF). With funding from the World Bank, the FCPF supports poor countries in devising suitable carbon emission reduction strategies by directing funds from carbon purchase to long-term investments under REDD+ country projects.

Given the plethora of initiatives in response to climate change as highlighted above, a number of fundamental questions arises. Why has the issue of climate change still not been addressed? Why is the threat of climate change more serious than ever? What are the key factors contributing and accelerating the pace of climate change? How serious is the problem? Is there prospect or hope for solution? What are the alternatives? What needs to be done? Addressing these questions will require further inquiry focused on the scale and impact of, and mechanisms or human responses to climate change.

Invariably, an effective solution to climate change is one that is comprehensive and holistic, one that addresses the various components (social, political, etc.) of climate change and the deeply rooted environmental consequences of capitalism. If the SDGs and the Forest Carbon Partnership Facility (FCPF), for example will achieve their full potentials, it is high-time we reflect more seriously on the level of use of our natural environment and resources and begin to take concrete actions, formulating and adopting more radically environmentally-friendly policies, legislations and programs to preserve and protect our natural resources/environment, maintain biodiversity in the ecosystem, and ensure our sustainability and continued survival on the earth.

Given the prevalence of environmental crises and their growing implications and connectedness to our everyday life, our social interactions and vocabularies,

the need to address the question of climate justice is urgent. Using a political ecology framework, McLaren, and Houston (2010) "explore schooling as one site of environmental injustice" (p. 27). They emphasize the importance of critical education as a tool for addressing environmental injustice, calling "for critical revolutionary pedagogy to be informed by a dialectics of ecological and environmental justice that highlights the situatedness of environmental conflict and injustice towards nonhuman nature without obscuring its historical production under capitalist value forms" (p. 27). Further, they argue, "the escalating environmental problems at all geographic scales from local to global have become a pressing reality that critical educators can no longer ignore" (p. 29). Because this area of critical education is a new direction in scholarship and has been greatly undermined by convergence of political, economic and other interests, including, for example, "the complicity among global profiteering, resource colonization and the wholesale ecological devastation that has become a matter of everyday life for most species on the planet (p. 29)," as McLaren and Houston (2010, p. 29) posit, "radical pedagogy grounded in Freirean and Marxist traditions, with its already well-developed critiques of exploitative economic conditions, provides a rich theoretical landscape to address issues of ecological and environmental justice educational theory and practice." "Greening critical pedagogy," they add, "ought not diminish its radical intent or its goals of transforming oppressive social economic conditions" (McLaren and Houston 2010, p. 28). Additionally, their work highlights both class exploitation as a major way in which environmental injustice is carried out through the logics of neoliberalism enabled by the spread of global capitalism, as well as the importance of the link between the local and global, for example, the centrality of the US in the global economy: "the US debt-financed economy," they insist,

"is keeping the global economy afloat, a country that relies on a permanent "war economy" (in which risk can be socialized and profit privatized) to carry out its domestic war on the working class and to crush "rogue states" that refuse to submit their natural resources and markets to structural adjustment programs imposed by the International Monetary Fund and other

international financial powers that ultimately work on behalf of the US corporate rule" (McLaren and Houston 2010, 27).

The inception of "Critical Environmental Justice (CEJ) Studies has been a welcomed development in expanding and filling the blind spots in Environmental Justice (EJ) Studies including an emphasis on questions about difference, intersectionality and representation, and creating "linkages across theory and social change politics that might not usually emerge from the "traditional EJ Studies," (Pellow 2010, p. 5). it has also been useful in highlighting the dichotomy and connections between, as well as impacts of climate change on human/nonhuman systems. "Critical EJ studies" as Pellow (2010, p. 5) explains, "speaks to ways in which various social categories of difference work to place particular bodies at risk of exclusion, marginalization, erasure, discrimination, violence and Othering," which are useful in understanding "the ways intra-human inequality and oppressions function and how they intersect with human-non-human oppression" (p. 5).

As stated earlier, the phenomenon of climate change is a global problem, and like globalization, where local processes have implications for and are increasingly impacting other locations sometimes concurrently. Climate change is occurring at a massive, global scale and irrespective of where it is occurring, climate change and most of the factors and forces accelerating climate change and the discourses shaping these are global. Thus, the local context is increasingly shaped by and cannot be discussed outside the global. Recognizing this link is critical in understanding of and addressing climate change. In a 2003 study to examine regional relationships between surface temperature, vegetation, and human settlement in metropolitan Arizona, Jenerette et al. (2011) underscore the significance of the recognizing the connections between the local and the global and the global link between urbanization processes, and how these connect to and accelerate the pace of climate change: "Urbanization [they stress] is a component of global change through both cumulative and systemic alterations to the Earth's atmosphere, surficial properties, species diversity, and quality of human life (Decker et al. 2000; Hope et al. 2003; United Nations

Centre for Human Settlements, 2001, cited in Jenerette et al. 2011, p. 362). Further, they indicate, "The interactions between global and regional climate changes are likely to exacerbate urban warming (IPCC 2001), thus increasing the severity of these problems" (Jenerette et al. 2011, p. 362). "Understanding urban induced climate change will help in managing these systems to better support the urban habitat," (Jenette et al, p. 362), they conclude. Their findings raise several important questions for 'better understanding ecosystem functioning in urban ecosystems, the response of ecosystem functioning to human settlement patterns, and the social consequences of altered ecological functioning" (p. 362).

Conclusion

In most humanistic disciplines, including anthropology, theories, concepts, and practices are shaped by a discursive logic. Narratives and discourses are powerful heuristic devices that help us to construct, deconstruct concepts and phenomena. Narratives and discourses have been useful in shaping understandings, analyses, perspectives and approaches to climate change and climate justice and have also stimulated serious controversies and debates, some of which are sometimes counterproductive to the challenge or quest to combat climate change. One of such debates borders around the question or efficacy/inefficacy of applying "terror" / "apocalyptic" discourses to the treatment of climate change, an area which has received massive investments of scholarship and has equally been heavily critiqued from many different fields in recent years.

Most critiques of the terror/apocalyptic discourse (Chaturvedi & Dole 2015; Bettini 2012; Hartman 2010) argue that it ignores pertinent processes associated with the construction of climate change, climate refugee, for example, and seeks to de-historicize, de-politicize, and de-contextualize these processes. For example, Bettini (2010, p. 63) "argues that apocalyptic narratives on climate refugees, although not totalizing or uncontested, represent a case of the depoliticization of global climate governance." She maintains, "The convergence into such narratives favors the drive towards a post-political discursive configuration,

which, by supplanting politics with governance, leaves underlying power relations untouched and (re)produces present forms of representational and material marginalization" (Bettini 2010, p. 63). Focusing on the rhetoric of 'climate terror' the depoliticizing politics of domination, the notion of 'post-political' neoliberal globalization, Chaturvedi & Dole (2015, p. 3) argue for "expanding the nature and scope of critical geopolitics through engagement with various 'critical' perspectives (in contrast with conventional wisdoms) of social sciences and humanities; as well as convergent critical perspectives around the notions of space, scale and power."

Describing climate change or displacement, for example as a "crisis" is an attempt by proponents of the terror/apocalyptic or dystopic discourse to ignore or downplay the interplay of political, social, economic, and other factors that converged to produce climate change or the critically dynamic nature of these processes. They try to supplant the agency of victims or sufferers, and to present such phenomena as abstract, fortuitous events in isolation of the grand scheme of themes disconnected from local, global, and other dynamics, void of context. A terror/apocalyptic approach contrasts sharply with the underlying assumptions and the central arguments guiding this essay, for example, the workings of social factors and forces in producing and addressing climate change, the mutually dependent relationships governing climate change and climate justice, and the need for recognition of the connections of processes, discourses shaping perspectives of climate change and climate justice at the local and global levels. This essay has demonstrated that climate change and climate justice occur in contexts that are deeply historical and political and thus cannot be treated or understood apolitically and a historically.

References

- BARTELINK, E J. ET AL. (2018). "BIOCULTURAL PERSPECTIVES ON INTERPERSONAL VIOLENCE IN THE PREHISTORIC SAN FRANCISCO BAY AREA." IN TEMPLE, D. H. AND STOJANOWSKI (EDS.), HUNTER-GATHERER ADAPTATION AND RESILIENCE: A BIOARCHAEOLOGICAL PERSPECTIVE (PP. 274-301). CAMBRIDGE UNIVERSITY PRESS.
- BÄCKSTRAND, K. AND LÖVBRAND, E. (2006). PLANTING TREES TO MITIGATE CLIMATE CHANGE: CONTESTED DISCOURSES OF
- ECOLOGICAL MODERNIZATION, GREEN GOVERNMENTALITY AND CIVIC. DOI :10.1162/152638006775991911.
- BETTINI, G. (2013). CLIMATE BARBARIANS AT THE GATE? A CRITIQUE OF APOCALYPTIC NARRATIVES ON 'CLIMATE REFUGEES', GEOFORUM, 45: 63-72.
[HTTP://DX.DOI.ORG/10.1016/J.GEOFORUM.2012.09.009](http://dx.doi.org/10.1016/j.geoforum.2012.09.009)
- BOND, P. (2012). POLITICS OF CLIMATE JUSTICE: PARALYSIS ABOVE, MOVEMENT BELOW.
- BULLARD, N. (2009, NOV. 19). "THE STATE OF CLIMATE POLITICS" [CONFERENCE PAPER]. ROSA LUXEMBURG FOUNDATION 2009 CONFERENCE, JOHANNESBURG, SOUTH AFRICA.
- CEPEK, M.L. (2011). "FOUCAULT IN THE FOREST: QUESTIONING ENVIRONMENTALITY IN AMAZONIA." AMERICAN ETHNOLOGIST, 38(3): 501–515.
- CHATURVEDI, S. AND DOLE, T. (2015). CLIMATE TERROR: A CRITICAL GEOPOLITICS OF CLIMATE OF POLITICAL SCIENCE. CHENNAI, INDIA: PALGRAVE MACMILLAN.
- DECKER ET AL. (2000). ENERGY AND MATERIAL FLOW THROUGH URBAN ECOSYSTEM. ANNUAL REVIEW OF ENERGY AND THE ENVIRONMENT, 25: 685-740. DOI: 10.1146/ANNUREV.ENERGY.25.1.685.
- DRESSLER, W. (2014). "GREEN GOVERNMENTALITY AND SWIDDEN DECLINE ON PALAWAN ISLAND." TRANSACTIONS OF THE INSTITUTE OF BRITISH GEOGRAPHERS, 39(2): 250–264. DOI:10.1111/TRAN.12026.
- FOUCAULT, M. (1991). "GOVERNMENTALITY." IN G. BURCHELL, C. GORDON, AND P. MILLER (EDS), THE FOUCAULT EFFECT: STUDIES IN GOVERNMENTALITY (PP. 87–104). UNIVERSITY OF CHICAGO PRESS.
- FOUCAULT, M. (1995). DISCIPLINE AND PUNISH: THE BIRTH OF THE PRISON. NEW YORK: VINTAGE BOOKS.
- FOUCAULT, M. (1997). "TECHNOLOGIES OF THE SELF." IN P. ROBINOW (EDS). ETHICS: SUBJECTIVITY AND TRUTH (THE ESSENTIAL WORKS OF FOUCAULT, 1954–1984 (PP. 223–251). THE NEW PRESS.
- FOUCAULT, M. (2003). SOCIETY MUST BE DEFENDED: LECTURES AT THE COLLEGE DE FRANCE, 1975–76. NEW YORK: PICADOR.
- FOUCAULT, M. (2007). SECURITY, TERRITORY, POPULATION: LECTURES AT THE COLLEGE DE FRANCE, 1977–78. PALGRAVE MACMILLAN.
- FOUCAULT, M. (2010). THE BIRTH OF BIOPOLITICS: LECTURES AT THE COLLEGE DE FRANCE, 1978–79. NEW YORK: PICADOR.

GYEONGSANG UNIVERSITY INSTITUTE OF SOCIAL SCIENCE, JINJU.

GORDON, C. (1991). "GOVERNMENTAL RATIONALITY: AN INTRODUCTION." IN BUSHELL, G., AND MILLER, P. (EDS). THE FOUCAULT EFFECT: STUDIES IN GOVERNMENTALITY. (PP. 1–48). UNIVERSITY OF CHICAGO PRESS.

HARLAN ET AL. (2015). CLIMATE JUSTICE AND INEQUALITY. IN DUNLAP, R AND BRULLE, R. J. (EDS.), CLIMATE CHANGE AND SOCIETY: SOCIOLOGICAL PERSPECTIVES. (PP. 127–163. OXFORD UNIVERSITY PRESS.

HARTMAN, BETSY. (2010). POLICY ARENA - RETHINKING CLIMATE REFUGEES AND CLIMATE CONFLICT: RHETORIC, REALITY AND THE POLITICS OF POLICY DISCOURSE. JOURNAL OF INTERNATIONAL DEVELOPMENT. RETRIEVED FROM WWW.INTERSCIENCE.WILEY.COM) DOI: 10.1002/jid.1676.

HOPE, A. G., ET AL. (2015). ARCTIC BIODIVERSITY: INCREASING RICHNESS ACCOMPANIES SHRINKING REFUGIA FOR A COLD-ASSOCIATED TUNDRA FAUNA. ECOSPHERE 6(9):159. HTTP://DX.DOI.ORG/10.1890/ES15-00104.1.

JENERETTE, G. ET AL. (2007). REGIONAL RELATIONSHIPS BETWEEN SURFACE TEMPERATURE, VEGETATION, AND HUMAN SETTLEMENT IN A RAPIDLY URBANIZING ECOSYSTEM. LANDSCAPE ECOLOGY 22:353–365. HTTPS://DOI.ORG/10.1007/s10980-006-9032-z.

LUKE, T.W. (1999A). "ENVIRONMENTALITY AS GREEN GOVERNMENTALITY." IN DARIER, E. (ED). DISCOURSES OF THE ENVIRONMENT (PP. 121–151). BLACKWELL.

LUKE, T.W. (1999B). ON ENVIRONMENTALITY: GEO-POWER AND ECO-KNOWLEDGE IN THE DISCOURSES OF CONTEMPORARY ENVIRONMENTALISM. CULTURAL CRITIQUE, PART 2 (PP. 57-81. HTTPS://WWW.JSTOR.ORG/STABLE/1354445. UNIVERSITY OF MINNESOTA PRESS.

MCLAREN, P. AND HOUSTON, D. (2004). REVOLUTIONARY ECOSOCIALISM AND CRITICAL PEDAGOGY. EDUCATIONAL STUDIES A JOURNAL OF THE AMERICAN EDUCATIONAL STUDIES ASSOCIATION, 36(1):1. HTTPS://DOI.ORG/10.1207/s15326993es3601_4. ROUTLEDGE.

PELLOW, D. (2016). TOWARD A CRITICAL ENVIRONMENTAL JUSTICE STUDIES: BLACK LIVES MATTER AS AN ENVIRONMENTAL JUSTICE CHALLENGE. DU BOIS REVIEW: SOCIAL SCIENCE RESEARCH ON RACE, 13(2):221-236.

RINGQUIST, E. J. (2005). ASSESSING EVIDENCE OF ENVIRONMENTAL INEQUITIES. JOURNAL OF POLICY ANALYSIS AND MANAGEMENT, 24(2): 223 – 247.

RUTHERFORD, S. (2007). GREEN GOVERNMENTALITY: INSIGHTS AND OPPORTUNITIES IN THE STUDY OF NATURE'S RULE. PROGRESS IN

HUMAN GEOGRAPHY, 31(3): 291-307. SAGE PUBLICATIONS. [HTTP://PHG.SAGE.PUB.COM](http://phg.sage.pub.com), DOI: 10.1177/0309132507077080.

RUTHERFORD, S. (2017). ENVIRONMENTALITY AND GREEN GOVERNMENTALITY. IN D. RICHARDSON, N. CASTREE, M. F. GOODCHILD, A. KOBAYASHI, W. LIU, AND R. A. MASON (EDS.), THE INTERNATIONAL ENCYCLOPEDIA OF GEOGRAPHY (PP. 1-81). [HTTPS://ABOUT.JSTOR.ORG](https://about.jstor.org). DOI: 10.1002/9781118786325.wbieg0111. JOHN WILEY & SONS LTD.

UNITED NATIONS CENTER FOR HUMAN SETTLEMENTS (HABITAT). (2001). CITIES IN A GLOBALIZING WORLD: GLOBAL REPORT ON HUMAN SETTLEMENTS 2001. EARTHSCAN PUBLICATIONS LTD.

CHAPTER 9

Climate Change and the Inequity of its Biological Impacts

Caroline Znachko and Armando Anzellini

Keywords: Intergenerational trauma, biological inequality, bioarchaeology

Abstract. The sociocultural, economic, and even biological effects of climate change are well documented in the literature of biological anthropology. These stressors can have wide-ranging biological effects on individuals and communities, including skeletal and health impacts, which can affect the quality of life and life expectancy for a significant number of people. However, while the inequity of the distribution of these effects has also been documented, few scholars have explored the intersection of climate-related inequities and their biological impacts. By exploring bioarchaeological research into the biological impacts of social inequality in historic and prehistoric contexts, in conjunction with the anticipated effects of climate change, we can refine our expectations of what the future potentially holds. From here, we can provide potential solutions to mediate the anticipated detrimental health outcomes that may result from climate change and associated complications.

Introduction

Many of the potential consequences of climate change on the human population are well documented both within and beyond anthropology. The specific impacts that climate change will have on our communities as it disrupts the current socio-cultural, economic, and political systems in place, will vary contextually. For instance, extended fire seasons in the Western United States and flooding and erosion in coastal Florida may both lead to increased homelessness and forced displacement. Yet the severity of events will be felt

differently in these areas depending on variables such as demographics, community specific buffering systems, and state policy. However, one thing is for certain, these disruptions hold the potential to carry wide-ranging biological effects on individuals and communities which can significantly affect their morbidity and mortality. Further, because of the pre-existing systems of social inequality within our societies, these burdens can be expected to be experienced disproportionately by those already marginalized within society. Looking back at the archaeological record can provide insight into the effects of catastrophic change, some of which approximates current expectations of climate change, and how it may impact our bodies. The purpose of this paper is to briefly explore the intersection of climate change, human behavioral responses in archaeological contexts, and pre-existing forms of social inequality to predict subsequent biological outcomes.

Biological Embodiment

Though the term “stress” is broadly used throughout various scientific fields. Huss-Ashmore and colleague’s (1982:396) describe stress in the clinical sense as the general disruption of an individual’s physiological balance (i.e., homeostasis). Factors that cause this disruption range from biological (e.g., biological pathogens and illness, malnutrition, physical labor) to sociocultural in origin (e.g., structural violence, psychosomatic illness, epigenetic accumulations of trauma), (Huss-Ashmore, Goodman

and Armelagos 1982; Klaus 2014; Temple and Goodman 2014). The ability to respond to various stressors in the environment, including disruptions to growth, developmental adaptations, and acclimatization, is referred to as plasticity and accounts for adaptive phenotypic variation observable in humans (Klaus 2014; Temple and Goodman 2014). However, severe enough stressors can lead to dysfunction of biological systems and result in worsened health outcomes. Additionally, severe stress has been shown to have intergenerational transmission, thereby impacting the descendants of those originally impacted (Agarwal 2016; Kellermann 2013; Krieger 2005; Murgatroyd et al. 2009; Skinner et al. 2013; Thayer and Non 2015; Zerach et al. 2017).

In accordance with the Developmental Origins of Health and Disease (DOHaD) hypothesis, the embodiment of biocultural stressors during an individual's early life development, in particular, can leave lasting signatures on the body and influence that individual's susceptibility to chronic diseases in adulthood (Agarwal 2016; Gluckman, Hanson and Buklijas 2010; Gowland 2015; Mazumder et al. 2010; Newnham 2007; Temple, 2018). However, these biological impacts are not uniform. When portions of the population experience differential risk for biocultural stress as the result of structural inequalities, unequal burdens of disease, and other sociocultural consequences of climate change (e.g., strain on social resources, social ties, etc.), gradients in the biological impacts can manifest. Further, when catastrophic events occur, those who experienced significant stress early in life are more susceptible to selective mortality. This could be for several reasons including underlying diseases (e.g., cardiovascular disease, diabetes, obesity), weakened immune system function, or social factors associated with socioeconomic inequality that exacerbate these issues (e.g., lack of access to medical services due to socioeconomic status or community, occupational exposures, etc.), (Yaussey 2016; Schulte and Chun 2009). There is no doubt that this is an oversimplification of the interaction between environmental stressors and the biological mechanisms that influence health trajectories. However, the main point – that the human body can physically embody the biocultural environment in which it is situated – is well supported.

Climate Change and Human Behavioral Responses

Climate Change and Sociocultural Change

The Intergovernmental Panel on Climate Change (IPCC)'s 2014 report identified 1) direct effects of climate and weather, 2) effects mediated by the ecosystem, and 3) effects heavily mediated through human institutions, as the main potential effects of climate change on human health (Smith et al. 2014). These areas of interest can host a wide range of influences (e.g., biological agents, drought and famine, sociopolitical violence, genocide, etc.). It is important to recognize that regardless of whether an influence is overt or indirect, together these stressors reshape the environment in which people live and can therefore impact the human body. Social inequalities underlying our cultural systems can become embodied by individuals through the interactions of their biology and the environments within which they reside, environments that include the socio-political context within which they find themselves. These socio-political environments can thus have a significant impact on the health of individuals and their descendants, and often the least privileged are the most at risk (Brauch et al. 2012; Brouwer et al. 2007; Máñez Costa, Moors and Fraser 2011; Wutich 2020).

Climate Change through History

The effects of undue stress and a changing climate on social structure are observable in the archaeological record. Global fluctuations in temperature outside of the norm often led to increasing social unrest and the outbreak of wars (Kaniewski et al. 2020; Osipov et al. 2020; Petraglia et al. 2020; Zhang et al. 2007; Zhang et al. 2005). In fact, a study by Zhang and colleagues (2005) demonstrated that all dynastic transitions in China, from the late Tang to the Qing dynasty (A.D. 705 to 1636), were preceded by significant decreases in average temperature precipitating decreased grain yields, increased disease loads, and, thus, social unrest. A similar history is present in the Mediterranean, where anomalies in temperature occurred in tandem with increases in social unrest with both plague and drought playing major roles (Kaniewski et al. 2020). Globally, correlations between decreased agricultural yield and climate change during

the Little Ice Age also correlate with increases in social unrest in the form of wars, both inter-state as well as civil (Zhang et al. 2007, 19217). This social unrest is not only present as a result of decreased agricultural yields, but it also results from an increase in disease loads and epidemics that also correlate with these climate anomalies (Zuckerman and Dafoe 2020). All these factors are intertwined as causes and effects, but all stem from climatic shifts in human history.

The effects of social unrest, increase in disease loads, and famine stemming from drought most often affect the least privileged in society (Brouwer et al. 2007), thus these differences in the extent of stress are unequally distributed within populations (Nystrom and Robbins Schug 2020). The biological effects of stress are often best exemplified in the archaeological record through the perspective of growth and development (Cardoso et al. 2019; Deschênes, Greenstone and Guryan 2009). For example, Watts' (2013) research highlights the embodiment of biocultural stress among individuals in a small market town of Lincolnshire, England (AD1700-1855). Increased skeletal indicators of stress (i.e., vertebral neural canal size, linear enamel hypoplasia, and cribra orbitalia) were associated with adulthood morbidity and mortality, indicating that the long-term health outcomes of those who experienced significant stress during childhood development were negatively impacted. When these biological stress markers are contextualized within biocultural systems of inequality, they have been shown to reflect the embodiment of the societal and ecological circumstances of those individuals (Goodman 2000; Krieger 2005; Kuzawa and Sweet 2009; Niewohner 2011; Lock 2015; Thayer and Non 2015).

However, modern, human-driven climate change differs from these cases from the past due to the interaction between macroscale environmental change and globalized social systems. In reference to these past cases, researchers often discuss the evidence for resilience in these communities, maintaining stability until the climate returns to their normal expectations. Primarily, most of the evidence for unrest stems from decreases in average yearly temperatures, not increases as expected in our current understanding of climate change, and these historical

climatic moments often return to normal in short spans of socio-cultural time, but that rapid return may not be the case any longer (McMichael and Dear 2010).

The long-term warming effects of human-driven climate change are already being experienced by the most marginalized. In the past, the main drivers of social instability appeared to be decreases in farming productivity (Máñez Costa, Moors and Fraser 2011; Zhang et al. 2007; Zhang et al. 2005), but modern examples are demonstrating that socioeconomic drivers are playing a larger role (Máñez Costa, Moors and Fraser 2011; Méndez 2020). In the Alentejan region of Portugal, for example, an increase in crop specialization resulting from governmental subsidies has led to local income being reliant on a limited number of crops (Máñez Costa, Moors and Fraser 2011). While food access in the region may no longer rely on local growers, the income of every individual in this region is tied to the growth of cash crops. This globalization and specialization create a more vulnerable population, especially as they compare to the urbanized populations that are consumers of the crops but are not reliant on them (Máñez Costa, Moors and Fraser 2011). The forced migration of climate change is already being observed in places like Honduras, where the combination of gradual climate change and extreme weather events precipitated by climate change have led to the loss of homes and income for many rural peoples, and entire populations along the coasts are losing their most valuable resource, their land (Méndez 2020).

Most researchers investigating the effects of modern human-driven climate change have explored the effects of famine, drought, and increased disease load on social stability (Brauch et al. 2012; Brouwer et al. 2007; Wutich 2020). These effects lead to forced migration and dramatic increases in social instability for the countries affected and those receiving the migrants (Brauch et al. 2012; Brouwer et al. 2007; Máñez Costa, Moors and Fraser 2011; Rechkemmer et al. 2016). In combination with this social instability, forced migration has an outsized impact on the stress, both psychological and physical, experienced by those people forced from their homes and facing the necessity of traveling, often by foot, to a new place.

Looking Forward

Climate change, and its impacts on human populations, is wide-ranging and it is, at times, difficult to comprehend realistic and doable preventive measures. It is important to recognize when exploring potential solutions that there is no “one size fits all” solution to preventing negative consequences to health. Rather, the unique layers of inequality present in each context (e.g., rural areas and restricted access to health care, urban settings, and socioeconomic exposures to risk factors) should be understood and addressed.

Evidence of resilience and adaptation abound in the archaeological record of climate change (Bartelink et al. 2018; Petraglia et al. 2020). This past also demonstrates that social inequality leads to differences in how climate change is experienced and embodied, with extreme differences in health outcomes that can be perpetuated over generations. All interventions must necessarily address these social inequalities to reduce the inequity in health outcomes within nations and across the globe. Evidence of resilience from the past demonstrates that local communities are best served through support, improving local community resilience and creating a well-being that is designed around the needs of the communities most affected.

Solutions that aim to minimize the long-lasting biological impacts of climate change need to consider the disproportionate rates of risk that various levels of the community experience to ensure equitable use of resources. While we have discussed social inequality as broadly impacting individuals at lower socioeconomic levels and those belonging to marginalized identities, solutions should also consider how intersecting aspects of an individual’s identity may further result in differential risk and allocate resources accordingly. For instance, considering the Multi-Dimensional Poverty Index (MPI) indicates “that children are the most vulnerable to poverty” (Nystrom and Robbins Schug 2020: 160), it is critical that projects aimed at mitigating (or minimizing) the effects of climate change target solutions geared towards children. This approach would also help to minimize the long-lasting biological impacts of climate change

by buffering influences that negatively alter health trajectories into adulthood and minimize intergenerational transmissibility of such effects.

Conclusion

Reviewing the archaeological record provides insight into the potential future impacts of catastrophic changes associated with climate change and the resulting effects on our bodies. Just as it is observable in the past, the burden of these impacts will likely fall onto the pre-existing systems of social inequality within our societies, disproportionately affecting the already marginalized. However, an understanding of this intersection (i.e., climate change, human behavioral responses, and pre-existing forms of social inequality) and its effects on human biology and health, also provides us with an improved understanding from which informed solutions can be developed and implemented.

References

- AGARWAL, SABRINA C. 2016. "BONE MORPHOLOGIES AND HISTORIES: LIFE COURSE APPROACHES IN BIOARCHAEOLOGY." *AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY* 159 (SUPPL 61): S130-149.
- BARTELINK, ERIC J. ET AL. 2018. "BIOCULTURAL PERSPECTIVES ON INTERPERSONAL VIOLENCE IN THE PREHISTORIC SAN FRANCISCO BAY AREA." IN *HUNTER-GATHERER ADAPTATION AND RESILIENCE: A BIOARCHAEOLOGICAL PERSPECTIVE*. EDITED BY D.H. TEMPLE AND C.M. STOJANOWSKI. PP. 274-301. CAMBRIDGE: CAMBRIDGE UNIVERSITY PRESS.
- BRAUCH, HANS GÜNTER, JANPETER SCHILLING, JÜRGEN SCHEFFRAN, MICHAEL BRZOSKA, AND PETER MICHAEL LINK. 2012. *CLIMATE CHANGE, HUMAN SECURITY AND VIOLENT CONFLICT: CHALLENGES FOR SOCIETAL STABILITY*. BERLIN: SPRINGER.
- BROUWER, ROY, SONIA AKTER, LUKE BRANDER, AND ENAMUL HAQUE. 2007. "SOCIOECONOMIC VULNERABILITY AND ADAPTATION TO ENVIRONMENTAL RISK: A CASE STUDY OF CLIMATE CHANGE AND FLOODING IN BANGLADESH." *RISK ANALYSIS* 27 (2): 313-326.
- CARDOSO, H. F. V., L. SPAKE, S. N. WASTERLAIN, AND M. T. FERREIRA. 2019. "THE IMPACT OF SOCIAL EXPERIENCES OF PHYSICAL AND STRUCTURAL VIOLENCE ON THE GROWTH OF AFRICAN ENSLAVED CHILDREN RECOVERED FROM LAGOS, PORTUGAL (15TH-17TH CENTURIES)." *AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY* 168 (1): 209-221.
- DESCHÊNES, OLIVER, MICHAEL GREENSTONE, AND JONATHAN

- GURYAN. 2009. "CLIMATE CHANGE AND BIRTH WEIGHT." *AMERICAN ECONOMIC REVIEW* 99 (2): 211-7.
- GLUCKMAN, P. D., M. A. HANSON, AND T. BUKLIJAS. 2010. "A CONCEPTUAL FRAMEWORK FOR THE DEVELOPMENTAL ORIGINS OF HEALTH AND DISEASE." *JOURNAL OF DEVELOPMENTAL ORIGINS OF HEALTH AND DISEASE* 1 (1): 6-18.
- GOODMAN, A. H. 2000. WHY GENES DON'T COUNT (FOR RACIAL DIFFERENCES IN HEALTH). *AMERICAN JOURNAL OF PUBLIC HEALTH*: 90(11):1699–1702.
- GOWLAND, REBECCA L. 2015. "ENTANGLED LIVES: IMPLICATIONS OF THE DEVELOPMENTAL ORIGINS OF HEALTH AND DISEASE HYPOTHESIS FOR BIOARCHAEOLOGY AND THE LIFE COURSE." *AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY* 158 (4): 530-540.
- HUSS-ASHMORE, REBECCA, ALAN H. GOODMAN, AND GEORGE J. ARMELAGOS. 1982. "NUTRITIONAL INFERENCE FROM PALEOPATHOLOGY." IN *ADVANCES IN ARCHAEOLOGICAL METHOD AND THEORY*. EDITED BY M.B. SCHIFFER. PP. 395-474. SAN DIEGO: ACADEMIC PRESS.
- KANIEWSKI, DAVID ET AL. 2020. "CLIMATE CHANGE AND SOCIAL UNREST: A 6,000-YEAR CHRONICLE FROM THE EASTERN MEDITERRANEAN." *GEOPHYSICAL RESEARCH LETTERS* 47 (7): e2020GL087496.
- KELLERMANN, NATAN P. F. 2013. "EPIGENETIC TRANSMISSION OF HOLOCAUST TRAUMA: CAN NIGHTMARES BE INHERITED?" *ISRAEL JOURNAL OF PSYCHIATRY AND RELATED SCIENCES* 50 (1): 33-39.
- KLAUS, HAAGEN D. 2014. "FRONTIERS IN THE BIOARCHAEOLOGY OF STRESS AND DISEASE: CROSSDISCIPLINARY PERSPECTIVES FROM PATHOPHYSIOLOGY, HUMAN BIOLOGY, AND EPIDEMIOLOGY." *AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY* 155 (2): 294-308.
- KRIEGER, NANCY. 2005. "EMBODIMENT: A CONCEPTUAL GLOSSARY FOR EPIDEMIOLOGY." *JOURNAL OF EPIDEMIOLOGY AND COMMUNITY HEALTH* 59 (5): 350-5.
- KUZAWA, CHRISTOPHER W., AND ELIZABETH SWEET. 2009. EPIGENETICS AND THE EMBODIMENT OF RACE: DEVELOPMENTAL ORIGINS OF U.S. RACIAL DISPARITIES IN CARDIOVASCULAR HEALTH. *AMERICAN JOURNAL OF HUMAN BIOLOGY*: 21(1):2–15.
- LOCK, MARGARET. 2015. COMPREHENDING THE BODY IN THE ERA OF THE EPIGENOME. *CURRENT ANTHROPOLOGY*: 56(2):151–177.
- MÁÑEZ COSTA, MARÍA A., EDDY J. MOORS, AND EVAN D. G. FRASER. 2011. "SOCIOECONOMICS, POLICY, OR CLIMATE CHANGE: WHAT IS DRIVING VULNERABILITY IN SOUTHERN PORTUGAL?" *ECOLOGY AND SOCIETY* 16 (1): 28.
- MAZUMDER, B., D. ALMOND, K. PARK, E. M. CRIMMINS, AND C. E. FINCH. 2010. "LINGERING PRENATAL EFFECTS OF THE 1918 INFLUENZA PANDEMIC ON CARDIOVASCULAR DISEASE." *JOURNAL OF DEVELOPMENTAL ORIGINS OF HEALTH AND DISEASE* 1 (1): 26-34.
- McMICHAEL, ANTHONY J., AND KEITH B. G. DEAR. 2010. "CLIMATE CHANGE: HEAT, HEALTH, AND LONGER HORIZONS." *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES* 107 (21): 9483-4.
- MÉNDEZ, MARÍA JOSÉ. 2020. "THE SILENT VIOLENCE OF CLIMATE CHANGE IN HONDURAS." *NACLA REPORT ON THE AMERICAS* 52 (4): 436-441.
- MURGATROYD, CHRIS ET AL. 2009. "DYNAMIC DNA METHYLATION PROGRAMS PERSISTENT ADVERSE EFFECTS OF EARLY-LIFE STRESS." *NATURE NEUROSCIENCE* 12 (12): 1559-1566.
- NEWNHAM, J. P. 2007. "THE DEVELOPMENTAL ORIGINS OF HEALTH AND DISEASE (DOHAD)—WHY IT IS SO IMPORTANT TO THOSE WHO WORK IN FETAL MEDICINE." *ULTRASOUND IN OBSTETRICS & GYNECOLOGY* 29 (2): 121-123.
- NEUHOFF, JORG. 2011. EPIGENETICS: EMBEDDED BODIES AND THE MOLECULARISATION OF BIOGRAPHY AND MILIEU. *BIOsocieties*: 6(3):279–298.
- NYSTROM, KENNETH C., AND GWEN ROBBINS SCHUG. 2020. "A BIOARCHAEOLOGY OF SOCIAL INEQUALITY AND ENVIRONMENTAL CHANGE." IN *THE ROUTLEDGE HANDBOOK OF THE BIOARCHAEOLOGY OF CLIMATE AND ENVIRONMENTAL CHANGE*. EDITED BY G. ROBBINS SCHUG. PP. 159-188. ABINGDON: ROUTLEDGE.
- OSIPOV, BENJAMIN ET AL. 2020. "THE EFFECT OF DIET AND SOCIOPOLITICAL CHANGE ON PHYSIOLOGICAL STRESS AND BEHAVIOR IN LATE ROMAN-EARLY BYZANTINE (300-700 AD) AND ISLAMIC (902-1,235 AD) POPULATIONS FROM IBIZA, SPAIN." *AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY* 172 (2): 189-213.
- PETRAGLIA, MICHAEL D., HUW S. GROUCUTT, MARIA GUAGNIN, PAUL S. BREEZE, AND NICOLE BOVIN. 2020. "HUMAN RESPONSES TO CLIMATE AND ECOSYSTEM CHANGE IN ANCIENT ARABIA." *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES* 117 (15): 8263-8270.
- RECHKEMMER, ANDREAS ET AL. 2016. "A COMPLEX SOCIAL-ECOLOGICAL DISASTER: ENVIRONMENTALLY INDUCED FORCED MIGRATION." *DISASTER HEALTH* 3 (4): 112-120.
- SCHULTE, PAUL A. AND HEEKYOUNG CHUN. 2009. "CLIMATE CHANGE AND OCCUPATIONAL SAFETY AND HEALTH: ESTABLISHING A PRELIMINARY FRAMEWORK." *JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL HYGIENE* 6 (9):542–554.
- SKINNER, MICHAEL K. ET AL. 2013. "ENVIRONMENTALLY INDUCED TRANSGENERATIONAL EPIGENETIC REPROGRAMMING OF PRIMORDIAL

GERM CELLS AND THE SUBSEQUENT GERM LINE." *PLoS ONE* 8 (7): e66318.

SMITH, KIRK R., ALISTAIR WOODWARD, D. CAMPBELL- LENDRUM, D.D. CHADEE, Y. HONDA, Q. LIU, L.L. WHITE (EDS.). 2014. CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY. PART A: GLOBAL AND SECTORAL ASPECTS. CONTRIBUTION OF WORKING GROUP II TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE: 709-754. CAMBRIDGE: CAMBRIDGE UNIVERSITY PRESS.

TEMPLE, DANIEL H. , AND ALAN H. GOODMAN. 2014. "BIOARCHAEOLOGY HAS A "HEALTH" PROBLEM: CONCEPTUALIZING "STRESS"AND "HEALTH" IN BIOARCHAEOLOGICAL RESEARCH." *AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY* 155 (2): 186-191.

TEMPLE, DANIEL H. 2018. BIOARCHAEOLOGICAL EVIDENCE FOR ADAPTIVE PLASTICITY AND CONSTRAINT:EXPLORING LIFE-HISTORY TRADE-OFFS IN THE HUMAN PAST. *EVOLUTIONARY ANTHROPOLOGY: ISSUES, NEWS, AND REVIEWS*.

THAYER, ZANETA M., AND AMY L. NON. 2015. "ANTHROPOLOGY MEETS EPIGENETICS: CURRENT AND FUTURE DIRECTIONS." *AMERICAN ANTHROPOLOGIST* 117 (4): 722-735.

WATTS, REBECCA. 2013. "CHILDHOOD DEVELOPMENT AND ADULT LONGEVITY IN AN ARCHAEOLOGICAL POPULATION FROM BARTON-UPON-HUMBER, LINCOLNSHIRE, ENGLAND." *INTERNATIONAL JOURNAL OF PALEOPATHOLOGY* 3 (2): 95-104.

WUTICH, AMBER. 2020. "WATER INSECURITY: AN AGENDA FOR RESEARCH AND CALL TO ACTION FOR HUMAN BIOLOGY." *AMERICAN JOURNAL OF HUMAN BIOLOGY* 32 (1): e23345.

YAUSSY, SAMANTHA L., SHARON N. DEWITTE, AND REBECCA C. REDFERN. 2016. "FRAILITY AND FAMINE: PATTERNS OF MORTALITY AND PHYSIOLOGICAL STRESS AMONG VICTIMS OF FAMINE IN MEDIEVAL LONDON." *AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY* 160:272-283.

ZERACH, GADI, YAFIT LEVIN, ROY ALONI, AND ZAHAVA SOLOMON. 2017. "INTERGENERATIONAL TRANSMISSION OF CAPTIVITY TRAUMA AND POSTTRAUMATIC STRESS SYMPTOMS: A TWENTY THREE-YEAR LONGITUDINAL TRIADIC STUDY." *PSYCHOLOGICAL TRAUMA: THEORY, RESEARCH, PRACTICE, AND POLICY* 9 (SUPPL 1): 114-121.

ZHANG, DAVID D., PETER BRECKE, HARRY F. LEE, YUAN-QING HE, AND JANE ZHANG. 2007. "GLOBAL CLIMATE CHANGE, WAR, AND POPULATION DECLINE IN RECENT HUMAN HISTORY." *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES* 104 (49): 19214-19219.

ZHANG, DIAN, CHIYUNG JIM, CHUSHENG LIN, YUANQING HE, AND FUNG LEE. 2005. "CLIMATE CHANGE, SOCIAL UNREST AND DYNASTIC TRANSITION IN ANCIENT CHINA." *CHINESE SCIENCE BULLETIN* 50 (2):

137-144.

ZUCKERMAN, MOLLY K., AND ASHLEY C. DAFOE. 2020. "DISEASE IN THE CONTEXT OF ENVIRONMENTAL CHANGE." IN *THE ROUTLEDGE HANDBOOK OF THE BIOARCHAEOLOGY OF CLIMATE AND ENVIRONMENTAL CHANGE*. EDITED BY G. ROBBINS SCHUG. PP. 43-59. ABINGDON: ROUTLEDGE.

CHAPTER 10

Fast Fashion: The World's Second Highest Poison

Dante Parker

Keywords: fast fashion, the real cost of cheap fashion, cheap fashion

Abstract. The purpose of this project is to divulge the damaging effects of the fashion and textile industry, specifically on the phenomenon known as fast fashion, and how efforts are being made to alleviate the amounts of pollution produced from the industry. Examples of major fast fashion companies will be presented while also showcasing alternative methods towards clothing production. Other problematic developments that correlate with or contribute to the manufacturing of these products will be further explained to further drive in the point that fast fashion is not only unsustainable for the environment, but also for the economy.

Introduction

Take a look at the tag of a piece of clothing in a retail store and chances are that it claims to contain 60% cotton among other fabrics, with a cheap price to seal the deal. But if such clothes cost so little, then the real cost must be elsewhere. I seek to examine the damaging effects that have risen from “fast fashion” and how this industry employs harmful methods of production. From the environmental toll it takes to create or dispose of cheap and short-lived fabrics, to the unhealthy chemicals workers are exposed to during the process in unsafe working environments, it's apparent that such exploitative methods are not conducive to a sustainable model. This in turn contributes to climate change thanks to things like CO₂ emissions and water waste while inversely being affected by climate change as using unsustainable measures makes it increasingly harder to extract raw

products like clothing material. However, there are attempts to reverse these effects on both the individual and corporate level, whether from anti-consumption sentiments to alternative and sustainable materials. Such endeavors will require the communal efforts of educating the masses and placing more pressure on fast fashion industries to make lasting impacts. The intention of this paper is to first discuss the emergence of the term “fast fashion,” and what major clothing companies propel this phenomenon by exploring the textiles used to construct clothes and where and how they're made *i.e.* who makes our clothes and how these workers are being treated. The paper will then go into detail about anti-consumption sentiments from some consumers and efforts they have made to combat pollution the industry produces through upcycling, DIYs, and sustainable materials before concluding on the damaging effects of fast fashion and how to curb such effects.

The conceptualization of fast fashion may be the result of a snowball effect. After the second world war, fashion had been minimalized to contribute to war efforts. As a result, *haute couture* (high fashion) in the 1940s and 1950s first emerged to accentuate “high quality, bespoke and exclusivity” (Heuer & Becker-Leifhold 2017, 52-53) to embrace style rivalry as a catalyst for sales to boost the economy. By focusing on style rivalry, this would encourage enough fashion companies to compete in order to move into the next stage of price rivalry. However, this model can only be maintained if production costs were kept low, and at the time 50% of clothes marketed towards the U.S.

were made in the U.S. (Anastasia 2017, 9). This would then result in lowered quality, especially with ready-to-wear clothes before exploding into fast fashion as it is known today (Tokatli 2008, 22).

With more clothes to choose from in conjunction with cheaper prices, this caused a surge in consumer demand, pushing companies to adopt tactics that favor developing countries for manufacturing fabrics (Tokatli 2008, 22). This is because as this surge in demand increases, the prices that companies offer wouldn't actually create a net profit unless they outsourced to countries where policies are more lenient on fair pay and treatment of workers. However, keeping such low prices is what entices consumers into choosing their brand over others in such a highly competitive market. Zara, for example, was especially known for using sweatshops from countries like Turkey, Morocco, and India for the sake of competitive advantage, and developing countries have shown their competence in manufacturing high-quality garments at high speeds (Tokatli 2008, 22). Now, retailers are competing to maximize speed and responsiveness of their supply chains to encourage shorter lead times, which is the length between how long a garment appears between the catwalk and retail stores, and high flexibility with consumer demands. It has even led to cases of developing countries creating what are deemed as counterfeits, where to an untrained eye they are "indistinguishable from the originals" (Tokatli 2008, 25). This can be problematic on both ends, since this produces an overabundance of products that leads to more waste while also letting competitors go unchecked in fabricating branding for more profit.

Making textiles isn't as cheap as it seems, especially when involving environmental cost. The fashion industry makes up 10% of greenhouse gas emissions, second only to the oil industry, as Americans buy 20 billion garments per year and the average weight an American throws away in clothes and shoes amounts to 76 pounds per year (Anastasia 2017, 9). The numbers are only increasing; consumers bought 60% more clothes in 2014 than in 2000, to an average of one garment bought per 5.5 days, but only keeping them at an average of 2.25 days (Kimbrough 2020, 1). Up to 92 million tons of textiles are burned or thrown in landfills, with one "British fashion brand Burberry

reporting that they burned or destroyed \$110 million worth of goods between 2013 and 2018 rather than sell at a discount and "devalue our brand" (Kimbrough 2020, 2).

When fashioning a garment, the cloth must be created from natural fibers grown in farms or chemically produced in labs. The material is then woven into fabric in factories where they can then be utilized as things such as clothes. About 20% of global wastewater is produced in the fashion supply chain, equating to about 79 trillion liters (Kimbrough 2020, 2). Cotton is the most egregious textile, as "one pair of jeans requires more than 2,500 liters, or enough to hydrate one person for 3.5 years" or 146 showers (Kimbrough 2020, 2). Distressed jeans produce worse results, and cotton alone accounts for 25% of all pesticides used in the U.S. (Anastasia 2017, 11). Pesticides aren't the only chemicals at fault, for the biggest carbon culprit is in fabric production. CO₂ emissions are at its most during the extraction process of synthetic fibers, made from petrochemicals that take "hundreds of years to biodegrade like polyester, rayon, nylon and acrylic" (Kimbrough 2020, 2). Polyester especially makes up 51% of textile production, and "since most manufactures are from developing countries where their factories are powered by coal, places like China have a 40% larger carbon footprint than Europe" (Kimbrough 2020, 2). These chemicals, compounded with greenhouse gas emissions and wastewater, leave not only a debilitating effect on the ecosystem but on people as well.

The ones most affected by these chemicals produced by factories are the workers within, but they also face other hazards while working in the industry. Locked in windowless rooms, garment workers in sweatshops based in Bangladesh are exposed to toxic fumes for extended periods with no breaks lest they risk losing their jobs (Anastasia 2017, 9). One of only many infrastructural issues, such atrocious conditions were highlighted when the Rana Plaza building in Bangladesh collapsed, killing 1,134 garment workers, and injuring 2,500 others (Kimbrough 2020, 2). The factory, which housed production for 29 major brands such as Benetton, Joe Fresh, and Mango, was overloaded with too many floors, workers, and equipment (Anastasia 2017, 10). Bangladesh is also

one of many countries that exhibit such working conditions in clothing factories, as this can similarly be seen in other developing countries.

Many of the victims of the clothing industry are young women who regularly endure health and safety hazards on top of low wages. In Ethiopia for example, factories pay \$26 a month, in comparison to the monthly living wage of \$100 a month (Kimbrough 2020, 3). There is also evidence of child labor and forced labor of women in recognizable brands like H&M, Forever 21, GAP, Zara from countries such as Argentina, Bangladesh, Brazil, China, India, Indonesia, the Philippines, Turkey, Vietnam and more (Kimbrough 2020, 3). A lot of these workers are treated extremely poorly; “[w]omen are routinely fired for being pregnant. They are harassed and abused on the factory floor” (Kimbrough 2020, 3). Many of whom will be fired if they even take a sick day from all the fumes they are exposed to or are immediately sent back to their workstation, to the detriment of their health (Anastasia 2017, 9-10).

What goes around comes back around, and the textile industry is intensely globalized. 35% of microplastics in the ocean are connected to fashion, a result of washing items constructed from acrylic and polyester, and can be found in seafood (Kimbrough 2020, 2). WWF even states that people may “ingest a credit card’s worth of plastic per week from drinking water, beer, shellfish, and salt” (Kimbrough 2020, 2). Even if those toxins were absent from these food products, chemical byproducts from the manufacturing process can affect personal health. Petroleum gas pollutes the air while pesticides washed into fresh water can cause a multitude of health problems such as asthma (Anastasia 2017, 11).

It even negatively affects the industry itself, as the carbon footprint they have left behind has contributed to climate change, shifting the demands of consumers to be as unpredictable as “natural” disasters (Kimbrough 2020, 2). As a result, retailers will start to see a decrease in sales that causes them to burn and destroy more of their products and will have to lay off more garment workers to cut losses. All of which will continuously lead towards a downward spiral as such a rise in unemployment can lead to backlashes from

lower global GDP to even protests and boycotts over unstable economic practices.

How the fashion and textile industry works is a series of long and complex supply chains. Manufacturing, dyeing, sewing, and storage can each take place in a different country. One clothing article is the result of at least a dozen actors and employs roughly 75 million workers, 80% of which “are often women [and] children” (Kimbrough 2020, 3). As this attire goes through the supply chain, each step takes up numerous energy and resources that result in environmental degradation and an excess of waste. One finished article sells on average for \$14.99, totaling to \$299.8 billion sold to Americans each year and contributes to a \$3 trillion global industry (Anastasia 2017, 9). Despite this, the income disparities are apparent as the end results aren’t completely fulfilled for those who made them.

Of those 75 million workers, workers in Bangladesh are paid less than \$3 for 1,000 garments per day, which equates to \$6.75 billion (assuming all 75 million were in Bangladesh): barely 2.3% of the gross domestic product from the U.S. alone (Anastasia 2017, 9). If Ethiopian workers were taken as an example with their base salary of \$26 per month, and it is assumed that all 75 million lived here, they make only 0.7% of total profit dividends. If it is assumed that the living wage was \$100 a month as stated before, for either example, this would still equate to only 2.5% of the gross domestic product (Anastasia 2017, 9). However, none of this would be able to sustain one person, let alone a whole family, in upkeeping a house, provisioning food, and ironically providing enough clothes that can last for the household.

Depressing realizations make any solution seem implausible, but there are ways to circumvent this reality. The most prevalent from consumers is to practice ethical consumption, which is defined as “the practice of consuming such clothing that is designed, sourced and manufactured in a way that maximizes benefits to people and communities while minimizing the negative impact on the environment” (Heuer & Becker-Leifhold 2017, 36). More shoppers are educating themselves on issues such as “animal welfare, fair wages, environmental and health

concerns,” the most pertinent being “child labor and human rights,” with changes apparent through examples like protests (Heuer & Becker-Leifhold 2017, 36). By practicing ethical consumption, consumers would be arguing for better pay and working conditions of garment workers that would also slow the tide of excess product and therefore allow for an ease of competition that doesn’t put human lives at risk for cheaper prices. Still, lack of changes in spending habits has been documented as “the ethical purchasing gap” phenomenon.

The ethical purchasing gap appears when there is a “significant gap between what consumers say about the importance of ethical issues and what they do at the checkout counter” (Heuer & Becker-Leifhold 2017, 37). This emerges due to a number of reasons codified under two factors. The first factor relates to the product itself, as the price and quality of the fabric tend to be the most important in the decision making process. Consumers may want to support ethical consumption but can’t handle the cost, or may assume that fair trade products are of inferior quality since the company is perceived to value ethical concerns more than quality standards. Hence why the fashion and style of the clothing also matters, since the purpose of clothes is for self-expression. Clients need to know there are a multitude of options that fall under fair trade.

Information can also be opportune for fair trade companies if provided adequately. Customers are even more likely to pay for premiums if the origins of the garments are spelled out explicitly, lest they accidentally support sweatshop purchases. Lastly, availability needs to be of high standards. As obvious as it may seem, there needs to be variety evident in clothing selection in order to suit different styles and a wider audience. Retailers also need to do better in advertising ethical garments because consumers rely on convenience. Not every potential buyer actively searches for fair trade products and needs to be given the option to make that choice.

The second factor in the ethical purchasing gap relates directly to the consumer. A major reason as to why desires for ethical consumption are over-reported is due to social desirability bias. This phenomenon is common in surveys when consumers tend to respond

in a socially acceptable way in surveys seeking to give “right” answers (Heuer & Becker-Leifhold 2017, 40). In essence, many respond that they yearn for it simply because they are expected to because “it’s the right thing to do.” A similar determinant is personal interest or relevance, as customers are more likely to adopt ethical issues if there is a personal interest or can be positively/negatively impacted as a result of such behavior. This also relates to values, as consumers also adopt brand personalities to express themselves. People are more willing to choose brands that express their personal values among society members.

This implies that consumers are heavily concerned with how others perceive themselves. Subjective and social norms can also influence their spending habits, as they assume certain products to be perceived as good by others. They then favor products that boost peer acceptance and social status. Habits through shopping inertia may impact them as well, to the point where such repetition is spontaneous. Therefore, their commitment towards brands can’t allow them to shift to more ethical alternatives. Inconvenience is cited by other customers to be the strongest barrier of them all. Because it takes considerable time and effort to seek out ethical purchases, most would rather not bother in doing so. For many, shopping is meant to be a fun way to escape daily routines, and this would only pile onto their other stressors and burdens.

The last curious factor concerns authenticity perceptions of brands. In regards to a brand’s pledge towards ethical issues, there comes to be two types of shoppers who oppose those assertions: the cynical and the skeptic. The cynic is informed about ethics but makes low ethical purchasing intentions. The skeptic “[questions] any claim to truth... consistency in logic, and adequacy of evidence” (Heuer & Becker-Leifhold 2017, 42). Certain customers are skeptical and cynical of a company’s ethical claims and therefore assume that they, the shoppers, are not actually making an impact. Instead, they believe the ethical claims to be nothing more than a marketing ploy to sway consumers.

These are no mere marketing ploys, as other consumers can testify. Fair trade apparel has seen a rise thanks to equally rising concerns about ethics in

the fashion industry, such as Germany's textile consumption increasing between 2014 and 2015 by 16.7% (Heuer & Becker-Leifhold 2017, 36). Fair trade apparel in Germany is noted however for being a niche market, which has encouraged hundreds of start-ups to create clothes from recycled or natural fabrics. They also "employ U.S. factories where they can better monitor working conditions, and some big retailers have even caught on by rewarding customers to recycle back to their stores" (Anastasia 2017, 11).

Fashion online platforms have been utilized to increase awareness or to streamline online shopping through sites like GreenApes, Better World Apparel and People Tree, but some studies point out that creativity is a great way to combat fast fashion (Heuer & Becker-Leifhold 2017, 53). Some participants were willing to go through a "fashion detox" of 10 weeks by banning fashion consumption. They discovered that they could find great alternatives through reusing and redesigning old clothing items, and afterwards were more willing to adopt other sustainable methods like rentals and clothes swapping. Researchers then concluded that by increasing creativity, they were encouraging slower fashion (Heuer & Becker-Leifhold 2017, 53).

Other DIY options have seen an increase in participation. Thrifting clothes and upcycling some of them, a process through modifying the base materials into new clothing articles, is seen to be the purest form of exercising one's creativity through fashion. Elizabeth L. Cline, who published *Overdressed: The Shockingly High Cost of Cheap Fashion*, had converted herself into a sustainable consumer "by mending and making her own clothes" (Biehl-Missal 2013, 245). She even coined this term as "make, alter, mend," and had chosen this lifestyle not because of ethical concern, but because it was a cheaper alternative (Biehl-Missal 2013, 255).

Solutions don't fall solely on the shoulders of consumers alone. Retailers must exercise what is known as the Emotionally Durable Design to understand the motives behind consumption while slowing fashion (Heuer & Becker-Leifhold 2017, 54). The design's intent is to create more meaningful products that instill emotional attachment from the

customer. This would extend the use-time of the product and would utilize some materials that are considered to age aesthetically, but place considerable importance on the pleasure of use. All of this would require further consumer-centered information to meet the needs necessary to make the garment last (Heuer & Becker-Leifhold 2017, 54).

Lastly, there are efforts to even create alternative materials to sustain fashion in a durable manner. One of the more promising experiments looks at the application of kombucha bacterial cellulose as textile fibers similar to cotton and rayon (Domskiene, Jurgita, Florentina Sederaviciute, & Judita Simonaityte 2019, 644). However, what makes it stand out is that it is a renewable source that is easy to replicate and can biodegrade food and textile waste as a source of fuel. The kombucha bacterial cellulose can utilize any carbon source but seems to function best with sugar. Nevertheless, it is an eco-friendly alternative to cotton and may prove especially beneficial in reducing the carbon footprint and water waste of fashion industries.

That isn't to say that the experiment is without faults. Still in its preliminary stages, the cellulose requires further testing with less impurities. The point of the experiment was to produce a material that not only replicates itself, but also to reduce needs in the makeup of raw materials by maximizing net product over margins of error waste. As such, signs of impurities implies that it has a long way to go. This can then properly assess the peculiar properties of the material with different binding agents and hydrophobic finishes to maintain elasticity and tensile strength. Until then, kombucha bacterial cellulose is too brittle and non-elastic for generalized use under room temperature but is a great step in curbing fast fashion's destructive practices and certainly isn't the only material under testing.

Fast fashion has taken a toll on the environment, the people, and to the industry itself. Some consumers have taken it upon themselves to develop more sustainable alternatives, while companies have been designed as a response to high retail brands like Zara and H&M. Even so, substantial efforts to reverse the effects of textile and chemical waste can only come from these very high-profile brands, and the

responsibility to put pressure on such demands falls on their consumers. Not to mention that companies can only go through so many workers before they find that willing laborers that aren't handicapped or suffering from other debilitations will be extremely limited. Time is limited; the fashion industry has already realized that its unsustainable practices won't last forever. Who knows if Earth will outlast the damages.

References

ANASTASIA, LAURA. 2017. "THE REAL COST OF CHEAP FASHION." *THE NEW YORK TIMES UPFRONT* 1: 8-11.

BIEHL-MISSAL, BRIGITTE. 2013. "ART, FASHION, AND ANTI-CONSUMPTION." *JOURNAL OF MACROMARKETING* 33 (3): 245-257.

DOMSKIENE, JURGITA, FLORENTINA SEDERAVICIUTE, AND JUDITA SIMONAITYTE. 2019. "KOMBUCHA BACTERIAL CELLULOSE FOR SUSTAINABLE FASHION." *INTERNATIONAL JOURNAL OF CLOTHING SCIENCE AND TECHNOLOGY* 31 (5): 644-662.

HEUER, MARK, AND CAROLIN BECKER-LEIFHOLD. 2017. "DRIVERS AND OBSTACLES OF ETHICAL FASHION CONSUMPTION"; "KNOWING BETTER, BUT BEHAVING EMOTIONALLY"; "FROM MYOPIA TO BOYCOTT"; "ENABLING SUSTAINABLE BEHAVIORS THROUGH M-COMMERCE APP DESIGN"; "CONSUMER COLOUR AND STYLE PREFERENCES"; "LOOKING BACKWARDS AND FORWARDS IN SUSTAINABLE FASHION." IN *ECO-FRIENDLY AND FAIR: FAST FASHION AND CONSUMER BEHAVIOR*, 36-91. LONDON: TAYLOR & FRANCIS.

KIMBROUGH, LIZ. "TRENDY, CHEAP, AND DIRTY: FASHION IS A TOP GLOBAL POLLUTER." ACCESSED SEPTEMBER 26, 2020.
[HTTPS://NEWS.MONGABAY.COM/2020/04/TRENDY-CHEAP-AND-DIRTY-FASHION-IS-A-TOP-GLOBAL-POLLUTER/](https://news.mongabay.com/2020/04/trendy-cheap-and-dirty-fashion-is-a-top-global-polluter/).

TOKATLI, NEBAHAT. 2008. "GLOBAL SOURCING: INSIGHTS FROM THE GLOBAL CLOTHING INDUSTRY - THE CASE OF ZARA, A FAST FASHION RETAILER." *JOURNAL OF ECONOMIC GEOGRAPHY* 8: 21-38.

Part IV

Climate Change and Applied Anthropology

CHAPTER 11

Postmortem Interval Estimation (PMI) Ramifications of a Newly Recorded Forensically Relevant Blow Fly Species in East Tennessee

Hayden McKee-Zech and Sara Fatula

Keywords: Climate Change, *Chrysomya megacephala*, PMI_{MIN} estimation.

Abstract. Minimum postmortem interval (PMI_{MIN}) estimations are a central part of death investigations that help establish a timeframe of events that have occurred after death. Entomological evidence in the form of larval development rate and arthropod succession are commonly used to generate PMI_{MIN} estimations. A previously undocumented blow fly species was collected during a longitudinal field experiment following two sets of human remains at the Anthropology Research Facility (ARF) at the University of Tennessee, Knoxville (UTK) in the fall of 2020 (Owings et al. 2021). The Oriental Latrine Fly, *Chrysomya megacephala* (Fabricius), is a tropical fly of economic, agricultural, and forensic importance that invaded the United States three decades ago and has continued to expand its range throughout the country (Jones et al. 2019; Owings et al. 2021; Whitworth 2006). When compared to the past 30 years, Knoxville witnessed its 3rd warmest January in 2020, followed by 2017 and 2016 (Tolleson and Joyner 2020), with similar trends predicted to continue and thought to be the result of climate change. This paper will examine the impact of climate change and how the resulting change to average seasonal temperatures may influence blow fly diversity in East Tennessee. Specifically, we hypothesize that average temperature changes have facilitated significant range expansions of forensically important insects. As these trends are likely to continue, it will be of utmost importance to

track these species as their presence may have broader agricultural and economic impacts and mistaking these species for native species could lead to inaccurate PMI_{MIN} estimations in death investigations.

Introduction

Estimation of the postmortem interval (PMI_{MIN}) is an important component of death investigations as it aids in establishing a timeframe for when events occurred following death. In addition to morphological changes to the body, the use of insect succession and developmental rates are often used to generate these estimates. Since entomological estimations of the PMI_{MIN} are dependent on temperature, climate change could potentially alter the accuracy of such estimations. The Anthropology Research Facility (ARF) at the University of Tennessee is an outdoor research facility dedicated to the study of decomposition. Here, a previously undocumented blow fly species was collected during a longitudinal field experiment following two sets of human remains in the fall of 2020. Why the tropical fly species *Chrysomya megacephala* (Fabricius) has invaded and expanded throughout the USA is thought to be a result of a changing climate (Owings et al. 2021; Owings and Picard 2018). In Knoxville, where the ARF is located, temperatures have been continuing to rise with 2020

being the 3rd warmest January, followed by 2017 and 2016 (Tollesfson and Joyner 2020). This paper will examine the impacts of climate change and changes to average seasonal temperatures, and how they may have facilitated the expansion of certain blow fly species to East Tennessee. As climate change trends are expected to continue, documenting the ranges of forensically relevant blow flies will be vital to producing accurate postmortem interval estimates.

Climate Change and Global Warming

Jozefat (2015, 61) defines global warming as “the gradual increase in temperature of the earth’s atmosphere, usually attributed to the greenhouse effect.” It is widely accepted that the earth’s climate is influenced by the amount of solar radiation present, which can increase or decrease with the distance between the earth and sun and whether more or less radiation can be reflected back into space from the earth’s surface (Jozefat 2015). Anthropogenic factors, such as the increased burning of fossil fuels and destruction of forests, have created a blanket of greenhouse gases that prevent infrared radiation from being able to escape the earth’s atmosphere. This has led earth to be in a consistent warming period for approximately the last 300 years, as well as creating more humid environments as one travels further from the equator (Jozefat 2015). In the United States, Tennessee is in the top one-third of total energy consumption due to the state economy’s reliance on manufacturing and transportation industries (Tennessee State Profile and Energy Estimates 2020). According to the Tennessee Valley Authority, there are five active coal-fired fossil plants within Tennessee with a total of 25 generating units (TVA 2020). However, in an effort to be more environmentally conscious, they have started repurposing the ash-byproducts of these plants for various projects and installing emission reduction technologies at each of the five plants. While these efforts are better than none, they are not enough to reduce the harmful effects that these plants have had since their inception in the 1950s.

In addition to the anthropomorphic effects of fossil fuel burning and deforestation, naturally occurring events

can have significant impacts on an area’s climate. In the eastern United States, one of these naturally occurring factors is the North Atlantic Oscillation (NAO), which reflects variations in the air pressure over the Northern Atlantic between a positive and negative phase, with a phase reversal occurring at least once every ten years (Wong and Pape 2015, 17). When the NOA is in a positive phase, the Eastern United States experiences above-average temperatures and increased precipitation and storms, while a negative phase brings below-average temperatures and drier conditions (Wong and Pape 2015, 17-18). The United States was previously in a positive phase with a negative phase expected to bring below-average temperatures and drier conditions. In contrast to the NAO, the Atlantic Multidecadal Oscillation (AMO) cycles can last 20-40 years, with warm phases bringing a reduction in rainfall across the United States and cold phases bringing increased rainfall (Wong and Pape 2015, 19). The United States is experiencing a warm phase of the AMO, thus experiencing reduced rainfall and increased temperatures (National Oceanic and Atmospheric Administration 2019).

In 2020, the contiguous United States experienced the 3rd warmest August, the 4th warmest summer, and 7th warmest January-August on record (National Oceanic and Atmospheric Administration 2020). The Contiguous United States also experienced below-average rainfall in August 2020, while the Southeast United States experienced above-average precipitation (National Oceanic and Atmospheric Administration 2020). It is likely these warmer temperatures are due to a combination of fossil fuel burning, deforestation, greenhouse gas emissions, and the United States currently being in the warm phase of the AMO, thus making more areas inhabitable to a wider variety of species, such as the blow fly *Chrysomya megacephala* (Fabricius). There is evidence that other species ranges are changing, recent scientific articles have been published that *Lucilia cuprina* and *C. megacephala* have expanded their range to central Indiana, a location where they have not previously been documented (Owings and Picard 2018; Picard 2013). *Chrysomya megacephala* has now been identified for the first time in an

additional location: the Anthropology Research Facility at the University of Tennessee, Knoxville (Owings et al. 2021). These articles have indicated that slight habitat changes each year may make a region more hospitable to different species and are likely to influence the new ranges observed; however, high resolution sampling each year of the population within a region and extensive climate data would be needed to validate this claim. (Owings and Picard 2018, Owings et al. 2021).

Climate Change at the University of Tennessee Anthropology Research Facility

In The Anthropology Research Facility is a fenced, forested environment meant to simulate outdoor decomposition scenarios. Like any forested area, the effects of climate change can vary based on site-specific factors, including: soil depth, soil water-holding abilities, and the capacity of the species inhabiting the area to adapt to increased temperature and precipitation (Dale et al. 2010). While the wider global and national climate data matters, immediate local conditions for East Tennessee (Climate Zone 4) (International Code Council 2012) have significant impacts on the types of flora and fauna that can successfully occupy the Anthropology Research Facility. In the 20th century, Tennessee experienced little overall warming except for the 1920s-1930s (Runkle et al. 2017). However, the opposite is expected to occur during the 21st century and significant warming episodes are expected (Runkle et al. 2017).

According to the Tennessee Climate Office housed at Eastern Tennessee State University, January 2020 was considered warmer and wetter than normal, with Knoxville experiencing its 3rd warmest January after 2017 and 2016 (Tolleson and Joyner 2020). It is expected that these trends will continue, having a major impact on which species may be able to invade this previously uninhabitable area. The National Centers for Environmental Information – Knoxville Airport Station provides daily summaries on temperature and precipitation data. When comparing 2000 to 2020, Knoxville experienced increases in the average high and low temperatures for January, while

April and August remained stable (National Centers for Environmental Information 2020).

This changing January climate may indicate that the effects of climate change for the Knoxville area (Climate Zone 4) (International Code Council 2012) are more pronounced during the winter months. This is important because springs and summers in Knoxville already experience warm and humid weather conducive to insect survival, however, the winter months may have previously inhibited long-term habitation. Some species of blow flies have subsistence strategies to survive over winter in a habitat via diapause or a period of arrested development and are able to continue development at relatively low temperatures. Other species are not able to survive the colder temperatures of late fall and winter and die off entirely in an environment only to re-enter an environment in the spring when the temperatures are viable again. Blow fly development is dependent on surrounding environmental factors, including but not limited to, temperature and adequate access to nutrients (Byrd and Allen 2001). When a deceased individual is found and entomological methods of (PMI_{MIN}) estimation are employed an accurate determination of the temperature that the larvae have been developing under needs to be established whether it was on or off the body. Then the size and feeding stage are related to a suitable published developmental dataset of size and stage at different temperatures to determine the duration of development (Amendt et al 2007). If the winter months are warming, this may provide a longer interval of survivability for *Chrysomya megacephala*, making the Anthropology Research Facility (Climate Zone 4) (International Code Council 2012) and the wider East Tennessee area, an appealing new environment to inhabit.

Species Range Expansion

Chrysomya megacephala is native species of south Asia, Australia and the Pacific and was most likely introduced to the Americas via Brazil around 1975 with an increase in trade along with three other *Chrysomya* species (i.e., *Chrysomya rufifacies* (Macquart), *Chrysomya chloropyga* (Wiedemann), *Chrysomya*

albiceps (Wiedemann)) (Baumgartner and Greenberg 1984, 105). *Chrysomya megacephala* arrived in the United States in the early 1980's (Baumgartner and Greenberg 1984, 105) and was first recorded in California in 1988 (Greenberg 1988). Over the next three decades *C. megacephala* was documented across much of the American south and southeast, including Texas (Wells 1991), Florida (Bryd and Butler 1997), Alabama (Wells 2000), Georgia (Tomberlin et al. 2001), Louisiana (Pharr 2009), North Carolina (Cammack et al. 2016) and East Tennessee (Owings et al. 2021) and as far north as Indiana (Picard 2013). Jones et al. (2019) considers *C. megacephala* an uncommon species in North America and not established; however, with a changing climate this is subject to change and further investigation is needed to document the full range of this species.

Another example of range expansion is *C. rufifacies*, which is native to Australia and expanded their range across Asia, South America and North America and experiences a seasonal range expansion north into Ontario, Canada (Rosati and VanLaerhoven 2007, 670). *Chrysomya rufifacies* was introduced at a similar time to *C. megacephala* and was documented to rapidly disperse through Central America (Baumgartner and Greenberg 1984, 105). *Chrysomya rufifacies* was then documented in Tuxtla, Chiapas, Mexico two years later, Durango State, Mexico within three years after, Brackettville, Texas, two and a half years later and then Texas-Oklahoma another two years later, thus expanding their range from Central America to south-western America in just under a decade (Baumgartner and Greenberg 1984). Since then, *C. rufifacies* has been widely documented throughout North America, including but not limited to Colorado (De Jong et al. 1997), Louisiana (Meeks et al. 1998), Tennessee (Shahid et al. 2000), Ontario, Canada (Rosati and VanLaerhoven 2007), South Carolina (Cammack and Nelder 2010), and Wisconsin (Marche II 2013).

These two species are both invasive to the Americas and are competing not only with one another but also with native species within their expanded ranges. There was no obvious barrier to the northward spread of the different *Chrysomya* species in South America,

and their eventual arrival to North America was inevitable (Baumgartner and Greenberg 1984, 112; Greenberg 1988, 200; Rosati and VanLaerhoven 2007, 671). The spread does seem to be impeded by seasonal differences; however, with the changing global climate condition trending to warmer temperatures leading to further range expansions for the *Chrysomya* genus.

Consequences of Climate Change Range Expansion

The introduction of non-native species within a system can have many ecological, economic, and genetic impacts (Lee 2002). Due to the inability to accurately predict the probability of successful invasion and its impacts, current methodologies that are employed to prevent and contain the widespread invasion of species are relatively ineffective (Lodge 1993; Lui 2020). Thus, the global impact on changing species ranges and invasion patterns is difficult to predict (Lui 2020). Over the past two decades, four species of Old World *Chrysomya* Robineau-Desvoidy species have been introduced into the New World. *Chrysomya albiceps* and *C. chloropyga* are currently established in South America (Wells 1991:471), while *C. megacephala* and *C. rufifacies* are the only two that can be found in North America (Jones et al. 2019). The introduction, establishment, and dispersal of these non-native species could have many potential negative impacts on native blow fly species and humans.

Ecologically, these impacts include disturbance to the food web, increasing competition to resources, and alteration of the abundance or diversity of native species. Over the past decades the impact of climate on pests and host species has been growing in significance (Liu 2020, 2). This impact and growth of disturbance correlates with distribution, physiology, phenology, genetics and behavior of many invasive species (Parmesan 2006).

Medically, *C. megacephala*, as well as other species of blow flies, poses a health risk as this species has the potential to produce myiasis, a parasitic infestation of developing fly larvae in the skin or muscle tissue of a living animal (Ferraz et al. 2010; Liu et al. 2013).

However, *C. megacephala* has a penchant for both feces and carrion, both of which they can employ as a developmental substrate which is a unique evolutionary trait of this species (Ferraz et al. 2010). This raises the concern of this particular species becoming a vector of disease and enabling the spread of antibiotic resistant bacteria (Liu et al. 2013). The common house fly, *Musca domestica* (Linnaeus) has long been vilified and documented as a disseminator of bacteria, protozoa, viruses and helminth eggs (Greenberg, 1968, 1973; Kobayashi et al, 1999). *Chrysomya megacephala* has only recently emerged as a leading vector of disease transmission among blowflies (Monzon et al 1991). In fact, *C. megacephala* has been documented as significantly more likely to carry bacteria, protozoa, viruses and helminth eggs than *M. domestica* and other flies (Brits et al. 2016, Monzon et al. 1991; Sukontason et al. 2007; Wallace 1971). While *C. megacephala* has been shown to carry a less diverse load of pathogenic species than its counterpart *M. domestica*; the species *C. megacephala* do carry are medically significant to humans (Liu et al. 2013; Sukontason et al. 2007;)

Consequences of Climate Change for Forensics

Forensically, by establishing new ranges in North America, these previously undocumented species challenge current understandings of blow fly diversity. If such changes to local carrion insect communities have not been tracked or considered by a forensic entomologist, the ensuing Minimum postmortem interval (PMI_{MIN}) estimation could be faulty. Specifically, misclassifying invasive species as native species is likely to produce inaccurate estimations as development rate (the phenotype used to make an entomological estimation) is highly species-specific. Therefore, active surveillance and tracking of introduced and invasive species is of utmost importance in forensic entomology. PMI_{MIN} estimations are a central part of the death investigation that helps establish a timeframe of events that have occurred after death. Entomological evidence in the form of larval development rate and arthropod succession are commonly used to generate PMI_{MIN} estimations. These methods are dependent on consistent,

predictable temperatures and species determination. For example, if larvae identified as *C. megacephala* were recovered from a crime scene, a published dataset specific for this species (e.g., Badenhorst & Villet 2018) would be used to estimate PMI_{MIN} dependent on the development rate at a specific temperature. Since insects are poikilothermic, their physiological activity is directly correlated with ambient temperature. Climate change is predicted to continue to result in variable temperatures across the contiguous United States, with more extreme temperatures having an impact on insect activity levels. Thus, since entomological estimations of the PMI_{MIN} are dependent on temperature, climate change could potentially alter the accuracy of such estimations.

Longitudinal studies have been conducted to document the succession of insects in varying environments and seasons; many of these studies in East Tennessee have not been updated since their inception in the late 80 to early 90s (e.g., Rodrigues and Bass 1983, Schoenly 1992). Varying species range creates an inherent problem within succession methods (i.e., the semi-predictable chronological changes in insect community composition on the body) of PMI_{MIN} estimation that may cause a misrepresentation of the true PMI. For example, *C. rufifacies*, can be cannibalistic in nature (Goodbrod and Goff 1990) to other established species in the US such as *Phormia regina* (Meigen), *Cochliomyia macellaria* (Fabricius) and *Lucilia sericata* (Meigen). At the ARF, we have observed resource partitioning between native species and *C. rufifacies* due to both consumptive effects (i.e., predation of other species by *C. rufifacies*) and non-consumptive effects (i.e., the mere presence of *C. rufifacies* causes other species to abandon the remains). Results of non-consumptive effects can be observed as premature *en masse* dispersal in an attempt to avoid *C. rufifacies*. This causes a disruption to the known arthropod community patterns which forms the basis of succession PMI_{MIN} estimations. With the continued dispersal and arrival of different blow fly species due to climate change and variable extreme temperatures, commonly employed PMI estimates may no longer be accurate.

Conclusion

Future efforts in East Tennessee should include baited sweep and trap experiments over numerous months to represent various seasons and temperature range. The results of these experiments would demonstrate the richness and abundance of these non-native species in East Tennessee. These efforts would allow for established changes in range and impacts of these species' arrival to native species populations and success to be quantified. The results of which would be beneficial for forensic entomologists that are looking to apply methods of PMI_{MIN} estimation in a death investigation in the region. The PMI_{MIN} is a vital part of the death investigation as it designates the timeline of events, which have an impact on other aspects of the death investigation, such as identification of the victim and potential suspects. The PMI_{MIN} allows the timeframe to be designated, thus influencing who the pool of potential missing persons could be and which alibis of potential suspects check out. Delays in the death investigation may cause unnecessary burdens to families seeking justice and the investigators working on the case. Having an accurate understanding of the blow fly species within one's area is crucial to allowing for a death investigation to proceed with limited resources lost.

References

- AMENDT, JENS, CARLO P. CAMPOBASSO, EMMANUEL GAUDRY, CHRISTIAN REITER, HELENE N. LEBLANC, AND MARTIN J.R. HALL. 2007. "BEST PRACTICE IN FORENSIC ENTOMOLOGY—STANDARDS AND GUIDELINES." *INTERNATIONAL JOURNAL OF LEGAL MEDICINE* 121:90–104
- BADENHORST, ROZANE AND MARTIN H. VILLET. 2018. "THE USES OF *CHRYSOMYA MEGACEPHALA* (FABRICIUS, 1794) (DIPTERA: CALLIPHORIDAE) IN FORENSIC ENTOMOLOGY." *FORENSIC SCIENCES RESEARCH* 3: 2-15.
- BAUMGARTNER, DONALD L., AND BERNARD GREENBERG. 1984. "THE GENUS *CHRYSOMYA* (DIPTERA: CALLIPHORIDAE) IN THE NEW WORLD." *JOURNAL OF MEDICAL ENTOMOLOGY* 21(1): 105-113.
- BRITS, DEVON, MARGOT BROOKS, AND MARTIN HERRER VILLET. 2016. "DIVERSITY OF BACTERIA ISOLATED FROM THE FLIES *MUSCA DOMESTICA* (MUSCIDAE) AND *CHRYSOMYA MEGACEPHALA* (CALLIPHORIDAE) WITH EMPHASIS ON VECTORED PATHOGENS." *AFRICAN ENTOMOLOGY* 24(2): 365-375.
- BYRD, JASON H., AND JERRY F. BUTLER. 1997. "EFFECTS OF TEMPERATURE ON *CHRYSOMYA RUFIFACIES* (DIPTERA: CALLIPHORIDAE) DEVELOPMENT." *JOURNAL OF MEDICAL ENTOMOLOGY* 34: 353-358.
- BYRD, JASON H., AND JON C. ALLEN. 2001. "THE DEVELOPMENT OF THE BLACK BLOW FLY, *PHORMIA REGINA* (MEIGEN)." *FORENSIC SCIENCE INTERNATIONAL* 15(120):79-88.
- CAMMACK, JONATHAN A., AND MARK P. 2010. "COOL-WEATHER ACTIVITY OF THE FORENSICALLY IMPORTANT HAIRY MAGGOT BLOW FLY *CHRYSOMYA RUFIFACIES* (MACQUART)(DIPTERA: CALLIPHORIDAE) ON CARRION IN UPSTATE SOUTH CAROLINA, UNITED STATES." *FORENSIC SCIENCE INTERNATIONAL* 195(1-3): 139-142.
- CAMMACK, JONATHAN A., ALLEN C. COHEN, KIMBERLY L. KREITLOW, MICHAEL R. ROE, AND WES D. WATSON. 2016. "DECOMPOSITION OF CONCEALED AND EXPOSED PORCINE REMAINS IN THE NORTH CAROLINA PIEDMONT." *JOURNAL OF MEDICAL ENTOMOLOGY* 53: 67-75.
- DALE, VIRGINIA H., LYNN M. THARP, KAREN O. LANNOM, AND DONALD G. HODGES. 2010. "MODELING TRANSIENT RESPONSE OF FORESTS TO CLIMATE CHANGE." *SCIENCE OF THE TOTAL ENVIRONMENT* 408:1888-1901.
- DE JONG, GRANT D., AND JAMES W. CHADWICK. 1997. "ADDITIONAL COUNTY RECORDS AND A CORRECTION TO THE CHECKLIST OF THE CALLIPHORIDAE (DIPTERA) OF COLORADO, WITH A NEW STATE RECORD FOR *CHRYSOMYA RUFIFACIES*." *JOURNAL OF THE KANSAS ENTOMOLOGICAL SOCIETY*: 47-51.
- FERRAZ, ADRIANA CP., BARBARA PROENÇA, BQ GADELHA, LM FARIA, MGM BARBALHO, VALÉRIA AGUIAR-COELHO, AND CLAUDIA LESSA. 2010. "FIRST RECORD OF HUMAN MYIASIS CAUSED BY ASSOCIATION OF THE SPECIES *CHRYSOMYA MEGACEPHALA* (DIPTERA: CALLIPHORIDAE), *SARCOPHAGA* (LIOPYGIA) *RUFICORNIS* (DIPTERA: SARCOPHAGIDAE), AND *MUSCA DOMESTICA* (DIPTERA: MUSCIDAE)." *JOURNAL OF MEDICAL ENTOMOLOGY* 47: 487-490.
- GOODBROD, JAMES R., AND M. LEE GOFF. 1990. "EFFECTS OF LARVAL POPULATION DENSITY ON RATES OF DEVELOPMENT AND INTERACTIONS BETWEEN TWO SPECIES OF *CHRYSOMYA* (DIPTERA: CALLIPHORIDAE) IN LABORATORY CULTURE." *JOURNAL OF MEDICAL ENTOMOLOGY* 27(3): 338-343.
- GREENBERG, BERNARD. 1968. "MODEL FOR DESTRUCTION OF BACTERIA IN THE MIDGUT OF BLOW FLY MAGGOTS." *JOURNAL OF MEDICAL ENTOMOLOGY* 5(1): 31-38.
- GREENBERG, BERNARD. 1973. "FLIES AND DISEASE. VOL. II. II. BIOLOGY AND DISEASE TRANSMISSION." *FLIES AND DISEASE. VOL. II. II. BIOLOGY AND DISEASE TRANSMISSION.*

GREENBERG, BERNARD. 1988. "CHRYSONYIA MEGACEPHALA (F.) (DIPTERA: CALLIPHORIDAE) COLLECTED IN NORTH AMERICA AND NOTES ON CHRYSONYIA SPECIES PRESENT IN THE NEW WORLD." *JOURNAL OF MEDICAL ENTOMOLOGY* 25(3):199-200.

INTERNATIONAL CODE COUNCIL. 2012. IECC CLIMATE ZONE MAP. 2012 IECC-INTERNATIONAL ENERGY CONSERVATION CODE. ACCESSED [MARCH 13, 2021] [HTTPS://BASC.PNNL.GOV/IMAGES/IECC-CLIMATE-ZONE-MAP](https://BASC.PNNL.GOV/IMAGES/IECC-CLIMATE-ZONE-MAP)

JOZEFAT, BRIAN. 2015. "CLIMATE CHANGE AND ALL EVIDENCES OF GLOBAL WARMING." IN *CLIMATE CHANGE*, EDITED BY KAU-FUI V. WONG, 61-74. NEW YORK: MOMENTUM PRESS.

KOBAYASHI, MUTSUO, TOSHINORI SASAKI, NORIKO SAITO, KAZUMICHI TAMURA, KENJI SUZUKI, HAROU WATANABE, AND NORIAKI AGUI. 1999. HOUSEFLIES: NOT SIMPLE MECHANICAL VECTORS OF ENTEROHEMORRHAGIC ESCHERICHIA COLI O157: H7. *THE AMERICAN JOURNAL OF TROPICAL MEDICINE AND HYGIENE*, 61(4): 625-629.

LEE, CAROL E. 2002. "EVOLUTIONARY GENETICS OF INVASIVE SPECIES". *TRENDS IN ECOLOGY & EVOLUTION* 17(8):386-391.

LIU, YANG, YU YANG, FENG ZHAO, XUEJUN FAN, WEI ZHONG, DAIRONG QIAO, AND YI CAO. 2013 "MULTI-DRUG RESISTANT GRAM-NEGATIVE ENTERIC BACTERIA ISOLATED FROM FLIES AT CHENGDU AIRPORT, CHINA." *SOUTHEAST ASIAN JOURNAL OF TROPICAL MEDICINE AND PUBLIC HEALTH* 44:988 - 996.

LIU, YANG, AND JUAN SHI. 2020. "PREDICTING THE POTENTIAL GLOBAL GEOGRAPHICAL DISTRIBUTION OF TWO ICERYIA SPECIES UNDER CLIMATE CHANGE." *FORESTS* 11(6): 684.

LODGE, DAVID M. 1993. "BIOLOGICAL INVASIONS: LESSONS FOR ECOLOGY." *TRENDS IN ECOLOGY & EVOLUTION* 8(4): 133-137.

MARCHE II, JORDAN D. 2013. "FIRST RECORD OF CHRYSONYIA RUFIFACIES (DIPTERA: CALLIPHORIDAE) IN WISCONSIN." *THE GREAT LAKES ENTOMOLOGIST* 46.1(1-2): 135-137.

MEEK, CHESTER L., C. PUSKARICH-MAY, AND CHRISTOPHER E. CARLTON. 1998. "NEW STATE RECORD FOR THE HAIRY MAGGOT BLOW FLY CHRYSONYIA RUFIFACIES (MACQUART)." *THE SOUTHWESTERN ENTOMOLOGIST (USA)* 23(4): 373-375.

MONZON, R. B., SANCHEZ, ALVARO BUENO, TADIAMAN, B. M., NAJOS, O. A., VALENCIA, E. G., DE RUEDA, R. R., AND VENTURA, J. V., 1991. "A COMPARISON OF THE ROLE OF *MUSCA DOMESTICA* (LINNAEUS) AND *CHRYSONYIA MEGACEPHALA* (FABRICIUS) AS MECHANICAL VECTORS OF HELMINTHIC PARASITES IN A TYPICAL SLUM AREA OF METROPOLITAN MANILA." *SOUTHEAST ASIAN J TROP MED PUBLIC HEALTH*, 22(2): 222-228.

NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION. "KNOXVILLE AIRPORT, TN, US. DAILY SUMMARIES STATION DETAILS." ACCESSED [OCTOBER 18, 2020]. [HTTPS://WWW.NCDC.NOAA.GOV/CDO-WEB/DATASETS/GHCND/STATIONS/GHCND:USW00013891/DETAIL](https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USW00013891/DETAIL).

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. "ATLANTIC HIGH-ACTIVITY ERAS: WHAT DOES IT MEAN FOR HURRICANE SEASON?" NOVEMBER 22, 2019. ACCESSED [FEBRUARY 24, 2021]. [HTTPS://WWW.NOAA.GOV/STORIES/ATLANTIC-HIGH-ACTIVITY-ERAS-WHAT-DOES-IT-MEAN-FOR-HURRICANE-SEASON](https://www.noaa.gov/stories/atlantic-high-activity-eras-what-does-it-mean-for-hurricane-season)

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. "FREQUENTLY ASKED QUESTIONS ABOUT THE ATLANTIC MULTIDECADAL OSCILLATION (AMO)." PUBLISHED NOVEMBER 9, 2005. ACCESSED [OCTOBER 7, 2020]. [HTTPS://WWW.AOML.NOAA.GOV/PHOD/AMO_FAQ.PHP](https://www.aoml.noaa.gov/phod/AMO_FAQ.PHP)

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION. "STATE OF THE CLIMATE: NATIONAL CLIMATE REPORT FOR AUGUST 2020." PUBLISHED ONLINE SEPTEMBER 2020. ACCESSED [OCTOBER 5, 2020] [HTTPS://WWW.NCDC.NOAA.GOV/SOTC/NATIONAL/202008](https://www.ncdc.noaa.gov/sotc/national/202008)

OWINGS, CHARITY G., AND CHRISTINE J. PICARD. 2018. "NEW DISTRIBUTION RECORD FOR LUCILIA CUPRINA (DIPTERA: CALLIPHORIDAE) IN INDIANA, UNITED STATES." *JOURNAL OF INSECT SCIENCE* 18(4):1-6.

OWINGS, CHARITY, HAYDEN MCKEE-ZECH, AND DAWNIE STEADMAN. 2021. "FIRST RECORD OF THE ORIENTAL LATRINE FLY, *CHRYSONYIA MEGACEPHALA* (FABRICIUS) (DIPTERA: CALLIPHORIDAE), IN TENNESSEE, USA." *ACTA PARASITOLOGICA* 66(3): 1-3.

PARMESAN, CAMILLE. 2006. ECOLOGICAL AND EVOLUTIONARY RESPONSES TO RECENT CLIMATE CHANGE. *ANNUAL REVIEW OF ECOLOGY, EVOLUTION, AND SYSTEMATICS* 37:637-669.

PHARR, LAUREN REBECCA. 2009. "A TAPHONOMIC MODEL OF CONCEALMENT: DECOMPOSITION AND THE POSTMORTEM INTERVAL (PMI) IN A 55-GALLON BARREL LOUISIANA STATE UNIVERSITY."

PICARD, CHRISTINE J. 2013. "FIRST RECORD OF *CHRYSONYIA MEGACEPHALA* FABRICIUS. (DIPTERA: CALLIPHORIDAE) IN INDIANA, USA." *PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON* 115(3):265-267.

RODRIGUEZ, WILLIAM C., AND WILLIAM M. BASS. 1983. "INSECT ACTIVITY AND ITS RELATIONSHIP TO DECAY RATES OF HUMAN CADAVERS IN EAST TENNESSEE." *JOURNAL OF FORENSIC SCIENCE* 28(2): 423-432.

ROSATI, J.Y., AND SHERAH L. VANLAERHOVEN. 2007. "NEW RECORD

OF *CHRYSOMYA RUFIFACIES* (DIPTERA: CALLIPHORIDAE) IN CANADA: PREDICTED RANGE EXPANSION AND POTENTIAL EFFECTS ON NATIVE SPECIES." *THE CANADIAN ENTOMOLOGIST* 139(5): 670-677.

RUNKLE, JENNIFER., KENNETH KUNKEL, DAVID EASTERLING, LAURA STEVENS, BROOKE STEWART, REBEKAH FRANKSON, AND LUIGI ROMOLO. 2017. "TENNESSEE STATE CLIMATE SUMMARY." *NOAA TECHNICAL REPORT NESDIS 149-TN*, 4 PP.

SCHOENLY, KENNETH. 1992. "A STATISTICAL ANALYSIS OF SUCCESSIONAL PATTERNS IN CARRION-ARTHROPOD ASSEMBLAGES: IMPLICATIONS FOR FORENSIC ENTOMOLOGY AND DETERMINATION OF THE POSTMORTEM INTERVAL." *JOURNAL OF FORENSIC SCIENCE* 37(6): 1489-1513.

SCHOENLY, KENNETH G., NEAL H. HASKELL, ROBERT D. HALL, AND J. ROBERT GBUR. 2007. "COMPARATIVE PERFORMANCE AND COMPLEMENTARITY OF FOUR SAMPLING METHODS AND ARTHROPOD PREFERENCE TESTS FROM HUMAN AND PORCINE REMAINS AT THE FORENSIC ANTHROPOLOGY CENTER IN KNOXVILLE, TENNESSEE." *JOURNAL OF MEDICAL ENTOMOLOGY* 44(5): 881-894.

SHAHID, SUMIA., ROBERT D. HALL, NEAL H. HASKELL, AND RICHARD W. MERRITT. 2000. "*CHRYSOMYA RUFIFACIES* (MACQUART)(DIPTERA: CALLIPHORIDAE) ESTABLISHED IN THE VICINITY OF KNOXVILLE, TENNESSEE, USA." *JOURNAL OF FORENSIC SCIENCES* 45(4): 896-897.

SUKONTASON, KABKAEW L., MANASANANT BUNCHOO, BANYONG KHANTAWA, SOMSAK PIANGJAI, YUPHA RONGSRIYAM AND KOM SUKONTASON. 2007. "COMPARISON BETWEEN *MUSCA DOMESTICA* AND *CHRYSOMYA MEGACEPHALA* AS CARRIERS OF BACTERIA IN NORTHERN THAILAND" *SOUTHEAST ASIAN JOURNAL OF TROPICAL MEDICINE AND PUBLIC HEALTH*, 38(1): 38-44.

TENNESSEE VALLEY AUTHORITY. "COAL." ACCESSED [OCTOBER 14, 2020]. <https://www.tva.com/energy/our-power-system/coal>.

TOLLESFSON W. AND JOYNER A. (2020). JANUARY 2020 TENNESSEE STATE CLIMATE SURVEY. TENNESSEE CLIMATE OFFICE. EAST TENNESSEE STATE UNIVERSITY. RETRIEVED OCTOBER 19, 2020 FROM https://www.etsu.edu/cas/geosciences/tn-climate/documents/2020_01.pdf.

TOMBERLIN, JEFFREY K., WILL K. REEVES, AND D. CRAIG SHEPPARD. 2001. "FIRST RECORD OF *CHRYSOMYA MEGACEPHALA* (DIPTERA: CALLIPHORIDAE) IN GEORGIA, USA." *FLORIDA ENTOMOLOGIST* 84(2):300-301.

U.S. STATES: TENNESSEE STATE PROFILE AND ENERGY ESTIMATES. LAST UPDATED JUNE 18, 2020. PROFILE ANALYSIS. THE U.S. ENERGY INFORMATION ADMINISTRATION (EIA). ACCESSED [OCTOBER 12, 2020.]

<https://www.eia.gov/state/analysis.php?sid=TN>.

WALLACE, GORDON D. 1971. "EXPERIMENTAL TRANSMISSION OF *TOXOPLASMA GONDII* BY FILTH-FLIES." *THE AMERICAN JOURNAL OF TROPICAL MEDICINE AND HYGIENE* 20(3): 411-413.

WELLS, JEFFREY D. 1991. "*CHRYSOMYA MEGACEPHALA* (DIPTERA: CALLIPHORIDAE) HAS REACHED THE CONTINENTAL UNITED STATES: REVIEW OF ITS BIOLOGY, PEST STATUS, AND SPREAD AROUND THE WORLD." *JOURNAL OF MEDICAL ENTOMOLOGY* 28(3):471-473.

WELLS, JEFFREY D. 2000. "INTRODUCED *CHRYSOMYA* (DIPTERA: CALLIPHORIDAE) FLIES IN NORTHCENTRAL ALABAMA." *JOURNAL OF ENTOMOLOGICAL SCIENCE* 35:91 - 92.

WHITWORTH, TERRY. 2006. "KEYS TO THE GENERA AND SPECIES OF BLOW FLIES (DIPTERA: CALLIPHORIDAE) OF AMERICA NORTH OF MEXICO." *PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON* 108: 689

WONG, KAUFUI, AND JACQUELINE PAPE. 2015. "CLIMATE CHANGE AND THEORIES." IN *CLIMATE CHANGE*, EDITED BY KAUFUI V. WONG, 5- 25. NEW YORK: MOMENTUM PRESS.

CHAPTER 12

Relations Between Wildfires and Forensic Anthropology

Riley Wal, Samantha Beier, Kamryn Dagel, Eric Tucker, and Alexa Reins

Relations Between Wildfires and Forensic Anthropology

Presenters: Riley Wal, Samantha Beier, Kamryn Dagel, Eric Tucker, and Alexa Reins

Camp Fire: California

- The Camp Fire started November 8, 2018 in Butte County, CA
- It is the most destructive fire on record
- Due to intense winds, the fire spread rapidly
- It devastated roughly 150,000 acres and 19,000 structures (Pilloud et al, 2020)
- 88 people died (Canepari and Cooper, Fire in Paradise, 2019)



Camp Fire: California

- A team of 68 anthropologists (archaeologists, biological anthropologists, bioarchaeologists, and forensic anthropologists) were used to quickly differentiate between human and nonhuman remains, or other debris
- Once human remains were found, anthropologists worked with coroners, officers, or search and rescue units to assist in recovery
- Forensic anthropologists were trained to systematically process, including recover and document remains (or other relevant material)
- The working conditions for the recovery teams were “extremely hazardous.”
- Recovery efforts continued through November 28, 2018
- Through skeletal analysis, radiographs, and DNA testing identification efforts could be made (Pilloud et al, 2020).

Camp Fire: California

“As the fire advanced across the landscape, approximately 52,000 residents were evacuated. Many people spent long hours in their cars during the evacuation, escaping with few possessions and limited means of communication. The result was an extensive list of possible missing individuals from fire-affected communities. The effort to search for these missing individuals fell largely on the Butte County Sheriff’s Department; however, they enlisted the help of state coroner and search and rescue teams, the California Office of Emergency Services, the National Guard, the California Department of Forestry and Fire Protection (CAL FIRE), and multiple local and regional fire departments to search for missing persons” (Pilloud et al, 2020).

Camp Fire: California

- This fire is tied to climate change
- There are 20 wildfires in the state of CA that are classified as “most destructive” on record: 15 have occurred in the last 20 years
- The Camp Fire served as a lesson learned for future disaster responses (Pilloud et al, 2020)



Smoky Mountain Wildfires

- When an explosion erupted in the Chimney Tops, a fire quickly spread to over 10,000 acres in size.
 - The drought Gatlinburg had been experiencing fueled the fire due to the lack of moisture in the air.
- The nights of November 28th and November 29th, firemen and park officials facilitated a mass evacuation.
 - The National Park surrounded roughly 4,200 residents.
 - An official count of deaths was released to the public which stated 14 lives were lost, 134 people injured, and 2,500 structures were destroyed.
- Immediately following this disaster, an abundance of relief teams jumped in to action.
 - Disaster relief tends to work in three phases: preparation, immediate response, and reconstruction.
 - Thousands of dollars were donated as well as an abundance of food and other necessary items such as toiletries (Daniel and Rodrigues, 2017).

Smoky Mountain Wildfires Cont.

The figure below depicts the successful and unsuccessful areas of disaster relief regarding the Gatlinburg Wildfires (Daniel and Rodrigues, 2017).

Metric	Rating
OPERATIONAL CONTEXT	
Identification of pattern of disasters in region and potential damage	2
Emergency plans exist, and are comprehensive / feasible	3
Functional areas integrated	N/A
Processes standardized and simplified	N/A
Integration agreements and development of strategic partnerships with suppliers	N/A
PLANNING & CONTROL CONTEXT	
Implementation of information management systems	N/A
Implementation of media and alert systems	2
Collaborative planning between organizations	2
Establishment of metrics and performance objectives	N/A
BEHAVIORAL CONTEXT	
Roles and responsibilities clearly outlined	2
Agreements exist establishing information and resource sharing	1

Table 9: Application of Framework – Preparation

Rating	Description
1	Metric is present
2	Metric is somewhat present
3	Metric is not present
N/A	Cannot determine if metric is present; not enough information available

Table 8: Description of Rating System

Smoky Mountain Wildfire Timeline

Wednesday, November 23rd

- At approximately 5:00pm, the National Park officials noticed smoke rising by the Chimney Top peaks.
- Officials left the area because of the difficult terrain and it was about to be dark
 - They stated in the Division of Fire and Aviation, "the smoldering fire was estimated to be less than one acre in size" (Daniel and Rodrigues, 2017)

Thursday, November 24th

- The officials stated, "the fire had only grown slightly in size from the day before and there was no active flame or fire, except the smoldering duff, which had caused the fire to only slightly increase in size," according to the Division of Fire and Aviation.
- The idea to contain the fire, was by constructing a "box".
 - The goal was to create human-constructed fire lines by using the natural features of the park.
- The *Knoxville News Sentinel* stated that "sixty-two active fires are currently burning" in East Tennessee. This caused a "code red" air quality alert and is thought to be caused by low rainfall (Daniel and Rodrigues, 2017).

Smoky Mountain Wildfire Timeline

Friday, November 25th

- There was no notable difference to the fire.
- The area near the fire was searched for the construction of the "box" that will contain the fire (Daniel and Rodrigues, 2017)

Saturday, November 26th

- The behavior of the fire had not changed and officials still believed that the mix of natural and man-made features could contain the fire.
 - However, the officials also acknowledged the difficult terrain, vegetation, and conditions were not ideal for fire line construction.
- On this day, multiple weather forecasts were issued. All calling for high winds in the park on Monday, November 28th (Daniel and Rodrigues, 2017).

Smoky Mountain Wildfire Timeline

Sunday, November 27th

- The National Weather Service issues many weather forecasts for the Gatlinburg area for high wind gusts which only spread the fire more. On top of wind, dry conditions and low humidity cause fire to spread.
- Overnight it was discovered that the fire had expanded and an attempt to box out the fire was attempted with the help of local fire departments and aircrafts.
- These efforts to “box” out the fire seemed to help as by nightfall, the fire looked to be somewhat contained and shrinking in size (Daniel and Rodrigues, 2017).

Smoky Mountain Wildfire Timeline

Monday, November 28th

- In the early hours, warnings for “strong gusty winds” were released.
 - The “High Wind Watch” had turned into a “High Wind Warning”
- Around 7:01 am, the crew arrived about a half mile out of the fire’s perimeter. The fire had spread to the picnic area and was estimated to be between **250-500 acres**.
 - In addition, there was a spot fire across Newfound Gap Road.
 - The captain of the Gatlinburg Fire Department was contacted for potential smoke in the city.
- At 11:00 am, an additional fire at Twin Creeks Picnic Pavilion, 1.5 miles from Gatlinburg city limits.
 - Aerial was unavailable because of the harsh winds
 - The fire department issued a request for mutual aid
- Approximately 12:00 pm, the protection of Mynatt Park became a focus and started to advise residents of Mynatt Park to evacuate
 - The city of Gatlinburg had be covered in smoke
- At 11:21 am, National Park deemed the air “unhealthy”. Schools and organizations started to evacuate
 - Pi Beta Phi Elementary School evacuated at 12:30pm
 - 1:48pm, Gatlinburg Community Center opened as an evacuation shelter (Daniel and Rodrigues, 2017)

Smoky Mountain Wildfire Timeline

Monday, November 28th Part 2:

- Firefighters fought the fires at Mynatt Park and twin Creeks throughout Monday afternoon and into the evening
 - Due to the movement of the fire, the Gatlinburg Fire Department began to play a large role
- Around 6:00 pm. The “wind speeds doubled” according to the Gatlinburg Fire Chief.
- Sometime after 5:00 pm, the fire moved towards the Great Smoky Mountain National Park headquarters that is located on the boundary of the City of Gatlinburg.
 - Within an hour of this the fire had moved to Ski Mountain Road area and 911 logs confirmed that multiple structures were burning.
- Approximately 6:00 pm, the city issued “immediate mandatory evacuation” of the Mynatt Park neighborhood and others, due to the fire.
 - However, this was not communicated with the city until 9:38 pm through the news
- At 11:00 pm, the Tennessee Emergency Management Agency (TEMA) stated that 30 structures were on fire in Gatlinburg.
 - Also, 1,200 people were sheltered in Gatlinburg Community Center and Rocky Top Sports Park (Daniel and Rodrigues, 2017)

Smoky Mountain Wildfire



How Forensic Scientists and Specialists Can Assist in Recovery

- Pilloud and colleagues' (2020) described methods including systematic house mapping and visiting/searching, which are extremely useful in more densely populated areas like some of those impacted in California. In this section, we will further explore the methods by which recoveries are conducted and how they might be improved.



Improved Methods

- Methods presented by Pilloud et al. (2020) for the California fires include systematic house mapping and visiting/searching. This requires relentless searching of houses and surrounding area by numerous volunteers to ensure all possible remains are found. Although in theory more volunteers sounds better, the presence of more volunteers creates potential confusion regarding who has searched what area and may result in some areas being left out of the search altogether.
- Improving the identification of animal components (such as bones and antlers) versus human remains help to speed up the identification process as pet remains and bones from food could hinder the identification process. For this reason, a zooarchaeologist on site could improve the identification process.
- The searches cover large areas, and the structured searches of these areas are crucial to what is recovered and how much is recovered. Dividing the affected areas into smaller grids allows for an increased likelihood of remains recovery.

Problems with the Recovery of Smoky Mountain Wildfires

Some of the most prominent issues in the Smoky Mountain recovery efforts likely mimicked problems teams faced in California. These issues include, but are not limited to:

- Extreme ground temperatures
- Respiratory danger from ash and smoldering materials
- No pre-decided team large enough to handle such a mass disaster
- Mental and emotional trauma from witnessing extreme damage
- Huge numbers of wild animals mean more bones that may be mixed with human remains/require more time to identify (Pilloud et al, 2020)

Conclusion

- California Camp Wildfires lasted from November 8th - 28th.
 - The dry conditions made it last longer
 - Anthropologists used radiographs, DNA testing, and skeletal analysis
- Smoky Mountain Wildfires lasted from November 23rd - December 22nd.
 - There was extremely dry conditions, low humidity, and time of drought.
 - Both qualitative and quantitative data was collected
 - Examples: ethnographic studies
- “The growing ACC [anthropogenic climate change] influence on fuel aridity is projected to increasingly promote wildfire potential across western US forests in the coming decades and pose threats to ecosystems, the carbon budget, human health, and fire suppression budgets that will collectively encourage the development of fire-resilient landscapes.” -Abatzoglou, John T. and A. Park Williams (2016)

Improved Methods Cont.

- Patiently and systematic searching ensures that all areas of the search field are looked over and ensure that all possible remains, or other identifiable objects such as jewelry or documentation, are found. Also, documentation of where and what was recovered help to speed up the identification process (Pilloud et al, 2020).
- Conventional DNA sampling and testing is a months-long process that would have severely limited the potential for timely victim identification. Further integration of Rapid DNA Identification, like that used in the Camp Fire, could increase the likelihood of victim identification multiple times over (Gin, 2020).
- While the cooperation of multiple departments and teams is crucial to the success of operations as large as the searches conducted in the aftermath of disasters like the Camp and Smokies fires, many of these groups are comprised of volunteer teams from across the nation. The wide range of backgrounds within these teams could pose potential discrepancies regarding the training and methods each group is equipped with (Pilloud et al, 2020)

Conclusion cont.

- “...heat alteration of the human body follows clear, normal and regular patterns, which can be detected and inferred through different means, both experimentally and through the proper documentation of forensic cases...” - Symes et al (2012)
- After evaluating the recovery methods used on both scenes; there are some improvements that should be made:
 - Rapid DNA testing should become a staple in the field for identification (Gin, 2020)
 - House mapping should be kept to a minimum due to the size or party required and the resources needed (Pilloud et al, 2020)
 - Zooarchaeologists should be on sight to assist the forensic anthropologists to differentiate human and non-human remains (Pilloud et al, 2020)

Works Cited

- Abatzoglou, John T. and A. Park Williams. 2016. "Impact of anthropogenic climate change on wildfire across western US forests". *PNAS*. 113 (42): 11770–11775.
- Canepari, Zachary and Drea Cooper, dir. 2019. *Fire in Paradise*. Los Gatos, California: Netflix Productions. Internet Stream.
- Daniel, C., & Rodrigues, A. (n.d.). 2017. "Disaster Relief Logistics: An Academic Framework Evaluation of the 2016 Great Smoky Mountain Wildfires". *Chancellor's Honors Program Projects*. 1 (1): 1-49.
- Gin, Kim et al. 2020. "The 2018 California Wildfires: Integration of Rapid DNA to Dramatically Accelerate Victim Identification". *Journal of Forensic Sciences*. 65 (3): 791-799.
- Pilloud, Marin A., Eric J. Bartelink, Ashley Kendell, and Colleen Milligan. 2020. "Forensic Anthropology in a Changing Climate". *Anthropology News*. April 22. [Accessed December 1, 2020]. <https://www.anthropology-news.org/index.php/2020/04/22/forensic-anthropology-in-a-changing-climate/>
- Symes, Steven A. et al. 2012. "Recovery and Interpretation of Burned Human Remains". *National Institute of Justice*. 1 (1) 1-236.

References

- ABATZOGLOU, JOHN T. AND A. PARK WILLIAMS. 2016. "IMPACT OF ANTHROPOGENIC CLIMATE CHANGE ON WILDFIRE ACROSS WESTERN US FORESTS". *PNAS*. 113 (42): 11770–11775.
- CANEARI, ZACHARY AND DREA COOPER, DIR. 2019. *FIRE IN PARADISE*. LOS GATOS, CALIFORNIA: NETFLIX PRODUCTIONS. INTERNET STREAM.
- DANIEL, C., & RODRIGUES, A. (N.D.). 2017. "DISASTER RELIEF LOGISTICS: AN ACADEMIC FRAMEWORK EVALUATION OF THE 2016 GREAT SMOKY MOUNTAIN WILDFIRES". *CHANCELLOR'S HONORS PROGRAM PROJECTS*. 1 (1): 1-49.
- GIN, KIM ET AL. 2020. "THE 2018 CALIFORNIA WILDFIRES: INTEGRATION OF RAPID DNA TO DRAMATICALLY ACCELERATE VICTIM IDENTIFICATION". *JOURNAL OF FORENSIC SCIENCES*. 65 (3): 791-799.
- PILLOUD, MARIN A., ERIC J. BARTELINK, ASHLEY KENDELL, AND COLLEEN MILLIGAN. 2020. "FORENSIC ANTHROPOLOGY IN A CHANGING CLIMATE". *ANTHROPOLOGY NEWS*. APRIL 22. [ACCESSSED DECEMBER 1, 2020]. [HTTPS://WWW.ANTHROPOLOGY-NEWS.ORG/INDEX.PHP/2020/04/22/FORENSIC-ANTHROPOLOGY-IN-A-CHANGING-CLIMATE/](https://www.anthropology-news.org/index.php/2020/04/22/forensic-anthropology-in-a-changing-climate/)
- SYMES, STEVEN A. ET AL. 2012. "RECOVERY AND INTERPRETATION OF BURNED HUMAN REMAINS". *NATIONAL INSTITUTE OF JUSTICE*. 1 (1) 1-236.

CHAPTER 13

Cemeteries and Climate Change: What Can We Learn from the Past, Do in the Present and Plan for the Future?

Marta Marie Paulson

Abstract. Cemeteries are important to the identity of a community. Unfortunately, with the rise in sea level and increased frequency of severe storm systems we see an increase in threatened coastal cemeteries and historical sites. Indigenous groups in the past also faced rises in sea level and relocated sites further inland. How can their example and the examples of the more recent past help communities to prepare for future storms and protect these sites of communal history? Some archaeological groups have developed Heritage Monitoring programs to monitor sites while others have taken it a step further and have conducted surveys and excavations of threatened sites. Both of these options hold promising results to help preserve the identity of local communities and individuals of the past for the future.

Introduction

In many parts of the world, people think of cemeteries as a permanent place of rest for the dead. However, cemeteries and gravesites can disappear over time either due to neglect or, in more recent cases, due to climate change. This can create issues for communities where the only records of the dead are found on their gravestones. Climate change has become an increasing issue not just for cemeteries but for historical sites around the world. Rising sea levels have caused loss of sites to the ocean and the increase in number and severity of coastal storms erode sites and flood cemeteries (Dawson et al. 2020; Miller and Murray 2018; Schexnayder and Manhein

2017). However, examples from the past show some groups relocated their dead in anticipation of rises in sea level (Sassaman 2016). How can we learn from the past and apply it to the present? More importantly, how can we plan for the future so that we do not just watch our ancestors slowly disappear into the ocean?

The Role of a Cemetery

In many cultures, cemeteries are considered sacred places (Mueller and Meindl. 2017; Francis et al. 2000). Cemeteries are thought of as eternal resting places of loved ones and therefore are intended to last in perpetuity. Cemeteries play a large role in the cultural landscape of communities. In smaller communities where centralized record keeping is not practiced or feasible, cemeteries are one of the few sources of information on the community's history (Foster and Lovekamp 2015). Cemeteries can provide a wealth of information about a community such as social demographics or the cultural values and beliefs of that group. In their book *Fragile Grounds*, Schexnayder and Manhein (2017) discuss how cemeteries in Louisiana reflect familial and cultural migrations across the coastal area, which can be helpful in areas that have many different ethnicities represented. In rural areas and small towns, cemeteries may signify the existence of a community, and when that cemetery is lost the community loses its history and identity (Foster and Lovekamp 2015). Not only is the information recorded on the gravestones informative, but the individuals interred can tell anthropologists about the

lifestyle of individuals in the community. From the bones of an individual, biological anthropologists can learn how a person lived and in turn learn more about the community as a whole. In a way, cemeteries make up a census of the local population. So how can we prevent communities from losing their histories to climate change?

Climate Change in the Past

Most historical cemeteries were located on raised ground, usually out of reverence, and while weathering of cemeteries is expected, the degree of weathering due to climate change has recently become more concerning (Mueller and Meindl 2017). However, while climate change is certainly an issue recently, that is not to say that climate change has not been an issue in the past. Sassaman's (2016) study of climate change, particularly rising sea levels, and its effect on prehistoric indigenous groups along the south coast of Florida is instructive. These groups built settlements, shell rings and cemeteries along the Gulf coast. Because of their "constellation of practice", which was centered around their past experiences with sea-level rise, they anticipated changes in sea level and preemptively relocated their settlements and cemeteries. Sassaman (2016) noted this pattern at three different sites along the coast (Bird Island, Cat Island, and McClamory Key. Fluctuations in sea level resulted in exhumation and reinterment of some graves at new settlement locations. This is evident at McClamory Key where around 32 secondary burials were identified in the cemetery (Sassaman 2016:281). For these indigenous groups, the role of ancestors was significant and, to avoid loss of ancestral ties, individuals were exhumed and reinterred further inland at future settlement sites as the sea levels rose. Indigenous groups in the Late Archaic period continued the trend of inland cemeteries in anticipation of rising sea levels as well as cemetery emplacement prior to establishment of a settlement (Sassaman et al. 2016).

Climate Change in the Present

While the exhumations and reinterments described by Sassaman (2016) happened proactively, most recent grave relocations happen retroactively in response to climate change. For example, in 2012, Hurricane

Sandy caused major damage to graves on Boston Harbor's Gallops Island, Massachusetts. Most of these graves were smallpox patients from the 19th century. While the state of Massachusetts was able to relocate 66 of the graves, they lacked funding to relocate the remaining graves of which there are estimated to be between 100 and 200 graves (Aton 2019). In Louisiana, where around 80 percent of the nation's coastal land loss takes place, families are forced to leave their homes and local cemeteries due to land instability as a result of coastal erosion and rising sea levels (Schexnayder and Manhein 2017). Families are facing similar situations in Alaska and northern Canada where they are watching not only deceased relatives but whole communities slowly sink into the melting permafrost (Cotsirilos 2017; Malbeuf 2018; Scott 2020; Sakakibara 2008). The historical cemeteries have become swamps and loved ones are unable to get to the graves of their relatives. In some cases, the location of graves is uncertain due to shifting of grave markers in attempts to drain the cemeteries (Malbeuf 2018). In the Outer Banks, North Carolina, cemeteries that were originally located on high ground are now falling into the sea or are now located in salt marshes due to shoreline erosion and rises in sea levels (Neal and Pilkey 2013). While it has been suggested that cemeteries be relocated, families are hesitant to do so because they do not want to be separated from their dead. This is also a large reason for families choosing to remain along the eroding coastline (Neal and Pilkey 2013).

Protecting Cemeteries for the Future

In their article *Cemeteries in the Sea*, Neal and Pilkey (2013) discuss three options that families have for dealing with the disappearance of cemeteries: hardening the shoreline, relocation of cemeteries, and leaving the cemeteries alone. Hardening the shoreline or creating protective barriers tends to be the most popular option. Many communities opt for protective barriers not only to shield cemeteries, but structures built along the coast. While these barriers can prove to be relief in the short term there can be some detrimental long-term effects. As landowners on Daufskie Island, South Carolina found out, building a seawall merely diverts the erosion points to the ends of the walls. In their case, their effort to protect their

properties resulted in the erosion of a local cemetery. Even if protective barriers are used to shield cemeteries specifically, we see coastal erosion occurring where these barriers end which could be the road that leads to the cemetery as seen in Colac Bay, New Zealand (Neal and Pilkey 2013).

The second option that communities have is to relocate cemeteries. While this is a solution that some ancient indigenous groups opted for it is not a popular option for more modern groups. One of the largest concerns that comes with relocating cemeteries is the cost of relocation. Relocation especially of large cemeteries is a large undertaking and communities usually rely on state or federal funding to achieve that goal (Aton 2019; Scott 2020). However, in small, low-income towns, relocation of cemeteries seems like the best option but is not financially feasible (Mueller and Meindl 2017).

The third choice of leaving the cemetery alone does not necessarily mean that we should ignore the cemetery altogether. In this case, the main focus is preserving the information of the cemetery. This data includes: location of the cemetery, number of people buried there, location of burials, types of burial (inground or above), who is buried there, and overall demographic of the cemetery. As archaeologists and anthropologists are finding at coastal sites, it is great to preserve sites, but if sites are disappearing at faster rates than can be preserved, then the next best thing is to document the site as much as possible. Schexnayder and Manhein (2017) discuss this extensively in their book where they travel to different cemeteries in Louisiana that are “endangered” or disappearing due to rising sea levels and coastal erosion and document the cemeteries while they still stand.

In Florida, a similar concern has arisen for, not just cemeteries, but also for historical sites along the coast. As a result, the Florida Public Archaeology Network (FPAN) launched the Heritage Monitoring Scouts (HMS) program. This program was tasked with monitoring historic sites along the coast, assessing environmental threats to sites and coming up with preventative measures to protect sites from further deterioration. To educate potential stewards, the

program offers a multitude of workshops which include Heritage Awareness Diving Seminar for dive instructors, Submerged Sites Education and Archaeological Stewardship for sport divers, and Cemetery Resource Protection Training (CRPT) for cemetery stewards (Miller and Murray 2018). In 2016 the HMS Florida shifted in focus when it collaborated with the Scottish Coastal Archaeology and the Problem of Erosion (SCAPE) organization and the Scotland Coastal Heritage at Risk Project (SCHARP). Monitoring was made more open to the public which allowed for more interaction with communities around historical sites. SCHARP also conducted surveys and excavations of some of the more threatened sites. From the collaboration stemmed more interest in data collection of sites and local interpretation of sites (Dawson et al. 2020). While monitoring is still a large part of groups like HMS Florida and the Midden Minders (MM) in Maine, more efforts are being made to document historical sites, including cemeteries, before they disappear completely. In addition to Scotland, we see international efforts to document at-risk sites. In 2017 a preliminary survey was done of at-risk cemeteries in the Caribbean Islands (Mueller and Meindl 2017). For cemeteries that are still active there has been a push for creations of disaster response plans, so that there is a set protocol when the next hurricane or major storm hits (Mueller and Meindl 2017; Foster and Lovekamp 2015).

Conclusion

Cemeteries play a large role in the identity of a community. While the past can provide us with helpful insight on how to protect our cemeteries, such as relocation of graves, it does not mean that we have to give up when we cannot achieve that ideal. We have to acknowledge that there are some sites that we can't save from erosion or sea level rise. Yet, we still have the power and resources to document and save the data that these sites have to offer. In this way, we can preserve the identity of the community long after individuals are gone.

References

- ATON, ADAM. 2019. “THE DEAD CAN’T ESCAPE CLIMATE CHANGE.” E&E NEWS WEBSITE, OCTOBER 31, 2019.
[HTTPS://WWW.EENEWS.NET/CLIMATEWIRE/STORIES/1061420585/SE](https://www.eenews.net/climatewire/stories/1061420585/se)

ARCH?KEYWORD=EVEN+THE+DEAD+, ACCESSED SEPTEMBER 28, 2020.

COTSIROLOS, TERESA. 2017. "CEMETERIES TURN TO SWAMPS AS ALASKA'S PERMAFROST MELTS." NATIONAL PUBLIC RADIO WEBSITE, DECEMBER 16, 2017.

[HTTPS://WWW.NPR.ORG/2017/12/16/571300619/CEMETERIES-TURN-TO-SWAMPS-AS-ALASKAS-PERMAFROST-MELTS](https://www.npr.org/2017/12/16/571300619/cemeteries-turn-to-swamps-as-alaskas-permafrost-melts), ACCESSED SEPTEMBER 27, 2020.

DAWSON, TOM, JOANNA HAMBLY, ALICE KELLEY, WILLIAM LEES AND SARAH MILLER. "COASTAL HERITAGE, GLOBAL CLIMATE CHANGE, PUBLIC ENGAGEMENT, AND CITIZEN SCIENCE." *PNAS* 117 (15): 8280-8286.

FRANCIS, DORIS, LEONIE KELLAHER AND GEORGINA NEOPHYTOU. 2000. "SUSTAINING CEMETERIES: THE USER PERSPECTIVE." *MORTALITY* 5 (1): 34-52.

FOSTER, GARY S., AND WILLIAM E. LOVEKAMP. 2015. "DISASTERS AND CEMETERIES: A CLARION CALL FOR MATTERS OF GRAVE URGENCY." *ASSOCIATION FOR GRAVESTONE STUDIES QUARTERLY* 39 (3): 14-19.

MALBEUF, JAMIE. 2018. "I DON'T KNOW WHERE SHE IS': FLOODING AT BEHCHOKO CEMETERY LEAVES GRAVES UNDER WATER." CANADIAN BROADCASTING CORPORATION WEBSITE, JUNE 20, 2018. [HTTPS://WWW.CBC.CA/NEWS/CANADA/NORTH/BEHCHOKO-CEMETERY-GRAVES-UNDER-WATER-1.4713579](https://www.cbc.ca/news/canada/north/behchoko-cemetery-graves-under-water-1.4713579), ACCESSED SEPTEMBER 27, 2020.

MILLER, SARAH E., AND EMILY JANE MURRAY. 2018. "HERITAGE MONITORING SCOUTS: ENGAGING THE PUBLIC TO MONITOR SITES AT RISK ACROSS FLORIDA." *CONSERVATION AND MANAGEMENT OF ARCHAEOLOGICAL SITES* 20 (4): 234-260.

MUELLER, NOAH J., AND CHRISTOPHER F. MEINDL. 2017. "VULNERABILITY OF CARIBBEAN ISLAND CEMETERIES TO SEA LEVEL RISE AND STORM SURGE." *COASTAL MANAGEMENT* 45 (4): 277-292.

NEAL, WILLIAM J., AND ORRIN H. PILKEY. 2013. "CEMETERIES IN THE SEA." *COASTAL CARE WEBSITE*, NOVEMBER 1, 2013. [HTTPS://COASTALCARE.ORG/2013/11/CEMETERIES-IN-THE-SEA/](https://coastalcare.org/2013/11/cemeteries-in-the-sea/), ACCESSED NOVEMBER 4, 2020.

SAKAKIBARA, CHIE. 2008. "'OUR HOME IS DROWNING': IÑUPIAT STORYTELLING AND CLIMATE CHANGE IN POINT HOPE, ALASKA." *THE GEOGRAPHICAL REVIEW* 98 (4): 456-478.

SASSAMAN, KENNETH E. 2016. "A CONSTELLATION OF PRACTICE IN THE EXPERIENCE OF SEA-LEVEL RISE." IN *KNOWLEDGE IN MOTION: CONSTELLATION OF LEARNING ACROSS TIMES AND PLACE*, EDITED BY ANDREW P. RODDICK AND ANN B. STAHL, PP. 271-298. TUCSON: UNIVERSITY OF ARIZONA PRESS.

SASSAMAN, KENNETH E., WALLIS, NEILL J., MCFADDEN, PAULETTE S., MAHAR, GINNESSA J., JENKINS, JESSICA A., DONOP, MARK C., MONÉS, MICAH P., PALMIOTTO, ANDREA, BOUCHER, ANTHONY, GOODWIN, JOSHUA M., OLIVEIRA, CRISTINA I. 2017. "KEEPING PACE WITH RISING SEA: THE FIRST 6 YEARS OF THE LOWER SUWANNEE ARCHAEOLOGICAL SURVEY, GULF COASTAL FLORIDA." *THE JOURNAL OF ISLAND AND COASTAL ARCHAEOLOGY* 12(2):173-199.

SCHEXNAYDER, JESSICA H., AND MARY H. MANHEIN. 2017. *FRAGILE GROUNDS: LOUISIANA'S ENDANGERED CEMETERIES*. JACKSON: UNIVERSITY PRESS OF MISSISSIPPI.

SCOTT, MACKENZIE. 2020. "CLIMATE CHANGE IS PUTTING N.W.T. CEMETERIES IN 'CRISIS' AND COMMUNITIES ARE WORRIED." CANADIAN BROADCASTING CORPORATION WEBSITE, MARCH 10, 2020. [HTTPS://WWW.CBC.CA/NEWS/CANADA/NORTH/NWT-CEMETARIES-CLIMATE-CHANGE-1.5491917](https://www.cbc.ca/news/canada/north/nwt-cemetaries-climate-change-1.5491917), ACCESSED SEPTEMBER 27, 2020.

CHAPTER 14

The Interconnection Between Climate Change and Mental Health

Lydia Lindsey and Shelby Saut

Keywords: Climate Change, Mental Health, Eco-Anxiety, Solastalgia

Abstract. This paper provides an overview of what climate change is, how climate change is linked to natural phenomena, and the effects and links between climate change and mental health. We discuss the following topics linked to climate change and mental health: direct and indirect effects of climate change on mental health; eco-anxiety and ecoparalysis; solastalgia and effects of climate change on culture; as well as failures of the present and thoughts on the future of climate change and mental health. This paper concludes with a final discussion on the effects of climate change on mental health and recommendations on education and policy that will lessen the effects of climate change on mental health.

Introduction

As global temperatures continue to rise and natural disasters become more prevalent, climate change has been brought to the forefront of the media, political policies, and global organizations. The effects of climate change are discussed in more detail, its effects on mental health are overlooked or not mentioned at all. Climate change has been found to be both directly and indirectly linked to mental health issues, which will be discussed later in this paper. The consensus is that climate change leads to a rise in mental health issues, violence, migration, and cultural degradation, as well as a few positive effects. These effects are rapidly increasing as climate change more drastically affects the environment. Climate change is affecting individuals, cultures, countries, and continents. Throughout all of these groups there is an inverse relationship between the impacts felt as a result of climate change and the responsibility for the impacts being present. Climate change also heightens existing

inequalities, especially among minorities. Mental health is a large part of psychosocial wellbeing, and there are drastic mental health issues already occurring due to climate change, so there needs to be action taken now to adapt. Hayes et al. (2018) states that “the World Health Organization estimates an increase of 250,000 excess deaths per year between 2030 and 2050 due to the ‘well understood impacts of climate change’” (1). There needs to be an increase in research done about the link between climate change and mental health. Additionally, governments need to implement better suited infrastructure, planning, and education on climate change, how to solve climate change, and the effects it has on mental health and society as a whole.

Background

One of the main issues with climate change is that people view it differently. Some people are already concerned about the changing climate and the effects it is having on them, but others feel that climate change is a hoax or that it isn't important because it is something that isn't affecting them at all or it isn't affecting them now. This can occur because people confuse climate change with seasonal or weather changes, and because climate change is a distant or abstract idea (Hayes et al, 2018: 5). Anthony Giddens, a sociologist, coined the phrase the ‘Giddens Paradox’, which describes how because the threat posed by climate change isn't definite, current, or visible in a person's daily life, people will do nothing to change for the better (Giddens, 2009: 1). The issue with this is that if individuals do nothing now, climate change will continue to be a threat until it is too late to change course. Climate change isn't a singular issue.

It is a past issue, a present issue, and it will be a future issue. Hayes et al. (2018) contends that as a species, we see just enough history of climate change to be familiar with it but don't place enough importance on it that we have to deal with the responsibility of its affects, and we know that things need to be done about it, but we push it off as a future problem because it isn't that serious yet (5). Climate change also isn't just a personal problem, it is a global problem. It is and will affect individuals, communities, countries, and continents. It is a threat to the human way of life (Hayes et al, 2018: 7).

Most people associate climate change as being a rise in global temperatures, sea levels, and an increase in extreme weather events, but there isn't evidence that specific weather events are or are not caused by climate change (Hayes et al, 2018: 3). The trend is that extreme weather is on the rise making natural disasters more numerous and powerful. Climate related extreme weather events have increased by 46% since 2000 alone (Hayes et al, 2018: 3). In areas where extreme weather events are more likely to occur, such as the Midwest or the Gulf of Mexico, there is a rise in mental distress (Ingle and Mikulewicz, 2020: 1). How much mental distress occurs is directly related to how much that community's or individual's environment is altered or threatened (Ingle and Mikulewicz, 2020: 1). Ingle and Mikulewicz coin the term eco-anxiety to describe this mental distress. Eco-anxiety refers to anxiety or worry as it relates to the threat of climate and ecological crises, and it can appear as loss of appetite, sleeplessness, and panic attacks (Ingle and Mikulewicz, 2020: 1). Eco-anxiety is the physical response to the accepted or ignored threat of climate change. Eco-anxiety is closely related to ecoparalysis. Ecoparalysis is the feelings people have about not been able to do something considerable to limit the effects of climate change (Hayes et al, 2018: 7). So while eco-anxiety is an unintentional physical response, ecoparalysis is a conscious psychosocial response to climate change. Eco-anxiety and ecoparalysis are felt on an individual level, but communities can also feel the reeling mental health consequences of climate change. This is where solastalgia comes into play. Solastalgia is the distress, sense of loss, and isolation felt about yours or your communities' sense of place in the environment

(Bourque and Willox, 2014: 419). Solastalgia is felt by long term changes in one's environment after the initial impact of climate change (Bourque and Willow, 2014: 419).

Professionals have had trouble linking mental health issues to climate change, and this is due to a variety of reasons. One is that, because they cannot directly link specific extreme weather events to climate change, they view each event as an isolated occurrence that isn't linked to other events happening across the globe (Hayes et al, 2018: 3). As such, the mental health effects seen in individuals affected by those isolated weather events are seen as also isolated responses not related to the overarching theme of climate change (Hayes et al, 2018: 3). Hayes et al. also talks about how it is easy to underdiagnose the mental health effects of climate change. They also discuss the many ways mental health manifests itself, and how the effects mentally of climate change vary in the amount of time that lapses from the initial event (Hayes et al, 2018: 3). Hayes and Poland (2018) also give some reasons why it is difficult to link climate change and mental health. They state that it is because mental health doesn't present itself physically often, it is a more behind-the-scenes problem, and mental health has been, and remains, stigmatized across the globe (Hayes and Poland, 2018: 6). People tend to ignore mental health or it is a topic that isn't widely discussed or treated due to the negative association between mental health and insanity. Mental health isn't just insanity. Mental health deals with mental illness, mental problems and disorders, mental wellness, emotional resilience and psychosocial wellbeing (Hayes et al, 2018: 1).

Although it has been difficult to link climate change and mental health, professionals have compiled symptoms that occur alongside specific weather events or are associated with a specific part of climate change. There has been a rise in vector-borne illnesses, water and food borne diseases, allergies and asthma, and morbidity and mortality related to extreme heat or weather events (Hayes et al, 2018: 2; Bourque and Willox, 2014: 415). Those are just the physical effects of climate change, but there are a wide variety of mental health issues related to climate change. Post-traumatic stress disorder (PTSD), major depressive

disorder (MDD), anxiety, depression, complicated grief, survivors' guilt, trauma, fatigue, substance abuse, and suicidal ideation have all been triggered by climate change (Hayes et al, 2018: 2). These disorders are felt as a direct result of the event, but the event can also showcase the failures of infrastructure that in turn place stress upon individuals, leading to a rise in violence and aggression that also lead to more mental health issues (Hayes et al, 2018: 2). While climate change has an overall negative effect on individuals and communities, it has also had a few positive effects. It can bring people together, increase civic action for climate mitigation and adaptation, inspire altruism, compassion, and growth (Hayes and Poland, 2018: 7).

Direct and Indirect Effects of Climate Change

Many of the articles we have or will discuss in this paper mention the direct and indirect effects of climate change on human physical and mental health. In order to understand the climate change effects on mental and physical health, we must first define the differences of direct vs indirect effects. Direct effects are those that focus on immediate health issues such as disease, in contrast to indirect effects that focus on social or resource strains (Hayes and Poland, 2018:2). Researchers over the years have found evidence that suggests that climate change directly causes an increase in the,

“risk, frequency, and distribution of foodborne, waterborne, vector borne, and zoonotic diseases sensitive to climate factors (e.g. *Escherichia coli*, *Campylobacteriosis*, *giardiasis*, *botulism*, *rabies*, *malaria*, *Lyme disease*, *dengue*, *West Nile virus*)” (Bourque and Willox, 2014: 415).

The increase of direct effects such as diseases and mental stresses such as anxiety and post-traumatic stress disorders also led to more violence, drug and alcohol abuse, and overall decreases in self-identity (Bourque and Willox, 2014: 416). The fact that these direct impacts cause increases in drug and alcohol abuse, violence, depression, and even suicide conveys a negative impact of climate change on the individual (Bourque and Willox, 2014: 416). Additionally, there has been evidence that climate change increases wildfires, heat stress and heat

related violence, respiratory issues, allergic disorders such as asthma, a decrease in air quality, and displacement of people forced out of their homes (Bourque and Willox, 2014: 417; Levy, 2017: 244). Many of these direct effects happen as a result of an increase in temperatures, sewage contamination, and longer transmission seasons for diseases due to more disease carrying vectors (Levy, 2017: 244). Indirect effects of climate change on the individual can include malnutrition, displacement health issues such as depression, and an increase in collective violence (Levy, 2017: 244). In particular, the indirect effects tend to be more apparent in middle- and low-income communities and countries around the globe (Levy, 2017: 244). Within several of the papers we discuss, there are many examples of how these direct and indirect effects cause many problems within communities around the world.

In many instances these issues led to lifelong mental problems including anxiety, mood disorders, stress, post-traumatic stress disorders, violence, drug and alcohol abuse, and even suicidal tendencies (Bourque and Willox, 2014: 416). This is apparent in several cases seen in recent years where the effects of climate change have affected many people in specific areas. The first case explains how the older farmers in Australia were experiencing a sense of loss due to chronic droughts leading to increases in recorded cases of depression and other mental issues (Levy, 2017: 416). In similar cases of drought, we see an increase in mental effects as well as collective violence due to loss of income and the changing economy (Levy, 2017: 248). A second case explores the flooding in England in the year 2000 where research showed “the exposed individuals had 4 times the risks of psychological distress” in adults as well as children due to the stresses of the floods (Levy, 2017: 418). A third case looked at the effects of Hurricane Katrina on the people affected, and the hurricane led to spikes in “post-traumatic disorders, domestic violence, and high rates of depression and suicide” (Levy, 2017: 418). These spikes are due to the increase in loss of self, loss of home, and sometimes family, which could easily impact the mental states of those who were affected (Levy, 2017: 418; Obradovich et al, 2018). This is expressed in the research done by Obradovich et al. (2018), where they look at mental health impacts

on those affected by Hurricane Katrina in 2005 via surveys. In particular, they were able to conclude that those who were directly impacted by Hurricane Katrina had worsened mental health than those who were not (Obradovich et al, 2018: 10956). The authors were able to conclude this by looking at surveys done before and after the hurricane to better understand if there is in fact a correlation between climate change and mental health, which they conclude that there is a correlation between them (Obradovich et al, 2018). All three of these cases are great examples of how climate change poses great risks to the mental health of those who are directly affected by natural disasters not only in the United States, but around the world. In order to eliminate these stressors on individuals we must find solutions to the present problems and support those affected by them. We suggest, as most of the articles discussed in this paper also suggest, to help support those affected physically and mentally by climate change by making their conditions known and find people to help guide them in the right direction. Additionally, we also suggest that world leaders promote actions to reduce the ever-changing climate as to eliminate these stressors on the individuals of low, middle, and even high-income countries.

Eco-Anxiety and Ecoparalysis

Climate change can appear as natural phenomenon or disasters in certain cases. There are natural disasters that are the product of predictable natural patterns, but there are also human disasters. Human disasters are the result of human mistakes or inactions, for example the Deepwater Horizon oil spill. The oil spill is a human disaster because it resulted from human intervention in the environment and it also could have been prevented. So, climate change is also a human disaster because it has been brought on by human intervention in the environment and it also can be prevented. Natural disasters are associated with better recovery and less mental health issues because they are naturally occurring. Human disasters are associated with more complex grieving and recovery processes because humans are aware that had action been taken, the disaster could have been avoided (Bourque and Willox, 2014: 418). As stated above, eco-anxiety is the anxiety felt about climate change, and more and more mental health care professionals

are noting eco-anxiety. Anxiety by itself is an alarm mechanism, it acts to protect individuals from perceived or real threats. If the probability of danger is accurate and the response is proportionate, then anxiety acts to ensure survival (Ingle and Mikulewicz, 2020:1). This means that individuals experiencing eco-anxiety, regardless of whether or not they believe in climate change, know that climate change is a threat. They experience this rise in anxiety as a response to the altering of their environment, and as Ingle and Mikulewicz explain, anxiety is a survival mechanism (Ingle and Mikulewicz, 2020:1). They can't sleep or eat because in their bones they know that the unnatural changes occurring threaten their survival as an individual.

We also established earlier that people have different ways of reacting to climate change. Some find themselves unable to process the situation, leading to senses of loss and helplessness, while other may become frustrated or ignore the threat all together (Ingle and Mikulewicz, 2020: 1). Heightened anxiety, a feeling of impending doom, hopelessness, and fatalism are feelings that are all closely associated with eco-anxiety, and these feelings can occur before the disaster takes place (Hayes et al, 2018: 3). While these symptoms occur before the event, there are also symptoms that occur after the event and can appear over an immediate, mid-range, or long-term time frame. The following all comes from Hayes and Poland (2018). The immediate time frame occurs within hours or weeks of the event, and some typical symptoms include normal responses to a disaster. The mid-range time frame occurs 6 months to a year after the event, and the long-term time frame occurs after a year post-event. The mid-range and long-term time frames are both associated with anxiety, depression, stress, and drug and alcohol abuse (Hayes and Poland, 2018: 6). For example, disorders like PTSD were found to be the most severe within 6 months of the event, and Hurricane Katrina survivors saw an increase in PTSD from 14.9% at the 5-8-month mark to 20.9% at the 1-year post Katrina mark (Hayes et al, 2018: 4). Overall, the mental effects of a disaster peak within one year of the event, but that doesn't mean the issues disappear after this. Hayes et. al cite a study that found that residents that were affected by extreme flooding due to Hurricane Katrina saw long-term anxiety 2.5 to 5

years after Katrina hit, and over 7,000 individuals still have trauma associated with Hurricane Katrina which struck in 2005 (Hayes et al, 2018: 4).

Solastalgia and Cultural Effects of Climate Change

Earlier we defined solastalgia as the distress, sense of loss, and feelings of isolation felt by individuals or communities in response to their place in the environment, and it is a long-term effect felt after the original climate impact (Bourque and Willox, 2014: 419). Solastalgia goes hand in hand with eco-anxiety and ecoparalysis, but where they deal with an individual, solastalgia deals more with communities and their relationship with their environment. Solastalgia is also linked with how at risk a community is to mental health impacts of climate change. These communities include those with pre-existing health conditions, low socioeconomic status, children, the elderly, and ethnic minorities (Ingle and Mikulewicz, 2020: 1). Mental health issues as well as solastalgia are more common in these communities because they lack the funds and social/community resilience to recover from climate change impacts (Ingle and Mikulewicz, 2020:1). Climate change has also led to an increase in migration and migrant communities. In their new home, these migrant communities face differences in language, culture, and lifestyle that increase stress, xenophobia (prejudice against people from a different country), and racism (Hayes et al, 2018: 7). These are effects felt as a result of human to human interactions that increase or enhance pre-existing effects of migration and climate change. Being forced to migrate affects the mental health of communities by breaking bonds between individuals in a community, losing cultural identity and integrity, and making the community or individual feel as though they don't belong or don't have a place in their environment or community anymore (Hayes et al, 2018: 7). Climate change is altering the traditions and way of life of certain communities. This loss of community/culture can lead to more criminal behavior, violence, and aggression as individuals are forced to react to stress (Hayes et al, 2018: 7). It can also reduce an individual's ability to deal with adversity (Obradovich et al, 2018: 1).

One thing to keep in mind about climate change and its effects is that there is an inverse relationship between risk/vulnerability and responsibility, and that climate change amplifies existing mental health issues (Ingle and Mikulewicz, 2020: 3). The Inuit community found in northern Canada is a great example of the mental health effects felt disproportionately at a community level, and Ingle and Mikulewicz (2020) as well as Bourque and Willox (2014) both cite the Inuit community in their papers. The Inuit are facing rapid changes in their climate and environment. They have historically had a larger portion of their population that experiences mental health issues when compared to the Canadian population, and this is believed to be a result of colonialism and its consequences (Ingle and Mikulewicz, 2020: 3; Bourque and Willox, 2014: 417). Northern Canada is experiencing rising temperatures, with the projection that there will be a 5°C increase in temperature over the next century. There is also a decline in ice thickness, permafrost, and an increase in the frequency and intensity of storms that are disrupting the livelihood, lifestyle, and health of the Inuit community (Bourque and Willox, 2014: 417). The Inuit have had a rise in the suicide rate, which is 11% higher than the Canadian average, and this rate is even higher in the individuals between the ages of 13 and 25 of the Inuit population (Bourque and Willox, 2014: 417). The Inuit are a community that rely heavily on their environment for sustenance, livelihood, and culture. These drastic climate change impacts are having large negative effects on the community (Bourque and Willox, 2014: 417). These effects include loss of land-based activities, identity, sense of place, increased family stress, increased drug and alcohol abuse, and an increase in suicide and suicidal ideation (Bourque and Willox, 2014: 417). The Inuit community is a minority group, and as such they have less access to mental health resources and services, which further exacerbates the mental health issues being faced by the community.

While the Inuit feel the effects of climate change as a community in the form of rising mental health issues related to the loss of cultural heritage and land, the Syrian migrant population has felt the effects of climate change in the form of forced migration and land loss. The majority of the Syrian migrants have been displaced as a result of the Syrian Civil War that began

in 2011. In 2011 alone, about 1.5 million rural Syrians fled their agricultural area to urban areas to escape drought, failed agriculture, and lack of water and food. Since 2013, the number of individuals forced to migrate reached over 5 million people (Hayes et al, 2018: 7). It is believed that the civil unrest is a result of tension between the rural migrants and the urban community, environmental degradation, along with policy responses failing to help with food and water insecurity (Hayes et al, 2018: 7). The climate change link to the Syrian civil war is the failed agriculture resulting from a drought that occurred from 2006 to 2009, and a drought that returned in 2011 that led to there not being sufficient food and water to sustain the Syrian population (Hayes et al, 2018: 7). This drought is a part of a long-term drying trend that is linked to climate change (Levy et al, 2017: 248). From 2006 to 2009, a severe drought made approximately 60% of the agricultural land into desert while also causing 80% of cattle to perish (Levy et al, 2017: 248). The forced migration of the agricultural communities raised the urban population to 13.8 million, which is 50% higher than it had been in 2002, and most of the individuals from the agricultural communities were unable to find work and felt that the government mistreated them (Levy et al, 2017: 248). When the drought returned in 2011, the Syrian government was unable to create policies to sustain the Syrian population, and as the food and water shortage increased, the unrest and tension grew amongst the population until it exploded in the form of the Syrian Civil War. The Syrian Civil War is a significant example of how climate change alters the way of life for individuals, in some cases forcing communities to migrate and as such alter their cultural heritage. As the stress associated with migration, such as a loss of community cohesion and cultural identity, increases we see a rise in violence and unrest. This was seen in Syria when the drought inflamed pre-existing civil unrest as a result of failed policy.

This rise in violence, as well as mental health issues resulting from climate change, will only continue to increase in minority and migrant populations. By 2050 the estimates of displaced individuals will rise to between 25 million and 1 billion, with most estimates putting the number at least at 200 million people (Hayes et al, 2018: 7). While these numbers can seem daunting, climate change can also have a few positive

effects on communities. Post-traumatic growth (PTG) can occur after a climate related event. PTG refers to the beneficial changes in cognition, emotions, psychological functioning, and life awareness that occurs after a trauma that changes their individual assumption about themselves, others, and the future (Hayes and Poland, 2018: 9). PTG is believed to be a form of resilience that is transformative, meaning it alters the way someone thinks, and it only occurs after a significant traumatic stressor, such as a natural disaster (Hayes and Poland, 2018: 9). PTG can create hope and renew a sense of belonging amongst communities, especially migrant communities who feel welcomed, safe, and experience better living conditions in their new host country (Hayes et al, 2018: 7). While PTG does occur, the majority of migrant and minority communities experience mostly negative effects and stress as a result of climate change.

Failure of Present and Future Thoughts

Throughout this paper we have discussed the problems of global climate change by not only the degradation of the earth, but also its suggested impacts on human physical and mental health. Researchers have suggested that in order to reduce these climate change obstacles that are faced today, we must have a “capacity to adapt, which is the ability and willingness to respond to climate change mediated by individual and collective agency” (Hayes et al, 2018: 8). In order to adapt, we must intervene in the issues at hand by monitoring diseases produced by climate change, educate people about mental health issues, and prepare to support those affected by disasters and other climate effects (Hayes et al, 2018: 8; Ingle and Mikulewicz, 2020; 1). This adaptive capacity issue is determined by how the government, economy, technology, institutions, and the overall infrastructure of the United States (and the world) handle the obstacles of climate change (Hayes et al, 2018: 8; Ingle and Mikulewicz, 2020; 1). In fact, we believe that by being able to adapt we could start the process to understand and find solutions to reduce climate impacts on the earth and the individual. In addition to adaptation, researchers suggest that there have been major failures when it comes to finding potential solutions for this major global issue. Major failures such as those suggested by researchers including

those in the Hayes et al. article, suggest that these failures affect indirect mental health problems which can “occur as a result of damages to physical and social infrastructure, physical health effects, food and water shortages, conflict, and displacement from acute, subacute and chronic climate changes” (Hayes et al, 2018: 6). This can occur due to turmoil within a country’s economic or even political aspects.

One major failure is the lack of addressing the gap between the stated goals created by certain countries to reduce climate change and what is really needed for change within the country or even community. It is suggested that the population of countries, including policy makers and the individual, should all take steps to understand the past, present, and future consequences of climate change in hopes of conserving the world for future generations (Hayes et al, 2018: 6). By understanding, reducing our pollution, and acclimating to what is going on now, we hope that we can attest to these failures and thus redeem what we have done in the past, in order to help those in the future. Despite this suggestion, there is still an additional issue with the failure “to address the gap between stated goals of emissions reduction commitments and the speed of actions required to keep global warming well below 1.5-2°C” (Hayes et al, 2018: 8). The lack of goal setting has been limiting the actions that need to be taken to eliminate the past, present, and future climate change problems. Not only are there issues with goal setting within countries, there is also a failure to recognize pre-existing health conditions and the ability to separate them from mental health problems caused by climate change. According to Hayes et al, organizing the ‘normal’ responses to climate events along with other pre-existing issues could lead to a misdiagnosis of severity and where the mental issue originated (Hayes et al, 2018: 4). The failure of misdiagnosis and its origin has been observed by Whaley in their research about Hurricane Katrina’s aftermath and how medical professionals “attributed disaster trauma as a typical stress response, ...when in fact there were much larger mental health issues related to the effects of the Hurricane that went undiagnosed” (Hayes et al, 2018: 4; Whaley, 2009). This failure has greatly impacted those who suffer from these traumas because of the lack of support and treatment the individuals received.

It’s important to understand that these pre-mental health problems can be triggered by climate change related events such as hurricanes and floods (Hayes et al, 2018: 6). By understanding these facts about pre-mental and mental health problems, medical professionals and others could help reduce the degree to which climate change affects individuals in more vulnerable areas around the world.

These failures of handling climate change and its effects on the mental health of humans are largely due to the limitations of applicable tools and research abilities. Researchers have been known to treat mental health as an illness in their studies and to use this generalization within their surveys (Hayes et al, 2018: 4). One example is the “generalized anxiety disorder, PTSD, and psychological distress” questionnaire used after major weather events (Hayes et al, 2018: 4). Due to the lack of available tools and empirical studies that focus on mental health due to climate change events, there is a lack of positive psychological implications to find ways to increase “compassion, altruism, sense of meaning, post-traumatic growth, or even increased acceptance of climate change” (Hayes et al, 2018: 4). A possible solution suggested by Hayes et al., is that we must acknowledge the anticipated patterns of mental illnesses due to extreme weather events and understand the unequal impacts of climate change on different groups of people, as well as possible prevention strategies for this (Hayes et al, 2018: 4).

The World Health Organization (WHO) has been adamant on setting a “framework for building climate resilient health system” to strengthen and guide health professionals to be prepared for potential climate related shocks that can cause mental health issues (Hayes et al, 2018: 5). This framework suggested in 2015, states that “by increasing health systems’ capacity to cope, adapt, sustain, and strengthen in the wake of a changing climate” health professionals can assist with apparent mental health issues (Hayes et al, 2018: 5).

Once the understanding of the linkages between climate change and mental health is established around the world there will be many potential benefits. Hayes et al. suggests that there will be an,

“enhanced knowledge of patterns of illness; an added emphasis on the global call to action to reduce and address climate change risks and impacts; in-depth knowledge of the risks and impacts to marginalized communities; and a better planning for mental health response and mental health systems resiliency” (Hayes et al, 2018: 5).

These benefits have the potential to establish more awareness, acceptance, and understanding of climate change and mental health effects around the world.

Once the effects of climate change on mental health are understood, mental health care workers and government officials can take action to assist and support those affected by these health problems. The big issue today is that society and the health-care systems are both unequally prepared to deal with mental health issues due to climate change (Ingle and Mikulewicz, 2020: 1). This is in part due to the lack of access to mental health services and resources for many people around the country who are more vulnerable to these health effects (Bourque and Willox, 2014: 4). If there is an increase in the overall awareness and education about mental health and its climate effects by health professionals and government officials, we could potentially provide accurate and adequate support for those who are highly affected by climate change (Bourque and Willox, 2014: 6). This assistance, along with an increase of general public awareness, needs to explain how bad climate change really is and how it is not only harming the earth but those who inhabit it (Hayes et al, 2018: 9). In addition to increasing awareness, we must prepare the mental health workforce to be able to intervene in climate-related emergencies to help with the aftermath of these disasters in a better manner (Bourque and Willox, 2014: 6). By preparing the work force and giving them comprehensive guidelines on how to handle the situation at hand, there is a possible benefit to how things are handled today (Bourque and Willox, 2014: 7).

In addition to preparing the mental health workforce and the government, several of the papers we discussed suggest collective action is needed by communities and individuals to survive the problems

presented in a changing climate and strengthen personal emotional resilience and increase community resilience, in hopes of changing climate for a better future (Hayes and Poland, 2018: 7). Furthermore, by addressing this dilemma of mental health and advocating for a betterment of the climate of the planet, we could reduce the direct and indirect issues that are being presented in individuals around the world.

Conclusion

This paper has presented many topics within the realm of climate change and mental health. Climate change directly affects food and water borne illnesses, heat stress, and respiratory issues such as asthma. It also has indirect effects on individuals and communities through malnutrition, violence, forced migration, and food security. As climate change continues to become a prevalent issue, these direct and indirect effects continue to grow, creating more problems within individuals and communities. These effects also exacerbate solastalgia and the loss of culture and cultural heritage. As individuals are stripped of their place in their environment and community, violence, drug and alcohol abuse as well as suicide are on the rise. This is especially noticeable in minority groups, such as the Inuit. On the individual level, climate change heightens existing mental health issues and creates new ones such as PTSD and increased anxiety. Eco-anxiety, which can occur at any point, is a mechanism by which our bodies warn us of the approaching doom created by climate change. Ecoparalysis occurs before and during an extreme weather event and it coincides with the feelings of helplessness associated with a changing environment due to climate change. Eco-anxiety and ecoparalysis can be felt by individuals who experience the failures of infrastructure and public policy that neglect to adapt to the changing environment. As these failures become more widespread, the indirect mental health effects of climate change increase because of the turmoil and unrest within a country's economic and political systems. These mental health issues often go undiagnosed or are downplayed as less significant problems in the scope of climate change, as shown with individuals affected by Hurricane Katrina.

It should be understood that climate change is not just the polar ice caps melting or global temperatures increasing. Climate change is rising diseases and mental health issues, anxiety about your future and the future of the environment. It is also the government's inability to protect their minority and majority citizens from food shortages, loss of identity, and environment changes. The effects of climate change are impacting minority groups now, but it is only a matter of time until the majority also feels the effects. As eco-anxiety and ecoparalysis continue to grow, individuals from the majority begin to see the threat posed by climate change. This begs the question: how long will it be until the entire majority feels the direct and indirect effects of climate change? How long will it be before the entire global population takes a stand to right the wrong that is climate change? And will it be too late by the time they do? These final questions are meant to open a discussion about not just climate change and mental health, but also climate change as a whole. For the future, there needs to be an increase in education about climate change and its effects. Without proper education, the current and next generations cannot make informed decisions about how to solve the issues created by a changing climate. Increasing education on climate change will also inform people about how mental health is greatly affected by climate change. We have concluded that there needs to be an increase in adequate research into the field of climate change and mental health; education among the public as well as medical professionals on the link between extreme weather events and strained mental health; and community resilience and interpersonal relationships so as to limit the loss of culture and sense of self. Only when these goals have been reached can we hope to mitigate climate change and thus reduce its effects on mental health.

References

- BOURQUE, FRANÇOIS AND ASHLEE CUNSOLO WILLOX. 2014. "CLIMATE CHANGE: THE NEXT CHALLENGE FOR PUBLIC MENTAL HEALTH?". *INTERNATIONAL REVIEW OF PSYCHIATRY* 26:4, 415-422, DOI: 10.3109/09540261.2014.925851.
- GIDDENS A. 2009. *THE POLITICS OF CLIMATE CHANGE*. POLITY PRESS: CAMBRIDGE, U.K.
- HAYES, KATIE, G. BLASHKI, J. WISEMAN, S. BURKE, AND L. REIFELS. 2018. "CLIMATE CHANGE AND MENTAL HEALTH: RISKS, IMPACTS AND PRIORITY ACTIONS". *INTERNATIONAL JOURNAL OF MENTAL HEALTH SYSTEMS* 12:28. DOI: 10.1186/s13033-018-0210-6.
- HAYES, KATIE AND BLAKE POLAND. 2018. "ADDRESSING MENTAL HEALTH IN A CHANGING CLIMATE: INCORPORATING MENTAL HEALTH INDICATORS INTO CLIMATE CHANGE AND HEALTH VULNERABILITY AND ADAPTATION ASSESSMENTS". *INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH* 15:1806. DOI: 10.3390/IJERPH15091806.
- INGLE, HARRIET AND MICHAEL MIKULEWICZ. 2020. "MENTAL HEALTH AND CLIMATE CHANGE: TACKLING INVISIBLE INJUSTICE". *THE LANCET* 4:128-130. DOI: 10.1016/S2542-5196(20)30081-4.
- LEVY, BARRY S., V. W. SIDEL, AND J. A. PATZ. 2017. "CLIMATE CHANGE AND COLLECTIVE VIOLENCE". *ANNUAL REVIEW OF PUBLIC HEALTH* 3:8:241- 257. [HTTPS://DOI.ORG/10.1146/ANNUREV-PUBLHEALTH-031816-044232](https://doi.org/10.1146/annurev-publhealth-031816-044232).
- OBRADOVICH, NICK, R. MIGLIORINI, M. P. PAULUS, AND I. RAHWAN. 2018. "EMPIRICAL EVIDENCE OF MENTAL HEALTH RISKS POSED BY CLIMATE CHANGE". *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES* 115:43: 10953-10958. [HTTPS://DOI.ORG/10.1073/PNAS.1801528115](https://doi.org/10.1073/pnas.1801528115).
- WHALEY AL. 2009. TRAUMA AMONG SURVIVORS OF HURRICANE KATRINA: CONSIDERATIONS AND RECOMMENDATIONS FOR MENTAL HEALTH CARE. *J LOSS TRAUMA* 14(6):459-76.