Washington College
Department of Anthropology

Foreman's Patch: Learning from Macroinvertebrates

Kami Lentzsch

A senior thesis submitted to the
Department of Anthropology
in partial fulfillment of the requirements for the degree of
Bachelor of Arts at Washington College

April 30, 2025

Washington College Honor Code:
I pledge my word of honor that I have abided by the Washington College Honor Code while completing this assignment.

____

Thesis Advisor: Dr. Scott Erich

____

INTRODUCTION 2

CHAPTER 1: DEEP DIVE ON PEOPLE AND PLACE 7

CHAPTER 2: THEORY 15

CHAPTER 3: METHODS AND FINDINGS 21

CONCLUSIONS 26

BIBLIOGRAPHY 34

Introduction

Walking through the stream in fall, the scenery is calling my name. The orange and yellow color of the leaves shine and shake in the wind. But I'm not looking up; my eyes are focused on the ground. I'm looking for aquatic macroinvertebrates. They are beautiful creatures. Walking along the stream edge, I'm zeroing in on pools; places in the stream where the water is not flowing, where large pebbles and stones settle out of the thalweg and fallen leaves congregate on the top. This is prime macroinvertebrate habitat. Places where they stand a chance to navigate underneath the surface, in a world of their own. Underneath the surface of the stream, there are newly-born organisms that dominate in terms of both diversity and abundance, and those organisms are aquatic macroinvertebrates. Benthic or pelagic, living in the bottom sediment or roaming around the water column, macroinvertebrates have adapted a wide range of characteristics to live life in the stream system. These traits may seem alien to an outsider: six or ten legs, a portable case, wing pads, hooks at the end of its body, three tails, lateral filaments, labial masks, eye spots, and more. But these are the same traits that make aquatic macroinvertebrates so uniquely well-suited to survive in their niche of the biosphere. There is beauty in that. Some even take those caddisfly portable cases to make jewelry.

If you are not a scientist, "aquatic macroinvertebrate" may be an unfamiliar term to you. Perhaps you know the word mayfly through your time flyfishing or through its adult form once it emerges from the stream. But macroinvertebrate is a broad category describing a set of small organisms large enough to be seen with a naked eye that do not have a backbone or vertebral column. Aquatic macroinvertebrates, more specifically, spend part (or all) their lives in the water. This includes aquatic insects at different life stages (adults, nymphs, and larvae), worms, snails, clams, crayfish, and other crustaceans. Some species you might not know spend their youth stages in the water, like dragonflies and damselflies of the order *Odonata*. These organisms may look completely different in their aquatic life stages than in their terrestrial life stages. Because some macroinvertebrates play so many different roles and make up many primary consumers in the bottom of the food web, they are vital for keeping a stream healthy. A healthy macroinvertebrate community not only benefits the stream, but it benefits humans. Without macroinvertebrates, the food chain collapses and cannot support top predators, like trout. This makes macroinvertebrates important not only culturally but also economically: the flyfishing industry, which is predicated on the relationship between aquatic macroinvertebrates and fish, was valued at $1.06 billion in 2024 (Business Research Insights, 2025).

Macroinvertebrates fill many different niches within the stream, based mainly on their functional feeding groups: shredders, collector-filterers, collector-gatherers, scrapers-grazers, and predators. Shredders are primary consumers which consume course particulate organic matter (CPOM), mostly made of leaf litter or only woody material, into smaller pieces of fine particulate organic matter (FPOM). Collectors accumulate this FPOM; collector-gatherers from the stream bottom and collector-filterers from the water column. Scrapers, also known as grazers, consume the algae and other material off the surface of rocks or other hard substrate under the water. Lastly, predators feed on other consumers (Naiman and Bilby, 2001; Carmel River Watershed Assessment, 2004). There are some macroinvertebrates who fit into multiple of these categories and some that do not fall perfectly into others; they are so diverse, and peak diversity reveals the existence of whole worlds within a single run of a stream. There are an estimated tens of thousands of species of macroinvertebrates in the world.

My curiosity into researching macroinvertebrates came based off building a better understanding of this diversity, and especially being how we, as humans, are impacting the lives of macroinvertebrates in the Anthropocene. The Anthropocene, as defined in *A Possible Anthropology: Methods for Uneasy Times* by Anand Pandian (2019), is "an era of human planetary domination, with more land, water, and biological life seized for our wants and wastes than ever before." In other words, it is an unprecedented time in the history of the Earth where processes have been impacted by dominating human actions. Humanity has become equal to a planetary force whose effects will be seen in the geologic record through what has been called the Great Acceleration. An example of evidence that will last in the geologic record is decreased plant stomata due to high levels of carbon dioxide. Fossil records also show increased interconnectivity and species migration due to globalization, as well as the impacts of intensified farming, industrialization, and urbanization (Williams et al., 2024). Anthropogenic sedimentary settings, for example, increase survivability of the record and include places like landfills and modified aquatic ecosystems (Williams et al., 2024).

In the following sections, I ask: How can the study of something so small— macroinvertebrates— teach us about what it means to be human in this era of environmental change, the Anthropocene? And what can we gain by understanding what I will later describe as the feral nature of both macroinvertebrates and plastics in the global and local systems?

For the past year, I have been conducting scientific research about macroinvertebrates. In the Anthropocene, it is important to understand our human impact on macroinvertebrate assemblages and behaviors in the stream ecosystem freshwater systems, which are the most threatened on Earth (Nieto et al., 2017). I am fascinated by the impacts humans have on macroinvertebrate behavior specifically, and the lack of current knowledge on the topic of anthropogenic plastic pollution. As an environmental scientist, I formulated the question: How does the substrate composition of leaf packs (plastic, leaves, and mixed) temporally influence the establishment patterns and feeding group diversity of macroinvertebrates in freshwater habitats? As an anthropologist, I ask: What are the stakes for us as humans who share fresh waterways with macroinvertebrates? In this thesis, I answer these questions by researching macroinvertebrate choice of substrate material, in plastics vs. natural leaf litter, over time and *in situ.* By informing an understanding of macroinvertebrate substrate choice, I aim to consider the risk of macroinvertebrates on the creation of aquatic microplastics and the risk of plastics on macroinvertebrate health, and ultimately on human livelihoods.

Growing up on the Chesapeake Bay, the biggest estuary in the United States, I've always been interested in environmental issues. I've always felt connected to the water and enjoyed boating, fishing, and swimming. It is recent that my personal interests have developed, moving up from the brackish system of the Chesapeake Bay into its headwaters and then its upper watershed streams. Recently, I have been learning to flyfish and have taken up fly-tying. Flyfishing requires a great appreciation for macroinvertebrates, which are among the favorite prey of freshwater fish like the native brown trout and stocked rainbow trout found in Maryland streams; it also requires a deeper understanding (or at least a desire to understand) the functionality of the stream community interactions within the abiotic setting: the ways that flies and fish relate to each other. My current positionality as an outdoor enthusiast and student scientific researcher situates me with a unique perspective to dig deeper into the social question of looking into macroinvertebrates and plastics to better understand ourselves.

Plastic pollution is a prevailing problem in today's global environment (Valentine et al., 2022; Artru & Lecerf, 2019). Macroinvertebrates contribute to the biological breakdown of macroplastics to microplastics (Valentine et al., 2022). Current understanding of habitat selection preferences for benthic macroinvertebrates is lacking, especially concerning plastic. With all of the anthropogenic environmental change occurring in the world today, it may be hard to think about our place in the world as humans. But maybe looking into the relationship between macroplastics, macroinvertebrates, and the natural environment can do just that.

Back at the stream, I hold a rock in my hand, with a stonefly crawling along the bottom. The juxtaposition of the fragile macroinvertebrate against the hard stone strikes me. I question, what can something so small tell us about how humans have altered geologic time in ways that will be seen centuries or even millennia from now?

Chapter 1: Deep Dive on People and Place

The anthropologist Anna Tsing and her interlocutors have described the Anthropocene as "patchy". This describes the heterogeneous effects of the Anthropocene across the earth and the certain areas where we can see these effects shine through if we look closely enough**.** Foreman's Branch is one such patch. Our patch of the Anthropocene, Foreman's Branch stream, located on the River and Field Campus of Washington College, historically and locally known as Chino Farms. Foreman's Branch flows into the broader Chester River and eventually connects to the Chesapeake Bay, the largest estuary in the United States. The small section of the stream where I studied is a miniscule speck in the watershed, but what lessons can we learn by studying it, and where do we see ferality in the system?

Waterways have always been of utmost importance to the Eastern Shore and to Chestertown, where our patch is located. Chestertown and the surrounding area are situated on lands that historically belonged to Piscataway and Nanticoke indigenous peoples (WC Center for Environment and Society, 2021). The Nanticoke and Piscataway used the Chesapeake Waterways to establish complex networks for fishing, hunting, and trading with other indigenous groups (Gorsuch, 2024). They harvested clams, oysters, fish, and other invertebrates from the main water bodies, rivers, and streams in the area. Records indicate that the Piscataway and Nanticoke peoples have lived in the area for more than 10,000 years (Gorsuch, 2024), though their societies have suffered from disease, war, and associated threats due to English colonization beginning in the seventeenth century. The waterways also suffered as a result of colonization.

Chestertown was founded as a port city in 1706 (Kent County Historical Society, n.d.). Waterways have continued to serve as essential places for transportation, commerce, work and recreation in the region. The town is in a protected stretch of the river and served as an access point for goods and people moving throughout the Delmarva Peninsula, as it offered the shortest route to people and goods traveling between Virginia and Philadelphia, and from Philadelphia north (Kent County Historical Society, n.d.). On the Eastern Shore and in the port of Chestertown, there was a large business in the trade of enslaved individuals (Kent County Historical Society, n.d.; Wilson, 2021). Waterways were utilitarian in terms of their use and also seen as places to exploit and ways to get rid of trash (Marshall, 2004). During the colonial period, waterfront property was not valued as it is in modern times.

During the 18th century, George Washington and many of the other founding fathers traveled through Chestertown, the former bestowing his name to Washington College in 1784. In fact, Washington College was known locally as the college on the hill. It was built on a raised land mass because before the invention of modern septic systems, the waste would flow down and away from affluent members of the college and directly into the river. A thriving free Black community started to grow in Chestertown, based within the un-valued waterfront community and exposed to polluted waters. This is only the beginning of the problems related to our local waterways.

Along with all of the social changes that have occurred in Chestertown are all of the environmental changes. As populations grew, overexploitation of the environment's resouces grew, and challenges popped up. One that developed over time is agriculture. Like many other histories in the area, farming can be traced back to the 17th century. Over 70% of lands in Kent County are agricultural (Maryland Department of Natural Resources, 2021). These lands have been in agriculture since the first land grants were given out to people such as Thomas Ringgold, Thomas South, Thomas Hynson, and Joseph Winkles in the 1650s (Kent Count Historical Society, n.d.). These people were the first English to move past Kent Island and up into land surrounding the Chester River (Kent County Historical Society, n.d.). By the 18^{th} century, Maryland plants were transitioning from the nutrient and labor-intensive tobacco plant into a more grain-based and diversified economy (Kent County Historical Society, n.d.). Then, later in the 20^{th} century, agriculture transitioned again as local canneries closed, with crops like corn, soybeans, and other grains that could be turned into broiler feed (Kent County Historical Society, n.d.). Chemical fertilizer use increased yield on monoculture fields, adding an unnatural source of nutrients with some unintended runoff consequences.

Today, Kent County is home to over 134,000 acres of prime farmland, providing the second highest crop output in Maryland (U.S. Department of Agriculture, 2019). The excess of farming has led to environmental issues related to runoff. Before relatively recent times, a lot of the fields were tilled every season to remove the after-harvest debris of crops from the fields. This pushed a lot of fine sediment into the air and into the waters, increasing suspended solids and turbidity of the water. Additionally, in the entire Chesapeake Bay Watershed, there has been problems with chemical runoff since the advent of these industrial fertilizers, like nitrogen, phosphorous, and potash in the 19^{th} and 20^{th} centuries (Krimer, 2025). The overapplication has led to runoff into the waterways, creating an excess of nutrients known as eutrophication. Eutrophic conditions are a precursor to extreme algal blooms.

These algal blooms are temporary and once they die, they sink to the bottom, decompose, take oxygen out of the water, and cause dead zones, where no organisms can survive (that is, depending on their threshold, which we will return to later).

If we want to look even closer at our patch to understand the dynamics, Chino Farms has been used as agricultural land since it was developed during the 18th century.

The land remained between owners until Dr. Harry Sears of New York purchased Chino Farms in 1950 to use for hunting (WC Center for Environment and Society, 2021). The Sears family accumulated over 5,000 acres of Chino Farms, consisting of waterfront, forest, grasslands, and agricultural fields. In 2001, the Sears family entered the farm into a conservation easement to protect the land from development in the future, seeing the negative environmental changes in the region and wanting to help protect the Eastern Shore. The easement they entered into is the largest of its kind in the state of Maryland (WC Center for Environment and Society, 2021). In 2011, Washington College's Center for Environment and Society began to coordinate student and research activities at Chino Farms, and in 2017 Dr. Sears announced his intention to gift the property in a trust to Washington College. This deal sealed its legacy of environmental protection and research on the Eastern Shore.

As agriculture became industrialized and polluting, harvesting seafood from local waters continued to be important too. Although, as populations grew and demand increased beyond supply, over-harvesting began to become a problem that threatened the future of both the bay and the watermen (Kent County Historical Society, n.d.). The uneven and patchy nature of this success story, a small rewilded easement in a sea of fertilizer heavy monocrop farms, makes it a perfect site to examine the effects of the Anthropocene.

Additional environmental challenges in the region include degradation through pollution and contamination of water resources. Humans are the only animal on the planet to create waste that will outlive them (Porta, 2021). One of these waste products, as we know is plastic. “The first synthetic plastic, Bakelite, was invented in 1907 by Belgian-American chemist Leo Baekeland. This marked the beginning of the commercial plastics industry” (Abrahms-Kavunenko, 2023). It is now the grocery bag you see weighted down in the stream or the bottle on the side of the highway, which will flow into the water directly or through a complex path through urban systems, eventually making their way into the flowing waterways that lead to the bays and the oceans. These problems have only exacerbated with population growth. The more people, the more waste, especially in the United States, which is the largest producer of plastic waste in the world. In 2016, the United States produced over 42 million metric tons (46 million U.S. tons) of plastic waste (Law et al., 2020). “The U.S. also ranks as high as third among coastal nations for contributing litter, illegally dumped trash and other mismanaged waste to its shorelines” (Parker, 2020).

These are only some of the environmental problems we are dealing with in our patch. These environmental issues matter not only for people, but organisms and non-living things as well. We can measure the amount of product applied to fields, the runoff coming off of them, where there are high nutrient levels. But, how much of the big picture can we actually see with all of this scientific monitoring and testing? We can accurately understand some of the abiotic conditions, but how do we know what impact it is actually having? What are the downstream effects to the environment and living things?

Here, macroinvertebrates are our allies. These macroinvertebrates show us the biological relevance for contaminants: they are important environmental indicators for things that might not be seen by the naked eye, like heavy metal or microplastic contaminants. Even though we know their sensitivities in general, we still don't know how they react to all things. But it is important to understand how all anthropogenic factors are impacting macroinvertebrate life, like feral macroplastics in the case of my study. I consider macroplastics to be feral for their propensity to step out of the purview of their original purpose as designed by humans (Tsing et al., 2024). Their sensitivity to environmental contaminants makes them an important indicator for aquatic pollution and habitat quality, with different families having specific pollution tolerance ranges (Alba-Tercedor, 2008). But all of the contaminants in the stream are also feral, polluting the stream in a way opposite to human design: the plastics, the metals, all.

Macroinvertebrates are not only environmental indicators; they play a vital role in ecosystem dynamics. They shape the nutrient cycles, primary productivity, decomposition, and translocation of materials occurring in the freshwater system (Wallace & Webster, 1996). Macroinvertebrates are important in part because of the timescale they operate on. The life cycle of some macroinvertebrates is determined by the conditions of the water they are living in. Depending on the species, a macroinvertebrate life cycle can range from just a few weeks to longer than two years (Miller, 2013). Many macroinvertebrates are sessile organisms, meaning they live in a state of relative immobility (Cai & Geritz, 2021). Since they cannot quickly move to another stream, given the one they are currently living in is contaminated, their survival is directly linked to their local habitat.

Humans only began to understand the deep importance of macroinvertebrates in 1902, when Kolwitz and Marsson formulated the relationship of aquatic organisms to the purity and pollution of water (Alba-Tercedor, 2006). We have developed that idea as overall scientific knowledge has advanced over the years, transitioning from relying on indicator organisms to entire indicator communities (Rosenberg and Resh, 1996). In general, if a scientist observes low biodiversity, low population density, but the stream appears clean, it is a sign that the stream could be exposed to possible toxic pollution or could be naturally unproductive due to limited light or nutrients. Examples of these toxins are chlorine, acids, heavy metals, oil, pesticides, etc. that would require additional testing. If there are only a couple of taxa groups present and high percentages of those taxa are collectors, it indicates possible severe organic pollution or sedimentation. Sources of organic pollution are things like nutrient enrichment causing eutrophic conditions (mentioned above). Streams with low biodiversity, high density, and lots of scrapers and collectors are likely to have organic pollution causing agal growth or sedimentation. But when we see a stream with high biodiversity, lots of sensitive taxa like stoneflies, mayflies, and caddisflies, this indicates that we have no problems with our water quality (South Carolina Department of Health and Environmental Control, n.d.). The beauty of using macroinvertebrates is the biological relevance and insight into life in the stream beyond normal human vision.

There are many benefits of using macroinvertebrates to evaluate water quality in streams, which can tell us a little bit more about them as creatures. The first one of these benefits is that they are a long-term indicator of water quality. Because macroinvertebrates integrate the effects of stressors over time, they can show the effects of pollution, habitat degradation, or other stressors over weeks, months, or even years in comparison to chemical testing which only shows the effects at one point in time (EPA, n.d.; Li et al., 2015). In other words, this allows us to trace changes that abound over time. Another benefit to using macroinvertebrates over chemical tests is that it gives us a more comprehensive view of ecosystem health. Because macroinvertebrates are so important to the aquatic and terrestrial food webs surrounding the stream, changes in their populations can signal broader ecosystem issues and other groups that might be affected (Wallace & Webster, 1996). A chemical test might lack these broader ecosystem wide implications that a macroinvertebrate can communicate with us. Even more, macroinvertebrates can be even more sensitive to environmental contaminants than chemical tests and can signal multiple stressors (Alba-Tercedor, 2008). Examples of these conditions' macroinvertebrates can be more sensitive to are dissolved oxygen, sedimentation, or heavy metals that a chemical test might detect, but not show at a level which can be seen as impacting aquatic life. In terms of multiple stressors, when we are studying a community of macroinvertebrates, different taxa or species will be more sensitive to different, specific environmental factors, so a shift in that community composition can point to multiple stressors. A chemical test that focuses on a specific pollutant won't tell you about any other factors or interactions.

In the Anthropocene, it is critical to understand our human impact on macroinvertebrate assemblages and behaviors in the stream ecosystems and other freshwater systems which are the most threatened on Earth (Nieto et al., 2017).

This is the science. We think we know to describe them. And despite what we think we know; they are more resilient that we might be giving them credit for. What are we missing by only looking through a scientific lens? How can looking at macroinvertebrates actually tell us more about ourselves?

Chapter 2: Theory

My work utilizes a multispecies perspective and draws on the methods of patchwork ethnography, both of which take place in what scholars call the Anthropocene: an unprecedented time of rapid anthropogenic planetary change. I consider my work to be within the methodology of patchwork ethnography. I am inspired by the principles of patchwork ethnography, which requires a rethinking of home and field; that field is home and home is field. Patchwork ethnography requires searching beyond the homogeneous big picture and to structural and out-of-scale effects (Tsing et al., 2024). This methodological and theoretical framework for anthropological research enables the acknowledgements of the constraints of researchers (Günel & Wantanabe, 2024). It enables ethnographers, like myself, to conduct fieldwork whist dealing with personal and professional limitations and responsibilities (Günel & Watanabe, 2024). I am conducting my research at the same time I am balancing my last semester of college coursework, commuting to campus, working part-time, and, importantly, beholden to responsibilities apart from academics. The patchwork framework allows for a more inclusive field of ethnographic research, for myself and others that cannot afford a prolonged stretch of time in the field and widens the methods of anthropology beyond mere ethnography (Günel et al., 2020).

Importantly, patchwork ethnography also blends feminist theory with traditional ethnographical research (Günel et al., 2020; Günel et al., 2024; Tsing et al., 2019). As Günel et al. (2024) point out, long before patchwork anthropology came into focus, it was being done. Ethnographic insights can emerge from what goes on in "unruly edges" (Tsing, 2015; Günel et al., 2024). Feminist ethnographers have historically and successfully drawn attention to the voices and experiences of marginalized peoples through collaborating with communities and cross disciplines, like the work of Le Guin on the Man the Hunter story (Le Guin, 1986; Günel et al., 2024). Extending this mode of theory can shape our understanding of capitalism. Masculinist approaches to the study of capitalism, for example, have focused on "master narratives of a singular all-powerful capitalism," while female social scientists have been better positioned to see "on-the-ground-dynamics" which have shaped diverse economies (Gibson-Graham, 1996; Tsing et al. 2024)

A "patchwork ethnography" approach to the study of the Anthropocene relies on the fact that effects of the Anthropocene are not homogeneous across the earth. There are certain "patches," in the terminology of Anna Tsing and her collaborators, where you can see the Anthropocene shine through; as "temporal conditions – and discontinuities – [as] key elements" (Tsing et al., 2024). This approach necessitates both a deep historical context and scientific thinking. My approach to patchwork ethnography pays specially attention to ferality. To be feral means to be transformed by human infrastructure, but not under the control of human designers (Tsing et al., 2024; Bubandt & Tsing, 2018). I look to feral entities to "points to ways in which other-than-humans elide binary categorizations," not obliging to the organizational principles that humans assign to other species and non-human entities (Barua, 2021). Feral entities in my research, include *both* plastics and macroinvertebrates, effected by human powers, but out of human control.

Many anthropologists also believe that non-human beings can have agency (Ingold, 2011; Kohn 2023; De la Cadena, 2015; Haraway, 2016; et al.). Agency, here, is defined by the ability to exert influence and is critical to what scholars have come to call "multispecies ethnography" and the study of the more-than-human. Multispecies ethnography bases itself in the notion that non-human entities shape the material environment in which humans live, influencing the configuration of human life and our understanding of the world and ourselves (Koenig, 2016).

The presence and interactions of the more-than-human with the human shape the ways that we, as humans, construct meaning, experience, and navigate life. The start of acknowledgement of the agency of non-humans came with non-human animals and first- and second-generation critical theorists, like Max Horkheimer and Theodor Adorno (Gunderson, 2017; Wadham, 2021). The expansion of this idea to include beings, things, and objects came with "new materialism" lead by anthropologists like Bruno Latour (Latour, 2007; Wadham, 2021). Latour's actor-network theory was innovative in its view of non-human actors as agents, shaping the world around us (Latour, 2007). And many ideas have since followed, categorizing agentive interactions between human and non-human species as essential to our conceptualization of culture and society (Koenig, 2016).

These modern perspectives have challenged the traditional human-nature divide dominant in traditional Western philosophical thought (Guest, 2023). Thus, setting a new post-humanism in motion, in what some anthropologists have called the "multispecies turn" (Seshia Galvin, 2018; Guest, 2023). Smart and Smart (2017) argue that post-humanism means adopting the claim that we have always been posthuman: that humans, more than any other animal, have been involved in deep and meaningful interactions with "more-than-human elements." Post-humanism is an anthropological concept that entails learning more about interacting differently with the environment through "webs of relations" by means of acknowledgment of agency on multiple levels of existence (Preiser et al., 2017; Gatto & McCardle, 2019; Moore 2015). In imagining a world without humans being so deeply entangled with non-human life, Guest (2023) argues that we can imagine a new and collective future, out of reach of our human destruction. The purpose of engaging with post-humanist theory related to the multispecies studies is to reevaluate prevailing concerns of the Anthropocene (Gatto & McCardle, 2019; Guest, 2023).

Post-humanism has also been used in many interconnected disciplines, like Sustainable Design and Ecological Thinking (Gatto & McCardle, 2019).

Anthropology of the more-than-human, based in post-humanism, was pioneered by social theorists like Donna Haraway. Haraway (2016) writes of the concept of kin in the Anthropocene and beyond, in what she calls the Chthulucene (a time in which humans and nonhumans coexist and interact in ways that are not dominated by human control). Kinship, in this case, is a relationship of mutual care and respect, rather than of domination (Haraway, 2010). Like the idea of multispecies studies in general, this concept was first accepted with relationships of humans and their pets but has since moved beyond to include other non-pet species and non-human entities (Haraway, 2003; Haraway, 2010). Humans have many kin and potential to build more kin relationships with the more than humans. This expansion of the limits to the ideas of kinship can be tied back to feminist thought (Seshia Galvin, 2018). In my own work, I have made kin with my fellow creature, the macroinvertebrate. They have become my "friends" and interlocutors, in the field, my confidants, and those with whom for many days, I spend most of my time with and learning from.

Another important point, argued by Donna Haraway, in her multispecies studies is against human exceptionalism, stating humans are just one part of a broader, more interconnected world (Haraway, 2003; Haraway, 2010; Haraway, 2016). This notion is shared by many ethnographers. Lacey Johnson's *What Slime Knows* (2021) tackles this idea that there is no hierarchy in the web of life. She approaches the concept of falsely hierarchical taxonomic classifications and slime molds that have not evolved much in the past two billion years but have withstood five extinction events having to do with climate. In Laura Ogden's *Swamplife* (2017), she writes of a complex ecosystem of mangrove forests and gators where, despite human efforts to tame and control, the Everglades (nature) is alive and growing. She gives agency to the nonhuman Everglades by describing it as having “its own logic and rules of entanglement.” An example of this is the mangrove logic, where the rhizome lays the foundation for mangals to spread and assemble into non-linear networks for shoreline buffer to build up sediment for later expansion (Ogden, 2017). To make the familiar strange, Kohn (2013) switches the dynamic and while studying the Indigenous Runa People’s relationship with the amazon rainforest in *How Forests Think*. Humans, in an infrequent twist, become prey as he is told to sleep face up so the Jaguar “will see his eyes and know that he, too, is a living being capable” (Kohn, 2017). Further engaging with this idea, Tsing (2015) highlights the interdependence that humans and non-humans have in an ecological context in the case of *The Mushroom at the End of the World.* The mushroom is just as much at risk from environmental change, and she goes further by saying they are not even “resources” to be exploited.

Scholars debate the utility of multispecies thought in the critique of capitalism (Moore, 2015), but there are many scholars (Donna Harraway, 2003; Anna Tsing, 2015; Laura Ogden; 2017) who believe it is crucial to understanding of the complex dynamics that shape ecological, economic, and cultural systems. In all of the broad work being done in this field, as mentioned above, when ethnographers view humans within ecological context, containing humans and more-than-humans, we gain new insights into humanity writ large. Human and non-human worlds are not static, these interactions are temporary assemblages, always transforming (Deleuze & Guattari, 1987; Ogden, 2017). Through my research in the field, I grapple with this idea and with a central, driving question: are humans really masters of the Earth or simply one part of a sphere of interconnected existence?

Focusing again on the concept of the study of the more-than-human in the Anthropocene, the discussion moves not only towards non-human species, but plastic ontologies as well. Plastics challenge the bounded and permeable limits of what it has traditionally meant to exist (Abrahms-Kavunenko, 2023). Plastic pollution also serves as a material contaminant in today's world, which faces us at a point to conceptually shift our ideas of purity, order, disorder, and categorization (Pandian 2019; Lynch & Littlewood, 2025). As heavily symbolic to the impact humans have had on the environment they are, plastics can often go unnoticed, signifying the disconnect people have with the space and entities around them (Abrahms-Kavunenko, 2023). Bridging this mental disassociation creates additional need for studies upon the more-than-human world to understand out place in current space and time. In the following chapter, I apply these ideas about plastics as pollution to work previously done on the multispecies post-humanist world to draw out meanings from the life of macroinvertebrates in my field site, which happens to also be my "home" and the home of these more-than-human entities: my local streambed.

Chapter 3: Methods and Findings

Heptageniidae, or flat-headed mayflies, are special macroinvertebrates. Their name accurately describes them, as they look like they have been flattened. They have two giant black eye spots on the top of their head, looking cutely back up at you, followed by six arms with a stiped pattern, feather-like external gills on its tapering body, down to three perfectly straight tails. It is easy to identify all mayflies for having this three-tail pattern. Their gills move majestically in the water, fluttering so quickly that if you were to blink, you would miss it. And they're so little, that you can't even feel the weight in your hand, so delicate, that one sudden movement could render them lifeless.

My field work was a time of beauty, discovery, and scientific exploration. The first time I visited the stream for my fieldwork was in late October. I went into the field a former professor, Professor Poethke, who was already working at the site in Foreman's Branch with her Restoration Ecology class, practicing their techniques to measure stream health. It was in that class that I had originally learned about the leaf-pack technique. The leaf-pack technique involves placing bundles of decaying leaves in the bottom of stream beds to mimic naturally occurring habitats for macroinvertebrates, which establish upon them over time. By collecting and identifying these organisms, researchers assess water quality and ecosystem health based on the diversity and abundance of species found in the leaf packs. I find this technique to be a particularly interesting way to measure macroinvertebrate diversity and stream health because with this technique, you can measure establishment rates and patterns. Since you are placing fresh, clean substrate into the streambed, anything that is on the substrate when you collect it must have established upon the leaf packs within the time it has been sitting in the water.

The techniques I used to learn about macroinvertebrate establishment patterns, I originally learned more about during a summer research assistant position with Penn State. I worked on multiple projects; the first about the effects of climate change drying on macroinvertebrate biodiversity in vernal pond ecosystems, a second about microplastic presence within macroinvertebrate tissues, and a third project I got to lead on the diversity of macroinvertebrates found on different types of plastic pollution in the stream bed. It was my first experience working in a professional laboratory setting with PhD students and changed my perspective on the scientific process and asking questions. It was a time when creativity was welcomed in a traditionally sterile academic setting. Science is messy and the process is also messy. Research questions grow out of one another and expectations and methods are welcome to change during the process. The scientific process is really one of collaboration and iterative. And with the rigor of such educational demands, we bonded as a team (I was able to reach out to them with questions regarding this research process). It was also out of that experience, which grew my own individual curiosity for the lives of macroinvertebrates and built this project.

Going in the field is a stressful yet peaceful time. It is the part of the season most scientists look forward to, but it is also a time that cannot be over with fast enough. This is the season of first-hand data collection for those curious about understanding the innerworkings of the outside world. Most of the time spent for environmental scientist researchers is in the lab, analyzing data and planning for this field season. But once it approaches, it is go-go-go. Materials have to be collected, methodology must be established, traveling to and from sites needs to be coordinated, and proper safety procedures are required to be followed. For my project specifically, I was focused on the process of organizing a partially incomplete block design for the layout of the leaf-packs in the stream as well as preparation of the materials. To answer my scientific question, "how does the substrate composition of leaf packs (plastic, leaves, and mixed) influence the establishment patterns and feeding group diversity of macroinvertebrates, temporally, in freshwater habitats?", I needed to gather leaf litter and HDPE (high density polyurethane) and cut, sort, and measure them. To answer my anthropological question, I need to take make observations beyond the pure science and record interactions and thoughts I have while conducting my research out in the field. All this preparation is worth it when you make it out into the field.

For this project, it focuses on one place at three specific sampling points in Autumn. I was extremely lucky to be granted access to Washington College's River and Field Campus (RAFC), the 5,000 acres of privately owned land and unobstructed Chester River waterfront. Making the short trek from Washington College's main college campus to RAFC transports you to a completely different environment. Making your way off the highway, to off the main road, to down a dirt path, the world gets a little bit quieter. No longer can you hear the lulls of constant cars down 213. Instead, the sound whistling through the branches, birds singing in the distance, and leaves crunching under your feet fill your ears in late fall. As I climbed through downed trees, prickly Greenbriar, and mossy ground that sinks beneath your feet as you step, it is a relief to finally come across the stream known as Foreman's Branch.

Waders are necessary to walk through deep pockets of the stream, the dryness being worth the clunky feeling of the boots that are slightly too large. A large crack and flash draws my focus as a Turkey flies out of a tree in front of me. Not too long after, my presence scares a doe out of hiding by the side of the stream. Her hopping through the orange and red scenery looks straight out of a novel. The warm feelings are short lasted as a large, sudden crash comes from behind my back. The sharp noise feels dangerous, alone in these woods for the first time. But as I spin around, I see a tree falling from its place. The ground shakes as it collides with the ground. As the only human in this landscape of many species, I am aware of my presences as a foreigner to this untouched land. It is hard to focus on the work when distractions are everywhere, but the work must be done in a timely matter, and I quickly finish up collection of the final leaf-packs for the day.

As I sample for the last time in early December, it is sad to think about not returning to the site I have become to accustomed to visiting over the last month. Proud of the work I have accomplished so far, I smile as I walk out of my truck and the site for the last time. This time, adorned in head-to-toe blaze orange attire. We have entered shotgun season in Maryland, having to acquire special permission to be on the property at this point. As part of the natural management that occurs here, the hunt club has priority access to the native White-Tailed deer. I go out in the early afternoon, between morning and late afternoon prime times. It is amazing to see the change in the environment that has occurred in a month's time. The landscape has undergone a transformation from its bright fall colors to its winter greys. Dead trees dominate in the temperate deciduous forests, and even the stream begins to freeze over in its slow-moving pools. Water temperature has gotten significantly colder in my waders, another sign of the end to fieldwork season.

Trampling through the ice, so clear it blends into the water beneath, I rush to finish up before Chino Farms hunt club comes out for the day. Removing the final neon orange flag, marking one of my sampling locations in the stream, it is nice to see the environment in its "natural state." As this stream is protected by a forested buffer, once I remove my plastic, it is pristine to the naked eye. It is nice to imagine all the stream reaches looking just as clean and beautiful. I take a moment as I walk back up the stream to my entry-point, to stop and quiet the clutter in my mind, before exciting the area and heading back to the busy college bustle of Chestertown proper.

Back in the lab, I get to admire my macroinvertebrates for the first time. My mission has changed, and it is my job now to search through all of the leaf and plastic litter that was within the leaf-packs. As a one-man team, I work countless hours in the lab, with my microscope, lamp, and petri dish combination. The monotony starts to get to me, until I spot a rare one. Odonatan, plecopteran, trichopteran, and ephemeropteran are what I'm after. In everyday parlance, these are dragonflies and damselflies, stoneflies, caddisflies, and mayflies. They are easy to spot because they share the same general body shape. A thin, lanceolate shaped body, with varying about of tails. They can be tiny and hard to spot, their naturally body color blending into the leafy-dirty sediment to hide for predators. But once you get them under the microscope, their true beauty can be seen.

> Despite the feeling of fragility holding a macroinvertebrate in your hand and the reputation, these small macroinvertebrates might be more resilient than people give them credit for. My original scientific hypothesis was as follows
>
> "We believe that we will find that plastic leaf packs will have the highest initial abundance of predatory macroinvertebrates because of the stable structure and large surface area for establishment. However, as time since deployment increases, overall macroinvertebrate abundance and feeding group diversity will be greatest on the natural leaf pack because macroinvertebrates will transfer to a substrate which they can both live and prey upon. The diversity of feeding groups will be greatest in the mixed leaf packs

because of the greatest diversity of substrate for shredders, collectors, grazers, and predators to prey upon" (Lentzsch, 2025).

However, what we found was no significant differences in diversity of macroinvertebrates between any of the substrate types (including plastic) or time periods. Significant differences were only found in family richness and within dominant macroinvertebrate feeding groups due to the plastic. What this tells us is that while macroinvertebrates can survive. They have evolved over centuries to specialize in stream survival. While they obviously cannot survive with only plastic in the stream, some plastic present will not destroy them. They will continue to adapt to changing conditions, competing with each other for available resources, and increasing fitness in that pursuit. There are so many factors that go into macroinvertebrate establishment preferences, a hard concept for scientists to try and understand from the outside. Factors like invertebrate mobility, substrate texture, associated food supplies, competition, and predation are just the beginning of factors to consider when looking at materials like plastic, considered contaminants in the stream (Mackay, 1992). We need to consider the interaction of all of the natural and anthropogenic substrates and the interactions of those substrates with food supplies, and predator relations to begin to understand macroinvertebrate preferences.

For my research, making my home into the field meant asking questions about a place and I considered familiar. However, as common practice, the more I learned about macroinvertebrates and Foreman's Branch stream, the more I learned about what I didn't know. By spending time in the stream over the course of autumn, learning from aquatic macroinvertebrates as my interlocuters, they had a wealth of knowledge to share with me. Macroinvertebrates know more about survival in a stream ecosystem than anyone on the outside, so what they consider contaminants in their home may differ from our understanding as humans. Trying to see the world through the lens of a macroinvertebrate leads us to new truths about how we understand the environmental impact we have had on the world around us.

Conclusions:

On a trip to Western Maryland, I was wandering through the town of Deep Creek on a spring afternoon in May. The weather was sunny with a slight breeze. My partner and I stopped to get gas and snacks at the local Arrowhead Market. We had fished Sang Run and Friendsville earlier that day and were headed back to relax. That's when we walked out to see a swarm of mayflies frenzying through the air. Those same creatures that I was playing with earlier, swimming in the stream, were now flying through the air with new wings. Their three tails, however, remained and made them identifiable in the sky. I marveled at the transformation. They tell us about the ecosystem, that those mayflies are what the fish will be feeding on because the hatch has happened. This hatch is a synchronized event where thousands of adults emerge at once, another step of their adaptive lifecycle (Mayes, 2024). They have spent all their lives in the water, a time period that can range from a couple weeks to two years depending on species and environmental conditions, to live as adult for a few days max (Harvey, n.d.). There is so much that we still don't know and still can learn about them.

To answer my anthropological question about the meaning we can glean from better understanding the dynamics of aquatic macroinvertebrates in the Anthropocene, I learned that I needed to be open to indeterminacy and sitting with questions in the stream. Combining home and field together, I needed to attune myself with the landscape, listening for what it had to share with me, beyond simply gathering "scientific" data. In the field, I, as human, was an intruder to the world of Foreman's branch. Once I stepped out of my car and familiarity of the dirt path made by people from Washington College and all of the machine activity on the farm, I entered into the "wild" of the woods. I was an outsider and subject to the world when in the field and especially the aquatic realm of the stream.

Through my work studying macroinvertebrates through the lens of an anthropologist, I look beyond an explanation for their behavior and instead into analyzing their behavior to better understand the dynamic relationship they have with others, their environment, and people. In the field and in the lab, I have seen how macroinvertebrates are feral organisms. Like Tsing (2015) defines the matsutake mushroom as feral for its ability to grow unpredictably, out of human control, in ruins or leftover spaces of human activities, the macroinvertebrates in the stream are feral for their ability to continue to thrive in plastic contaminated environments, which was previously not understood to be possible. Scientifically, I found in my work that macroinvertebrates may act differently than myself and other scientists have through when reacting to human pollutants. Known pollution intolerant species, like Capniidae (Small Winter Stonefly) or the Philopotamidae (Finger-net Caddisflies), were found in leaf packs that contained either 100% or 50% High-density polyurethane (HDPE) plastics (Lentzsch, 2025). I never expected to find these "fragile", "intolerant" creatures living in the stream, yet here they were. These "intolerant" creatures were tolerant of the invading plastic, continuing about their lives.

Like previously mentioned, the diverse community of macroinvertebrates is used to define a healthy stream (Rosenberg and Resh, 1996). However, in the stream, I found that there were no significant differences in Simpson or Shannon diversity indices between macroinvertebrate communities settled in plastic vs natural leaf or mixed substrate. Simpson and Shannon diversity are two indices used to measure the diversity of the macroinvertebrate community, considering the richness or number of species and evenness or the relative abundance of each of those species. Shannon Index focuses on species richness and evenness and is sensitive to rare species while Simpson Index focuses on dominance and the abundance of common species (University of Florida Entomology and Nematology Department, n.d.). By using both indices, we as humans can analyze the diversity to get the best idea of community dynamics as possible. And seeing no differences, to the best of our ability, we don't find distinguishable differences. By understanding that, we can reframe our understanding of the science as hubris. How can we claim to know what impacts our decisions as humans will have in the natural environment, outside of the laboratory, even with anthropogenic-caused problems in the stream? Even when studying natural conditions in the laboratory, how can we be certain that our results will hold true in the complex, natural systems (Rodríguez et al., 2024)?

In my scientific experiment out in the stream, I artificially placed plastic in the otherwise uncontaminated and protected Foreman's Branch, our patch of the Anthropocene. However, plastic invades the natural system in ways that do not follow the human designed plastic-use systems. This system includes the cycle of raw material extraction, chemical production, transport, sale, use, and disposal. Mannheim (2021) tells of three common pathways for human disposal of single-use plastic: plastic scrap recirculated with looping method, plastic scrap incinerated, or plastic scrap sent to a municipal landfill. None of this includes the 20 million metric tons of plastic lost to the system by ending up in the environment and out of human control (IUCN, 2024). This leads me to the conclusion that plastics, despite being completely human by creation, are themselves feral.

Plastics are made with a purpose and that cycle doesn't include being physical contaminants in the stream. They then act in the environment in ways we can't control. They breakdown into microplastics, and interact with other more-than-human, non-human things, like macroinvertebrates. Humans did not plan for microplastics to be found in all aquatic environments, human blood and placenta, or even tap water (IUCN, 2024). And until recently, did not understand how the biological breakdown of macroplastics to microplastics was even assisted by macroinvertebrates in freshwater systems. So, we know that we, as humans, are constantly discovering new things about environmental processes and relations. Thinking about our current understanding and role in shaping our system can impact our process of scientific inquiry and the methodology for which we plan to discover answers.

Scientists can and should consider ferality when designing and looking at experimental results, and the importance of understanding themselves as a scientist, who, once they leave the laboratory can only observe (rather than control). We need to think about ferality and experimental design together because a good experiment accounts for things out of human control- ironically by using a "control." This control is a standard or baseline condition used for comparison with whatever experimental group you are manipulating. However, ferality challenges the traditional ideas of order, control, and predictability that are central to the concept of an experimental control. You may not be able to rely on feral elements to behave in a way that is predictable throughout sampling or following rigid guidelines and definitions. The mess that makes feral entities, so alluring is also what makes them challenging to consider when trying to follow traditional scientific methods.

As social scientists, we need to understand ourselves to figure more about our bias and the questions we are asking. We need to see ourselves as part of the environment, instead of totally dominant over it. This is important because it can encourage holistic science with a system-thinking mindset, to recognize intertwined processes and broader, long-term goals. It can improve problem solving by encouraging interdisciplinary research, like this project. Furthermore, it can promote ethical considerations, especially in respect to the more-than-human world. As a scientist, life and death is a part of research, even in this project as it was necessary to kill my aquatic macroinvertebrates in an ethanol bath directly from the field for later analysis under the microscope in the lab. However, as an anthropologist, as I continued to research more for this project, I began to consider the merits and benefits to this death, questioning if it was a necessary cost for the results I gathered or if I was playing God by deeming my research worthy of the loss of an organism I considered less-than as an other-than-human species.

Humans are not the masters of earth, no matter definition of the Anthropocene as being marked by humans dominating the landscape. We are merely a part of it. Human power is not hegemonic, and it is to think otherwise. Our patch on the Eastern Shore is just one system where we can see that this is not true, macroinvertebrate agency trumps human influence. Despite inserting plastic into the stream environment, the macroinvertebrates were able to continue shaping the environment through nutrient cycling and decomposition, larger food web dynamics, habitat formation, and substrate aeration and structure.

The contaminated and uncontaminated macroinvertebrates exemplify unruly edges in the world which exist at the crossroads of different forces like human economies, global markets, ecological processes, and social patterns. As Anna Tsing's *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (2015) reflects the concept: "At the unruly edges of capitalist destruction, we find places where life persists through unexpected encounters, through unexpected mixes of forces." Like in the case of understanding the aquatic macroinvertebrate relationship, caused by human industry but impacting other recreation and tourism related to stream health, the relationship on the unruly edge is often messy, complex, and resistant to any neat explanations.

Like mushrooms as a metaphor for resilience and adaptability in the face of environmental devastation, we can look to macroinvertebrates to find similar possibilities. We might not know the full impact that humans have had or haven't had, dominating some patches and maybe not others. But we can have hope in the future knowing that feral entities and Earth's systems are acting in ways that we still can't understand in science, so there is uncertainty and perhaps solace in that uncertainty. A multispecies perspective reveals beauty in the more-than-human world and the importance of building a world where non-humans might resist the seeming inevitability of destruction by human hands (Preiser et al., 2017; Guest, 2023).

My experiment allowed me to focus in on the Anthropocene on a unique scale. Natural scientists and anthropologists alike focus on changes that have occurred in deep time and even the geologic time scale. But, in studying this patch, we can focus on current ecosystem changes happening now and adaptations of creatures actively. We see specific macroinvertebrates interacting with plastics in a way not part of human design or expected following human-understood principles. This helps us as humans to gain a broader understanding of our significant-but not totally dominant- role in shaping today's environmental systems, which we are a part of. Aware that feral entities still act in unruly edges out of human design, we should learn to sit with the beauty that comes with the indeterminacy of the still-yet unknown more-than-human worlds buried in streams or other patches of the Anthropocene.

Bibliography:

Abrahms-Kavunenko, S. (2023). Toward an anthropology of plastics. *Journal of Material Culture*, 28(1), 3-23.

Agouridis, C. T. (n.d.). ID-228: Aquatic macroinvertebrates: Biological indicators of stream health.

Alba-Tercedor, J. (2008). Aquatic macroinvertebrates. In G. Ziglio, M. Siligardi, & G. Flaim (Eds.), *Biological monitoring of rivers* (pp. 71-87). John Wiley.

Artru, M., & Lecerf, A. (2019). Slow degradation of compostable plastic carrier bags in a stream and its riparian area. *Annales de Limnologie-International Journal of Limnology*, 55, 18. https://doi.org/10.1051/limn/2019017

Barua, M. (2022). Feral ecologies: The making of postcolonial nature in London. *Journal of the Royal Anthropological Institute*, 28(3), 896-919. https://doi.org/10.1111/1467-9655.13653

Blettler, M. C., & Wantzen, K. M. (2019). Threats underestimated in freshwater plastic pollution: Mini-review. *Water, Air, & Soil Pollution*, 230(7), 174. https://doi.org/10.1007/s11270-019-4220-z

Blettler, M., Abrial, E., Khan, F., Sivri, N., & Espinola, L. (2018). Freshwater plastic pollution: Recognizing research biases and identifying knowledge gaps. *Water Research*, 143, 416-424. https://doi.org/10.1016/j.watres.2018.06.015

Bubandt, N., & Tsing, A. (2018). Feral dynamics of post-industrial ruin: An introduction. *Journal of Ethnobiology*, 38(1), 1-7.

Cai, Y., & Geritz, S. A. H. (2021). The evolution of the irreversible transition from a free-swimming state to an immobile sessile state in aquatic invertebrates modelled in a chemostat. *Journal of Theoretical Biology, 522*, 110681. https://doi.org/10.1016/j.jtbi.2021.110681

Chesapeake Bay Program. (n.d.). Oysters: What's at risk? *Chesapeake Bay Program*. https://www.chesapeakebay.net/issues/whats-at-risk/oysters#:~:text=this%20same%20amount.-,Historic%20over%2Dharvesting,be%20easily%20buried%20by%20sediment

Cortes, R. M. V., Abelho, M., & Rebelo, S. B. (1997). The macroinvertebrate colonization of leaf bags: Is there a pattern? *Limnetica*, 13(2), 71-75. https://doi.org/10.23818/limn.13.18

De la Cadena, M. (2015). *Earth beings: Ecologies of practice across Andean worlds*. Duke University Press.

Deleuze, G., & Guattari, F. (1987). Introduction: Rhizome. In *A thousand plateaus: Capitalism and schizophrenia* (Vol. 2, pp. 3-25).

Dumeier, A. C., Lorenz, A. W., & Kiel, E. (2020). Active reintroduction of benthic invertebrates to increase stream biodiversity. *Limnologica*, 80, 125726. https://doi.org/10.1016/j.limno.2019.125726

Ferreira, V. (2023). Macroplastic litter colonization by stream macroinvertebrates relative to that of plant litter: A meta-analysis. *Environmental Pollution*, 123108. https://doi.org/10.1016/j.envpol.2023.123108

Fritz, S. F., Albertson, L. K., Hobgood, J. L., Mohr, E. J., Oakland, H. C., & Poole, G. C. (2023). Macroinvertebrate ecosystem engineering affects streambed retention of microplastics. *Freshwater Science*, 42(2), 133-145. https://doi.org/10.1086/724584

Gatto, G., & McCardle, J. R. (2019). Multispecies design and ethnographic practice: Following other-than-humans as a mode of exploring environmental issues. *Sustainability*, 11(18), 5032.

Gibson-Graham, J. K. (1997). The end of capitalism (as we knew it): A feminist critique of political economy. *Capital & Class*, 21(2), 186-188.

Guest, K. J. (2023). *Cultural anthropology: A toolkit for a global age*. WW Norton & Company.

Gunderson, R. (2017). Sympathy regulated by communicative reason: Horkheimer, Habermas, and animals. In *The persistence of critical theory* (pp. 187-203). Routledge.

Günel, G., Varma, S., & Watanabe, C. (2020). A manifesto for patchwork ethnography. *Member Voices, Fieldsights*. https://culanth.org/fieldsights/a-manifesto-for-patchwork-ethnography

Günel, G., Watanabe, C., Jungnickel, K., & Coleman, R. (2023). Everything is patchwork! A conversation about methodological experimentation with patchwork ethnography. *Australian Feminist Studies*, 38(115-116), 211-229.

Günel, G., & Watanabe, C. (2024). Patchwork ethnography. *American Ethnologist*, 51(1), 131-139.

Haraway, D. (2003). *The companion species manifesto: Dogs, people, and significant otherness*. Prickly Paradigm Press Chicago.

Haraway, D. (2010). When species meet: Staying with the trouble. *Environment and Planning D: Society and Space*, 28(1), 53-55.

Haraway, D. J. (2016). Staying with the trouble: Making kin in the Chthulucene. In *Staying with the Trouble*. Duke University Press.

Ingold, T. (2021). *Being alive: Essays on movement, knowledge and description*. Routledge.

Johnson, L. M. (2021). What slime knows. *Orion Magazine*. https://orionmagazine.org/article/what-slime-knows/

Koenig, D. (2016). The year 2015 in sociocultural anthropology: Material life and emergent cultures. *American Anthropologist*, 118(2), 346-358. https://doi.org/10.1111/aman.12530

Kohn, E. (2013). *How forests think: Toward an anthropology beyond the human*. University of California Press.

Law, K. L., Starr, N., Siegler, T. R., Jambeck, J. R., Mallos, N. J., & Leonard, G. H. (2020). The United States' contribution of plastic waste to land and ocean. *Science Advances*, 6(44), eabd0288. https://doi.org/10.1126/sciadv.abd0288

Latour, B. (2007). *Reassembling the social: An introduction to actor-network-theory*. OUP Oxford.

Le Guin, U. (1986). The Carrier Bag Theory of Fiction. https://theanarchistlibrary.org/mirror/u/uk/ursula-k-le-guin-the-carrier-bag-theory-of-fiction.pdf

Lentzsch, K. (2025). *Streamlining Diversity: Unraveling the Establishment Patterns of Aquatic Macroinvertebrates (Unpublished thesis*). Washington College.

Li, K., He, C., Zhuang, J., Zhang, Z., Xiang, H., Wang, Z., Yang, H., & Sheng, L. (2015). Long-term changes in the water quality and macroinvertebrate communities of a subtropical river in South China. *Water*, 7(1), Article 1. https://doi.org/10.3390/w7010063

Lynch, R., Littlewood, R., & Calabrese, J. (Eds.). (2025). *Matter Out of Place: Anthropological Explorations of Bodies, Dirt and Morality*. Berghahn Books.

Maryland Department of Natural Resources. (2021, March 30). *Kent County 2017 Land Preservation, Parks and Recreation Plan* [PDF]. https://dnr.maryland.gov/land/Documents/Stewardship/Kent-County-2017-LPPRP-Final.pdf

Miller, S. (2013, May 8). *The role of macroinvertebrates*. Science Scene. http://www.science-scene.org/blog/the-role-of-macroinvertebrates

Moore, J. W. (2015). *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*. Verso Books.

Nieto, C., Ovando, X. M., Loyola, R., Izquierdo, A., Romero, F., Molineri, C., ... & Miranda, M. J. (2017). The role of macroinvertebrates for conservation of freshwater systems. *Ecology and Evolution*, 7(14), 5502-5513. https://doi.org/10.1002/ece3.3101

Ogden, L. A. (2011). *Swamplife: People, gators, and mangroves entangled in the Everglades*. University of Minnesota Press.

Pandian, A. (2019). *A possible anthropology: Methods for uneasy times*. Duke University Press.

Preiser, R., Pereira, L. M., & Biggs, R. O. (2017). Navigating alternative framings of human-environment interactions: Variations on the theme of 'Finding Nemo'. *Anthropocene*, 20, 83-87.

Porta, R. (2021). Anthropocene, the plastic age and future perspectives. *FEBS Open Bio*, 11(4), 948-953.

Rodríguez, A. M., Kratina, P., & Jones, J. I. (2024). Microplastic pollution and nutrient enrichment shift the diet of freshwater macroinvertebrates. *Environmental Pollution*, 359, 124540. https://doi.org/10.1016/j.envpol.2024.124540

Rocky Mountain Institute. (n.d.). The what, where, and why of fertilizer. https://rmi.org/the-what-where-and-why-of-fertilizer/#:~:text=While%20today%20both%20phosphate%20and,era%20in%20nitrogen%20fertilizer%20production

Rosenberg, D. M., & Resh, V. H. (1996). Use of aquatic insects in biomonitoring. In R. W. Merrit & K. W. Cummins (Eds.), *An Introduction to the Aquatic Insects of North America* (3rd ed.). Kendall/Hunt Publishing.

Schulz, R., Bundschuh, M., Gergs, R., Brühl, C. A., Diehl, D., Entling, M. H., ... & Schwenk, K. (2015). Review on environmental alterations propagating from aquatic to terrestrial ecosystems. *Science of the Total Environment*, 538, 246-261. https://doi.org/10.1016/j.scitotenv.2015.08.038

Slavery and Freedom at Washington College. (n.d.). *Freedom seekers*. Slavery and Freedom at Washington College. https://slaveryandfreedomatwashingtoncollege.org/freedom-seekers/

Smart, A., & Smart, J. (2017). *Posthumanism: Anthropological insights*. University of Toronto Press.

Seshia Galvin, S. (2018). Interspecies relations and agrarian worlds. *Annual Review of Anthropology*, 47(1), 233-249.

Tsing, A. L. (2015). *The mushroom at the end of the world: On the possibility of life in capitalist ruins*. Princeton University Press.

Tsing, A. L., Deger, J., Saxena, A. K., & Zhou, F. (2024). *Field guide to the patchy Anthropocene: The new nature*. Stanford University Press.

Tsing, A. L., Mathews, A. S., & Bubandt, N. (2019). Patchy Anthropocene: Landscape structure, multispecies history, and the retooling of anthropology: An introduction to supplement 20. *Current Anthropology*, 60(S20), S186-S197.

U.S. Department of Agriculture, National Agricultural Statistics Service. (2019). *2017 Census of Agriculture: County profile, Kent County, Maryland (Publication No. CP-24-029)*. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Maryland/cp24029.pdf

U.S. generates more plastic trash than any other nation, report finds. (2025, March 8). *Environment*. https://www.nationalgeographic.com/environment/article/us-plastic-pollution

Wadham, H. (2021). Relations of power and nonhuman agency: Critical theory, Clever Hans, and other stories of horses and humans. *Sociological Perspectives*, 64(1), 109-126. https://doi.org/10.1177/0731121420921897

Wallace, J. B., & Webster, J. R. (1996). The role of macroinvertebrates in stream ecosystem function. *Annual Review of Entomology*, 41(1), 115-139. https://doi.org/10.1146/annurev.en.41.010196.000555

Windsor, F. M., Tilley, R. M., Tyler, C. R., & Ormerod, S. J. (2019). Microplastic ingestion by riverine macroinvertebrates. *Science of the Total Environment*, 646, 68-74. https://doi.org/10.1016/j.scitotenv.2018.07.271

Williams, M., Zalasiewicz, J., Barnosky, A. D., Leinfelder, R., Head, M. J., Waters, C. N., McCarthy, F. M. G., Cearreta, A., Aldridge, D. C., McGann, M., Hamilton, D. P., & Haff, P. K. (2015). The Anthropocene: A new epoch of geological time. *The Anthropocene Review*, 2(1), 1-3. https://doi.org/10.1177/2053019614564891

Wilson, E. O. (2016). *Half-earth: Our planet's fight for life*. Liveright.