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PLINY AND PALEOCLIMATOLOGY

TOWARDS AN ARCHAEOLOGY OF ROMAN CLIMATE AWARENESS

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by

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Report

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Arts

The University of Texas at Austin

May 2018

Dedication

This report is dedicated to my parents, Pat and Jana Millar.

Acknowledgements

I am very grateful to Professors Ayelet Haimson Lushkov and Rabun Taylor for their helpful advice and insightful feedback on this report, and to all the faculty of the departments of Classics and Geography at the University of Texas at Austin with whom I have had the pleasure to work, for their support of interdisciplinary graduate research.

Abstract

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This report examines the past and potential contributions of Pliny the Elder's *Historia Naturalis* on the subject of Roman perceptions and experiences of environmental change. It asks in particular whether classicists, archaeologists, and environmental historians can responsibly use the *Historia Naturalis* as a source on ancient climate. It begins with a brief introduction to paleoclimatology of the Roman world, a rapidly advancing discipline enabling the identification of ancient climate changes with increasing precision and confidence. It then turns to the reliability of Pliny as an authority on ancient climate by examining his accuracy, objectivity, and use of source material in literary and historical context, including his understudied rhetorical goals. A close reading of passages on environmental and climate change follows, then a discussion of phenology and meteorology in Pliny's unique agrarian calendar. The final section discusses Pliny through the lens of the Anthropocene, the era wherein humans are the major drivers of global environmental change. For his anthropocentrism, pragmatic observations, and emphasis on local knowledge, I argue that Pliny has much to contribute to an understanding of Roman-period climate change beyond the isolated facts for which he is often cited, by offering a contextualized intellectual framework for Roman climate awareness.

Table of Contents

I. INTRODUCTION

The people who lived and worked within the boundaries of the Roman Empire had profound effects on their local and regional environments, while experiencing a climate subject to its own dramatic shifts in temperature and precipitation. Though major historical works have long relegated the environment to their background and introductory chapters, it is becoming increasingly clear that environmental change impacted the Roman Empire at multiple scales, providing a dynamic medium for the lives of its people, aiding in its growth, and exacerbating the conditions of its eventual decline.[1] Recent interdisciplinary efforts to address the theoretical and practical issues of an integrated human, climate, and environmental history of the Mediterranean have focused on the roles of natural scientists, archaeologists, and historians (e.g. Izdebski et al. 2016; Caseldine and Turney 2010), but the contribution of ancient literature remains under-theorized.

The *Historia Naturalis (HN),*[2] an attempt by Gaius Plinius Secundus (Pliny the Elder) to systematize all human knowledge about the natural world in the first century CE, has so far held a persistent place in the footnotes of studies on the physical realities of the Roman environment. But as paleoclimate science enables scholars to identify ancient climate changes with increasing precision and confidence, Pliny's continued relevance is well worth revisiting. This paper is therefore intended to challenge the *HN's* uncritical use by examining its historical and authorial context, and to demonstrate its potential

[1] See most recently Harper, *The Fate of Rome* (2017) and Brooke, *Climate Change and the Course of Global History* (2014), with articles by Drake (2017) and McCormick et al. (2012). Major syntheses that gave the Mediterranean environment a prominent role include Broodbank 2013, Abulafia 2011, and Horden and Purcell 2010.

[2] Titles of classical works are abbreviated in accordance with the *Oxford Classical Dictionary.*

contributions towards the ancient understanding and experience of environmental change, offering a framework for Roman climate awareness.

II. PLINY'S CONTEXT: NATURE, EMPIRE, AND THE ENCYCLOPEDIA

Paleoclimatology of the Roman World

The climate record of the Roman world is a synthesis of increasingly high-resolution natural archives, 'proxies' for ancient climate laid down in seafloors, lake sediments, cave deposits, and tree-rings. Physically and chemically differentiated layers of deposits record vicissitudes of temperature and precipitation driven by the orbital, solar, and volcanic 'forcings' (that is, drivers) of Earth's climate (Wanner et al. 2008). Analysis of these records falls to paleoclimatology, an increasingly rigorous and quantitative discipline of earth science seeking to describe local, regional, and global climate patterns and their variability across time. This is new ground. Five years ago, Michael McCormick wrote that "the scientific study of the ancient climate has barely begun" (2013, 63). Interdisciplinary research efforts especially over the last decade have gathered multi-proxy evidence across the Roman world, most recently assessed and published comprehensively by Sturt Manning (2013). Collations of paleoclimate data reveal regional differentiation across the highly variegated microclimates of the Mediterranean, but they also exhibit some general trends. The data converge to show that diverse regions from the Alps to the Levant enjoyed a period of warm, wet, and remarkably stable conditions contemporary with the rise and maximum extent of the Roman Empire.[3] This period, commonly referred to as the Roman Climatic Optimum (hereafter the RCO) is widely known but poorly defined: ca. 200 BCE-150 CE by Kyle Harper's reckoning, but with estimates ranging as far afield as

[3] Manning 2013, Fig. 21 offers a comparison of paleoclimate proxy records for the period 300 BCE – 800 CE from central Europe, Spain, Turkey, and the Levant. See also Luterbacher et al. 2012: 98-159 for an overview of the last 2000 years of paleoclimate data across the Mediterranean.

550 BCE to 350 CE, due to the sensitivity of individual proxies to local conditions (Harper 2017, 15; Luterbacher et al. 2012).

Mild conditions did more than provide a scenic backdrop to the glory days of Rome: climate factors were deeply implicated in the empire's expansion and decline by offering variable opportunities and constraints. For the empire's sprawling agrarian economy, the RCO's uniquely stable climate regime reduced some of the usual variability and uncertainty inherent to Mediterranean ecosystems, resulting—for example—in a more favorable Nile flood regime adding to the breadbasket of the burgeoning early empire (McCormick 2012, 78-79). Unfortunately, natural archives running on geologic time scales rarely produce data at a resolution suitable to historians' work. Before the advent of instrumental records in the 19th century, paleoclimate reconstruction has been for the most part an imprecise science, which tends to emphasize crisis over stability. This is due largely to the nature of the evidence, wherein trigger points of major stress are easier to diagnose than normal conditions: tree-rings, for example, will reveal periods of life-threatening drought, but responses to improved conditions are never so clearly represented (Büntgen et al. 2011). Furthermore, despite the increasing resolution of paleoclimate archives from the arid outer reaches of the empire, the Italian peninsula has been less well represented, though the situation has improved since Manning's (2013) synthesis with the publication of new evidence.[4]

[4] See Mensing et al. 2015 on central Italy, Sadori et al. 2016 on southern Italy and Sicily, and Cremashi et al. 2016 on the Po Plain.

The question at hand is the relationship between climate, environmental change, and past societies. Publications on the Mediterranean have so far trended towards universal explanations, large-scale syntheses, and long-term trends, identifying periods of "unusual climate" then seeking evidence of reactions that affect the central narrative of a given period (Izdebski et al. 2016, 10). In keeping with the processualist roots of scientific applications to the study of the past, regional landscape studies and accounts of the rise and fall of societies dominate scholarship at the interface of climate, history, and archaeology. Fewer studies attempt to investigate the social and political dimensions of human–environment relationships. Paleoclimate proxy data has generally been collected and published by specialists without archaeological or historical research questions in mind, which creates difficulties for cross-disciplinary communication. In sum, though indispensable for their record of general climate trends, natural archives and empire-wide syntheses of them do not offer an entirely satisfactory impression of the nature and conditions of the RCO, much less the human experience thereof.

Fortunately, the story of Roman climate is not written only in the language of geochemistry. Contemporary treatises, letters, inscriptions, and papyri by attentive classical authors offer firsthand accounts of climate events.[5] Though classical scholars long overlooked such sources, attention from geoscientists (e.g. Strothers and Rampino 1983; Neumann 1985) and bestselling books on ancient catastrophes (e.g. Keys 1999, Diamond 2005) drew popular attention, and in good time, scholarly attention followed (Arjava 2005,

[5] Hundreds of records have recently been gathered into a database by Michael McCormick and colleagues the Initiative for the Science of the Human Past at Harvard. Their database is available for download at darmc.harvard.edu (McCormick et al. 2013).

73). The documentary record is also generally crisis-focused. For example, modern environmental historians have cited flood records for the Nile and the Tiber with particular enthusiasm.[6] Still, the different chronological resolutions and geographical sources of natural archives and written evidence make it difficult to demonstrate correlation, much less causality, between any given environmental crisis and historical developments. The temporal distribution of climate events can be informative to some extent on general climate trends, but ancient views on day-to-day conditions require an ancient author with an appreciation for the particular.

Here we turn to Pliny the Elder and his all-encompassing *Historia Naturalis*. Only rarely do his observations pertain to specific and dateable climate events plucked from the Roman annals, as when he reports remarkable Nile floods associated with portentous moments in Roman history (5.58), or the unusually bountiful harvest enjoyed when the Phrygian Mater Deum was carried to Rome during the Second Punic War (18.16). Instead, taking all of nature as his subject, Pliny offers the kinds of granular data useful for reconstructing everyday conditions. When natural scientists and archaeologists quote Pliny, he tends to appear briefly as a purveyor of isolated facts.[7] I will show that the *HN* still has untapped potential as a source on Roman climate change, and that it casts a flood of light not only on the cultural world of first-century Rome (Wallace-Hadrill 1990, 81) but also on its natural environment. First, a close reading of Pliny's own preface with

[6] On the Tiber see Aldrete 2007 and Benito et al. 2015; on the Nile see Bonneau 1971 and the reexamination of her work by McCormick 2013.

[7] e.g. Allevato et al. 2016, 8 on the introduction of peaches to Italy; Harper 2017, 54 and Lamb 1995, 141 on beech trees, discussed in Part II. In an early effort to bring together ancient sources on climate change, Neumann (1985, 447) gives Pliny three sentences, only considering his quotations of Theophrastus.

attention to its implications for the *HN*'s originality, accuracy, and objectivity, will set the evidence in its historical and literary context.

The Encyclopedia: Goals, Uses, Sources, and Context

Gaius Plinius Secundus came from Como (Novum Comum) in the foothills of the Italian Alps, where he was born in 23 CE. While pursuing a military and administrative career of some distinction, he also published broadly, but the thirty-seven books of the *Historia Naturalis* make up his only surviving work.[8] Most details of his life and works come from the writings of his nephew (Pliny the Younger), whose famous account of his uncle's death in the 79 CE eruption of Vesuvius gives some insight into the character and motivations of the man behind the first surviving western encyclopedia (*Ep.* 3.5, 6.16, 6.20).

Pliny the Elder's stated goal in the *HN* was to present a compendium of all knowledge about the natural world, having gleaned something on the order of 20,000 topics from 2,000 volumes by 100 authors, by his own reckoning (pref. 17).[9] He assures the reader, "I have not knowingly omitted any piece of information, if I have found it anywhere" (17.137). The project was by his own estimates unprecedented in scope and scale, attempted by neither Roman nor Greek before him, and covering all subjects encompassed by "what the Greeks called ἐγκύκλιου παιδείας" (pref. 14). Marrou (1981,

[8] See Conte (1994b, 498-504) for a full account of his lost works, including contributions to equestrian combat, a biography of his commander Pomponius Secundus, an account of Roman campaigns against the Germans used by Tacitus, and works on oratory and rhetoric.

[9] Quotations are numbered according to the conventions of the Budé editions (e.g. Le Bonniec 1972), the most recent authoritative publication of the *HN*. Translations are my own.

176-177) translates ἐγκύκλιος παιδεία as "general education," which encompassed such teachable skills as rhetoric, grammar, and medicine (Morgan 1998, 33-39, 50-89; Doody 2010, 45-51). Here we have at least solid etymological grounds for calling the *HN* the first western encyclopedia, though the genre would not be self-consciously defined until the sixteenth century (Collinson 1966, 79-80). Given that the *HN* fulfills the basic modern requirements of an encyclopedia—it is a large-scale reference work equipped with retrieval devices (Pliny's *summarium*, p. 9)—I am comfortable referring to the *HN* as such, but refer to the thoughtful accounts of Aude Doody and Robert Fowler for the caveats.[10] As Doody (2010, 6) puts it succinctly, "the *Natural History* is an encyclopedia precisely because people read and use it as one." Rarely is the *HN* read as a whole, and the inclusion of the *summarium* suggests that a consecutive reading was not Pliny's intent. Nevertheless, important themes unify the massive and multivalent work.

Unlike Cato, Varro, and Celsus, Pliny's predecessors in the Roman encyclopedic tradition, he was less interested in teachable skills (*artes*) than a large-scale enquiry into nature, which widens his observational scope considerably (Murphy 2004, 196-7).[11] Cataloging tendencies also emerge in Vitruvius on architecture, Mela on geography, Columella on agriculture, but only in Pliny at an all-encompassing scale. After listing his sources in the *summarium* (Book 1), he proceeds from the cosmos and heavenly phenomena (2) through various lands and peoples (3-7), to animals and plants in

[10] Doody 2010 explores how the reception of the *HN* as an encyclopedia has changed with reception of the genre, reassessing its assimilation into the modern encyclopedic genre. See Fowler 1997 on the problems applying the modern concept of encyclopedism to antiquity.
[11] On Cato's lost *Praecepta ad filium,* Varro's *Antiquitates* (41 books), and Celsus' *Artes* (26 books), see Grimal 1965, 459-82.

descending order of size or significance (8-27) and their medicinal uses (28-32), to the earth and its minerals in the final books (33-37). Pliny describes his topic as "the nature of things, that is, life (*rerum natura, hoc est vita*), and often its lowest department, so that in many cases I am obliged to use rude and foreign, or even barbarous terms" (*rusticis vocabulis aut externis, immo barbaris etiam*, pref. 13). However apologetically, Pliny welcomes varied explanations for natural phenomena in the interest of breadth, sometimes citing the views of Babylonians (on earthquakes, 2.79) and Egyptians (on lunar orbits and stars, 2.23) alongside Greeks and his own countrymen. He incorporates a wide variety of sources, all loyally listed in the opening *summarium,* in which he names the authors consulted in each book out of courtesy (*benignum*) and modesty (*plenum ingenui pudoris*, pref. 21). Fewer than a third of his sources wrote in Latin, though it seems probable he encountered many in translation or summaries.[12] He also refers to authors intermittently throughout the text, as he judges appropriate (*ut quemque verissimum in quaque parte arbitrabor*, 3.1.)

Pliny's inclusion of the *summarium* for the reader's convenience and the public good (*publico bono*, pref. 33) makes an implicit claim that the text is meant to be used as a reference work, but throughout the *HN* there is tension between this segmentation into specialist sections and the unifying discourse of an all-encompassing subject (Howe 1985). Within the framework of an encyclopedia, Doody (2010, 8) identifies three prevalent methods of reading Pliny's *HN*: for an overriding political or rhetorical point; for isolated

[12] For this figure I follow French (1994, 218) by only counting the authors he lists more than once in the *summarium.*

facts; or in specialist sections. On the subject of climate and environmental history, it is in the latter two ways that Pliny has primarily been read, with short excerpts cited uncritically as relevant to particular studies. Only recently have scholars begun to consider seriously the elements of literary form and authorial choice within ancient scientific and technical texts: in Pliny's case, how his goals affect his presentation of the subject matter and the strategies he employs (Carey 2003, 12; Doody, Föllinger, and Taub 2012, 233-236).

Considering not only the preface but all thirty-seven books, Roger French identifies three goals in Pliny's *HN*: first, to instruct readers morally, with many major sections opening with a criticism of the moral laxity of man, especially with respect to proper use of natural resources; second, to report wonderful things for the entertainment of the reading classes; and third, to serve as a broad reference work (French 1994, 231). Readings of Pliny as a source on ancient climate have thus far considered only his third goal, sharing in which I first will present specific passages of the *HN* that offer evidence of climate change (see below, Section III). However, I also propose to address the first two goals. Pliny's moral instruction features prominently in Sections IV and V, on the Roman experience of climate and its effect on environmental change. For its focus on the unusual and the exaggerated, his second goal—of presenting wonderful things (*mirabilia*)—is of less relevance to the current project but deserves discussion here as an index of Pliny's reliability.

For its breadth and organization, the *HN* continues to be an invaluable compendium. But is Pliny a reliable source? His accuracy and objectivity have been open questions among scholars for decades, the subject of battles waged mostly in the footnotes of major historical studies (Doody 2010, 2). That Pliny was a mere compiler, uncritical and

derivative, is the most common critique of his work and remains largely uncontested.[13] Pliny himself was no expert in any particular area. He is perhaps best understood as a self-conscious popularizer, providing information to a broad audience. Taub (2003, 173) describes his approach as follows: "The dual themes of curiosity and duty play throughout the work; it is filled with lists of information and wonders, with a sprinkling of mortal exhortation." The *HN* is the fullest expression of Roman imperial encyclopedism, which appeared in its earliest forms as didactic handbooks, growing in popularity with the expansion of the technical and professional classes in imperial Rome. Scientific curiosity became a kind of cultural consumerism as miscellanies of *mirabilia* became increasingly popular, authored by dilettantes whose interest in detail and exploration was not supported by a unified method. Conte (1994a, 499-501) and Beagon (1992, 3, 8) note the particular influence of Licinius Mucianus, a possible patron of Pliny and author of a *Mirabilia* based on his experiences as legate and provincial governor; Healy (1999, 101-2) notes elements of *mirabilia* throughout.

To some commentators, Pliny undermines his reliability with exclamations of wonder and surprise at facts of nature and expressions of doubt over some facts since proven accurate.[14] Though Pliny certainly holds a place in the history of science (e.g. French and Greenway 1986), the nature of his project involves some unscientific tendencies—his derivativeness and his untheoretical mindset—though as a loyal compiler

[13] e.g. Conte 1994b, 73-5; Rose 1966, 347; Hughes 2014, 231. Pliny's rhetorical style, characterized as "torturous" (Norden 1909, 314) and "exasperating" (Duff 1966, 307-9) is beyond the scope of this study.
[14] For example, Pliny dismisses the testimony of Trogus on the possibility of propagating palms from their leaves, which can in fact be done (17.58).

his general lack of interest in advancing any particular argument is in practice a great strength, as it contributes to the completeness of his work (Doody 2010, 22). In keeping with the scientific limitations of his era, he is most often non-committal, and leaves the assessment of veracity up to the reader.

Pliny dedicates his work to the emperor Titus but identifies a lowly target readership, saying: "It is written for the common public (*humili vulgo*), the masses of farmers and workmen, and finally for those with the leisure time for study" (pref. 6). If we take him at his word, this should excuse Pliny from some of the harsher criticism of his style (n. 14), since a literary masterpiece was clearly not the goal (Locher 1986, 21). Pliny was a member of the equestrian order, whose authors—like Seneca—were perhaps more willing than the old aristocracy to concern themselves with prosaic and practical matters (Beagon 1992, 5). The *HN* is sometimes characterized as a handbook for the Roman layman, devoid of literary ambition but important in its very "typicalness," inasmuch as it encompasses the average interests and competence of a first-century Roman man (Doody 2010, 3-4). By claiming ἐγκύκλιος παιδεία as his framework, Pliny promises the reader a general education, but what constitutes common knowledge is culturally conditioned, so Pliny must be read with an awareness of the contemporary power dynamics that determined what counted as basic, essential, and worth knowing.[15] The administrative unity of the Pax Romana gave Pliny and his contemporaries access to classical and earlier Greek sources, and the fact that he preserves some texts that would otherwise be lost, however selectively,

[15] Foucault's *Order of Things* (1966) broke down the obvious or innocent nature of knowledge texts, but classical technical and scientific writing remains under-investigated in compared to more literary texts.

adds much to his appeal for modern scholars. For topics like Greek art and certain aspects of Roman technology, Pliny is our only (or dominant) source, but on the topic of Roman climate there are paleoclimatological and archaeological records with which to compare his testimonies.

To summarize, Pliny's approach was unscientific in the modern sense but pragmatic, focused on information he judged useful to the typical literate Roman man. For his broader rhetorical point, he is also a source on Roman imperialism. Wallace-Hadrill (1990) probes the *HN* for links between Roman knowledge and Roman power. Mary Beagon (1992, 19) calls it "an epitome of first-century culture." Taub (2017, 74-85) identifies themes of expansion, assimilation, and synthesis throughout. There is still relative silence on the nature and intention of Roman imperialism, which Fear (2011, 21) explains in this way: "[The Roman Empire] was assumed to be an unchanging and unchangeable constant of their [Romans'] lives and as such no more worthy of comment than the weather." In fact, for Pliny, the weather is worthy of extensive comment, and the ways in which he discusses it are telling. Pliny's is a quintessentially Roman and unapologetically imperialist project, organizing the complex whole of the universe with the confident order of the Roman governing class.[16] Throughout his work runs a none-too-subtle strand of old-fashioned moralizing and Italian exceptionalism. At times the sun

[16] Naas (2002) and Murphy (2004) have been particularly influential in their arguments for an imperialist reading, building on seminal 1990s studies by Wallace-Hadrill (1990), Beagon (1992), and French (1994). See also Carey (2003, 33-4) on Pliny's imperial taxonomy, derived in part from Augustan administrative lists.

shines on Pliny's Italy more kindly even than the most optimistic readings of paleoclimate proxies suggest:

> Iam vero tota ea vitalis ac perennis salubritas, talis caeli temperies, tam fertiles campi, tam aprici colles, tam innoxii saltus, tam opaca nemora, tam munifica silvarum genera, tot montium adflatus, tanta frugum vitiumque et olearum fertilitas… tamquam iuvandos ad mortales… (3.41)!
>
> This [country] so replete with life-giving and everlasting vitality, such serenity of climate, fields so fertile, hillsides so sunny, glades so free from danger, groves so shady, forest products so bountiful, breezes from so many mountains, such a bounty of grain, vines, and olives… as if to aid [the endeavors of] men!

Such passages are in the tradition of *laus Italiae,* which famously suffuses the Italian landscape in the optimistic passages of Virgil's *Georgics* (Jenkyns 1998, 364). This quotation also brings up some terminological concerns. In the following section, before moving on to *loci* for climate change, I will attempt to arrive at a definition of climate in Pliny's vocabulary.

Defining Climate in the *Historia Naturalis*

In the passage quoted above, I have translated *caelum* as climate, and this is the word we will encounter throughout this study to describe the source of the atmospheric conditions of temperature and weather.[17] It can also refer more broadly to the heavens and is not without religious implications, as in the opening to Book 2, on the heavens and cosmological phenomena: "the world (*mundum*), and whatsoever by another name may be called the heavens (*caelum*), in whose vault all things exist, we must hold equal to a deity,

[17] At 2.28, Pliny quotes Varro (*Ling.* 5.18) to explain the word's 'undoubted'—though, as we know, mistaken—origins in *caelati* [engraved]. See also Quintilian, *Inst.* 10.3.18.

eternal, without bounds (*aeternum, inmensum*)" (2.1). On each of these grounds, Pliny criticizes the efforts of the Greeks to measure the height of clouds and distance to the moon (2.20). Just as *mundus* can mean the earth and its immediate surrounds or the entire universe, *caelum* is used variously, either describing the visible firmament of the heavens or occasionally celestial regions more generally, like the Greek οὐρανός.[18] These heavens rotated around the immobile globe, which served as the pivot of the world. In its context most relevant to the current study, *caelum*—or sometimes *aer*—is the source of weather and the sum of its expressions: "hence clouds, thunder and lightning; hail, frost, rains, storms, and whirlwinds" (2.102). He explains the mechanisms of causation, such as they were, as follows:

> Tempestatum imbriumque quasdam statas esse causas, quasdam vero fortuitas aut adhuc rationis inconpertae, manifestum est. Quis enim aestates et hiemes quaeque in temporibus annua vice intelleguntur siderum motu fieri dubitet? Ergo ut solis natura temperando intellegitur anno, sic reliquorum quoque siderum propria est cuiusque vis et ad suam cuique naturam fertilis (2.105).
>
> It is clear that there are certain causes of the seasons and precipitation, as stated, but also that there are some that happen by chance or whose reason is as yet undiscovered. For who could doubt that summer, winter, and the annual turn of seasons are understood to be caused by the motion of the stars, as the nature of the sun is understood to influence the temperature of the year? Thus each of the other stars has its own power and produces its own effects on the nature of fertility.

In addition to the effects of the stars, winds—especially the west wind, Favonius—served as an enlivening principle for the world, similar to the Stoic *pneuma,* as the "generative spirit of the nature of things" (*ille generabilis rerum naturae spiritus,* 2.116).[19] Pliny is

[18] cf. Cicero's translation of Plato's *Timaeus: omne igitur caelum sive mundus, sive quovis alio vocabulo gaudet, hoc a nobis nuncupatus sit* (4.6).
[19] For the influence of Stoic philosophy on Pliny's *HN,* see below (p. 16).

careful to leave room for variation, though, acknowledging the possibility of other causes for rains and winds (2.111).

The origins of such an understanding of climate, based on the nature and movement of the stars, are varied. Though Pliny's subject matter (*rerum natura,* pref. 13) invites comparison with the Epicurean masterwork of Lucretius (ca. 99-55 BCE), his conception of the universe has its roots in the cosmological theories of Plato and Aristotle, viewed through the lens of anthropocentric Stoicism. In the Stoic worldview the earth was designed for humans, who gave it significance and coherence, and commentators have noted how Pliny's presentation of the natural world is arranged around the extraction and utilization of its resources, just as his encyclopedic project is arranged to facilitate the extraction of information (e.g. Doody 2010, 65). According to French (1994, 207), describing this anthropocentric world: "Man was at the centre of the story: nature had made all things for him, and Pliny's book was partly a survey of what was available." Beagon (1992, 50) characterized Pliny's interpretation of Stoic philosophy as "more a matter of absorption than conscious practical analysis." His guiding philosophy is not entirely consistent; Grimal (1986) has noted Empedoclean elements as well. French (1994, 207) explains the absence of philosophical coherence as a deliberate dismissal of Greek parochialism in favor of the practicalities of empire. Greek education in the liberal arts required theoretical understanding, but Pliny's encyclopedia evidently did not (French 1994, 230). This is especially true of Pliny's descriptions of climate, as later books make clear that his interest in astronomical phenomena is pragmatic and related to its benefits for agriculture. The use of both prosaic and ideological, practical and theoretical language and themes offers

diverse representations of the ancient climate in a single work. The differences between theoretical and practical astronomy will be significant in Section IV on astrometeorology, but for now a brief examination of the relevant passages in Pliny's geography (Books 3-6) will round off his understanding of climate.

In addition to being the source of weather, the various expressions of *caelum* affect the productivity of the earth and the nature of its people. Like Virgil (*G.* 1.233–239) and Ovid (*Met.* 1.45) before him, Pliny divides the globe into five parts (*zonas*, 2.172) by climate regime: a central band of extreme heat, frigid poles, and the two habitable zones in between. Only the regions between the heat and cold gave rise to people (i.e. Romans) capable of conquering the rest, so climate is not an altogether apolitical subject. After his ethnographic excursus in Books 3-6, Pliny spends most of the *HN* in these *fertiles tractus* (2.190), with reference to exotica only for contrast.[20] Nature seems to "go ragged at the extreme edges," producing skewed fertility where the elements are out of balance, as seen when Pliny provides examples of trees growing outside their accustomed zones: cold-averse laurel on Mount Olympus, heat-loving cedar in the mountains of Lycia and Phrygia (16.136) (Beagon 2007, 22). He attributes much of the adaptability of foreign flora to human cultivation, marveling at the soil management techniques that enable such exotic transplants to survive and thrive, but adding conscientiously that human ingenuity can only go so far: climate cannot by changed (*caelum nullo modo flecti*, 16.136).

[20] Descriptions of climate are a basic feature of Roman ethnography as defined by Thomas (1982, 1), but because Pliny's geographical chapters (3-6) are so focused on the sensational, I chose to focus on his more pragmatic agricultural chapters (17-19).

An unchanging climate may seem an unlikely object of study for perceptions of climate change, but this is where Pliny's sources come into play. The content of his borrowings creates tension with his professed Stoic philosophy of an unchanging nature, especially when he pairs them with observations of conditions in contemporary Roman Italy. Most of these are observations of plants, the subject of sixteen books (about two-fifths) of the *HN*. His self-conscious comparisons of his own observations with readings of his predecessors reveal changing environmental conditions over the centuries and across the Mediterranean. Some changes he attributes to human action, but others are without any anthropogenic explanation, and especially when paired with archaeological and paleoclimatological information do indeed point to a changing climate.

III. *LOCI* FOR CLIMATE CHANGE IN THE *HISTORIA NATURALIS*

To identify environmental changes in Pliny's text, I have adapted a methodology developed by the Intergovernmental Panel on Climate Change (IPCC 2014). IPCC scientists identify the biological fingerprint of climate change in range shifts and spring events—changes in plant and animal behavior characterized as spatial and temporal sign-switching respectively (Parmesan and Yohe 2003). Range shifts refer to changing habitat boundaries—the tree-line moving higher up the mountainside under warmer conditions, or a northern-hemisphere bird species moving farther south in response to colder northern temperatures. Spring events are seasonal changes, measured for example as the dates of leaf emergence or blossoming, which do vary from year to year, but exhibit convincing trends in aggregate. Both carry wide ecological implications and are key indicators for the impacts of climate change today.[21] Pliny, as it turns out, offers examples of both.

Range Shifts and Spatial Sign-Switching

The changing range of beech trees (*Fagus* sp.), a form of spatial sign-switching, is one of a few passages from the *HN* cited by modern environmental historians as evidence for Roman-period climate change. H. H. Lamb compares Pliny's characterization of beeches as a mountain plant to earlier reports (e.g. in Livy) that they grew along the Tiber, near sea level, around 300 BCE (Lamb 1995, 141).[22] Lamb, who correctly characterized

[21] With phenological data from Catalonia, Spain, Peñueles et al. (2002, 532) found that, on average, leaves unfolded sixteen days earlier and fell thirteen days later in 2000 than in 1952, spring migratory birds arrived fifteen days later, and butterflies appeared eleven days earlier.

[22] Probably also referring to Theophrastus, who notes beeches of exception size on the plain of Latium (*Hist. pl.* 5.8.3).

the basic outlines of the RCO when there was much less paleoclimatological evidence than is available today, takes this to mean that the climate was too warm for beeches in Rome by the first century CE. Harper (2017, 45) cites Lamb on Pliny's testimony (neither authors refers to the original sections in the *HN*) to say that beeches, "which used to grow only in the lowlands, had become a mountain plant." In fact, Pliny refers to Roman beeches only in passing, when he mentions a shrine to Jupiter Fagutalis marking where a grove once stood (16.37). He also notes a standing grove of beeches (*fagei nemoris,* 16.242) sacred to Diana in the territory of Tusculum in the Alban Hills. As for their range, Pliny says that they "descend to the plain" (*descendunt et in plana,* 16.74) along with temperate trees like hazel, ash, maple, and hornbeam, quite counter to the aforementioned interpretations by modern environmental historians. This would mean beeches grew at considerably lower elevations than today, since they are now a true mountain tree, only growing above 800 meters above sea level in Italy. This does not necessarily imply that conditions were colder in the first century CE, however, for less arid summers could also have allowed their broader range (Grove and Rackham 2001, 142).

Another possible check on Pliny's testimony is the pollen record (palynological evidence), which reveals differing vegetation patterns even across the Italian peninsula (Peyron et al. 2013). With their palynological and archaeobotanical analyses on the waterlogged sediments of Roman harbors, Laura Sadori et al. (2015, 222-7) report higher levels of beech than expected in the Roman period. However, the presence of wind-borne pollen does not necessarily suggest these trees grew by the sea, and the beech-wood recovered as waterlogged remains in harbor sediments might have been brought some

distance as building material—two of three shipwrecks off Neapolis and one of six at Pisa were built partially of beech, though Pliny warns that beech planks quickly warp (*marcescunt,* 16.218) in water (Allevato et al. 2010). In this case, the archaeology and Pliny's testimony are inconclusive, and he does not reveal his sources, whether ancient or contemporary, for this particular piece of information. On other trees, there is more to say.

The range of the olive tree (*Olea europaea)*, on which Pliny pulls together the testimony of earlier authors, does testify to a warmer climate in the first century CE. In the opening of Book 15 Pliny quotes Theophrastus (ca. 372-288 BCE), the most consistently ecological of his sources, who assigns each plant an *oikeios topos* (its own place) in the microclimates of the Mediterranean (Hughes 1985, 297). For the rigorous theoretical framework and original observations in his two surviving treatises on botany, Theophrastus is credited with the beginning of this discipline in the west. Pliny recognizes him as the supreme authority on plants, listing him first among his foreign sources (*externis*) in ten cases, second after the more ancient Hesiod, Herodotus, or Democritus in the other six (Morton 1986, 89). Pliny compares the Greek botanist's fourth-century views on the olive's range to those of his own predecessors, including the antiquarian annalist Fenestella, whose death Pliny placed at the end of Tiberius' reign (ca. 19 CE, 33.146). Fenestella's work survives only in fragments, but in the *HN* he is cited as on an authority on such diverse subjects as art history, metallurgy, and zoology, in addition to arboriculture. Comparing the accounts of these two venerable sources, Pliny observes that the frost-averse olive tree had in fact made some striking progress:

> Oleam Theophrastus e celeberrimis Graecorum auctoribus urbis Romae anno circiter CCCCXL negavit nisi intra XXXX passuum ab mari nasci, Fenestella vero

> omnino non fuisse in Italia Hispaniaque aut Africa Tarquinio Prisco regnante, ab annis populi Romani CLXXIII, quae nunc pervenit trans Alpis quoque et in Gallias Hispaniasque medias (15.1).
>
> Theophrastus, among the most famous Greek writers, around the year 440 of the city of Rome [314 BCE] denied that the olive grew more than forty miles from the sea; indeed, Fenestella [tells us that] it did not exist in Italy, Spain, or Africa in the reign of Tarquinius Priscus,[23] in the year 173 of the Roman people, whereas now it has crossed even the Alps, into Gaul and the middle of Spain.

The genus *Olea* is an acknowledged Mediterranean climate indicator, thriving in the calcareous soils that dominate rugged topography near the sea, and able to endure long droughts but not harsh winters (Moriondo et al. 2013). During the RCO the olive and its fellow iconic cash crop, the grapevine (*Vitis vinifera*), traveled farther inland and uphill than ever, into areas where the "unremitting severity of winter" prevented cultivation before.[24] Here Pliny's testimony, which might have been based on his own observations during his military service in Gaul and Spain, is supported by archaeology. Archaeobotanical findings attest to the expansion of olive trees from eastern Spain in the Roman period (Terral and Arnold-Simard 1996). They appear on the coastal plain near Rome and Lombardy starting around the first century BCE (Castelletti et al. 2001; Bellotti

[23] Legendary fifth king of Rome, traditionally reigned 616-579 BCE.

[24] Columella, *Rust* 1.1.4-5. This passage cites the lost author Saserna to offer as convincing an ancient account of climate change as anywhere in Pliny, though Columella ultimately defers to the astronomers: "… I have found that many authorities now worthy of remembrance were convinced that with the long wasting of the ages, weather and climate undergo a change; and that among them the most learned professional astronomer, Hipparchus, has put it on record that the time will come when the poles will change position, a statement to which Saserna, no mean authority on husbandry, seems to have given credence. For in that book on agriculture which he has left behind he concludes that the position of the heavens had changed from this evidence: that regions which formerly, because of the unremitting severity of winter, could not safeguard any shoot of the vine or the olive planted in them, now that the earlier coldness has abated, and the weather is becoming more clement, produce olive harvests and the vintages of Bacchus in the greatest abundance. But whether this theory be true or false, we must leave it to the writings on astronomy." The changing positions of the poles comes tantalizing close to the phenomenon of orbital precession, which combined with orbital tilt is a major driver for global climate change not believed to have been widely known in antiquity, discussed in Section IV (p. 29-30).

et al. 2011), thereafter spreading to France (Leveau et al. 1991).[25] *En passant* Pliny later mentions wheat grown in the mountains (18.63), suggestive of new high-altitude landscapes of cultivation (Hin 2013, 85). To a greater extent than forest trees like beeches, the spread of cultivated plant species was due to human influence as well as more accommodating climatic conditions, as interconnectivity and a growing population incentivized economic growth through expanded agricultural production. Mercuri et al. (2013, 24) even propose that the spread of olive trees, along with walnut (*Juglans*) and chestnut (*Castanea*) can serve as an indicator of increasing human activity and "anthropization" throughout the Mediterranean.

These botanical migrations were not due solely to human introduction, however, but were enabled by the onset of rather extraordinary climatic conditions at the RCO's regional peak. Evidence for Alpine glacier retreat and tree-ring growth patterns suggest that central European temperatures were higher in the first century CE even than in the last 150 years of our own era (Harper 2017, 46). According to temperature reconstruction by Christiansen and Ljungqvist (2012), temperatures in central Italy were comparable to those of the first half of the 20th century, but an increase of just 1° Celsius from the last centuries BCE would have rendered, conservatively, another five million hectares of arable land suitable for cultivation (Lo Cascio and Malanima 2005, 27). The RCO facilitated dramatic expansion and increasing production in the agricultural landscapes of the Empire, and Pliny

[25] Fugazzola Delpino (1982, 133-4; 1988, 23) argued for an earlier introduction of the olive to Italy, based on the excavation of a jar containing olive pits from Early Iron Age settlement submerged in Lake Bracciano. She was of the opinion that they were cultivated and harvested nearby, but further scientific analysis is needed.

was right to take notice through observing his surroundings and comparing contemporary evidence against his sources. In the case of olive trees, he offers a *locus* for climate change by accepting the validity of both authors and his own observations, but in the following examples sources and observation are in conflict, leaving the nature of change for the reader to judge.

Spring Events and Temporal Sign-Switching

Though Pliny's treatment of Theophrastus is generally positive and his quotations frequent, his relationship with other authors—particularly Greeks—is ambivalent, in keeping with the suspicion towards Greek culture and scholarship typical of Roman authors at the time. Pliny was in an awkward position, though, particularly in subjects like astronomy and medicine, where he had no other options. Throughout the *HN* three of the four sources he cites the most are Greek—Aristotle, Democritus, and Theocritus; Varro is the fourth (Beagon 1992, 18-20; French 1994, 219-22). Discussing agriculture, he was on more solidly Roman ground, and able to rely on his own observations as well. Pliny makes one of his more dismissive statements against the testimony of his sources concerning the seasonal habits of bees, our next *locus* for climate change:

> Circa apes aut temporum locorumve ratio mutata est, aut erraverunt priores. Conduntur a Vergiliarum occasu et latent ultra exortum; adeo non ad veris initium, ut dixere, nec quisquam in Italia de alvis existimat ante fabas florentes (11.13).
>
> With reference to bees, either the reckoning of seasons and conditions has changed, or else former [writers] have been mistaken. [Bees] are out of sight from the setting of the Vergiliæ [November 11] and stay hidden past their rising [May 10]; not till the beginning of spring, as some have said, does anyone in Italy consider [releasing them] from the hives, nor before the beans blossom.

Denying that any *Italian* bee-keeper would open his hives before the rising of the stars we know as the Pleiades in mid-May could imply this apiary misinformation comes from a foreign source, those labeled *externis* in the *summarium.* The later emergence of bees, which require dry conditions to do their work, is a possible consequence of the higher levels and longer duration of spring precipitation characteristic of the RCO, suggested by isotopic evidence from Italian lakes (Sadori et al. 2016, 180). Pliny and his sources associate the rising of the Pleiades with rainy weather—the Greeks called them the Ὑάδες from ὕω, to rain (18.247)—making it a dangerous time for vines and olives as well, whose fertilization processes are impaired by precipitation (17.11).

Pliny notes another discrepancy between past and present conditions in the ripening of the vintage (*vindemia*, 18.315). Harvest dates for grapevines make up a significant class of climate historical documentary data: records extend back to the medieval period in the parish and municipal archives of Europe, and harvest dates are strongly linked to temperature (García de Cortázar-Atauri et al. 2010). Pliny remarks that for the ancients (*antiqui*), the vintage was never ripe before the [autumn] equinox, but observed that in his day it was often gathered well before then, and he intended accordingly to update his readership.[26] Pliny does not refer specifically to his sources in this passage, nor the geographical region to which they refer. Harvest date can vary significantly with the geographical conditions of the vineyard—precipitation, temperature, elevation, and soil—as well as grape variety and the type of wine being produced. Reading this passage in

[26] In full, "*Vindemiam antiqui numquam existimavere maturam ante aequinoctium; iam passim rapi cerno. Quamobrem et huius tempora notis argumentisque signentur"* (18.315).

context is encouraging, however, since references immediately preceding and following it to the Vulcanalia (18.314) and the recommendations of augurs (18.316) suggest an Italian context. It seems likely that he is drawing from Cato the Elder, since he quotes the Republican author as the first to write about viticulture, though Cato himself described only a few varieties of wine. Pliny notes that the number of varietals cultivated in Italy had greatly increased since (14.44-46), and notes that yields per acre had greatly exceeded anything Cato described (French 1994, 215). In addition to greater variety, an earlier autumn harvest would add to this broader transformation of viticulture, suggestive of the RCO's mild climate and warmer temperatures, which would enable earlier planting and faster ripening, with the accumulation of more growing degree days by the autumn equinox.[27]

The emergence of bees and the ripening of grapes are phenomena of temporal sign-switching and phenology, a field which concerns the timing of periodic plant and animal life cycle events and their variations under different conditions. Pliny reports phenological information most often as the times for sowing, flowering, and harvest, and notes differences among his sources: principally Cato, Caesar, Vergil, and Hesiod (ca. 750-650 BCE), the last a temporal outlier with archetypal significance. Pliny attributes Hesiod's divergent dates to a difference in geography, though when Hesiod describes Ascra in Boeotia as "bad in the winter, sultry in summer, and good at no time," we should probably ask ourselves whether his goal was really an accurate portrayal of the contemporary local

[27] Growing degree days (GDDs) are a phenological unit for heat accumulation, used to predict stages of development like blooming and—in this case—harvest date.

climate (*Op*. 640). Pliny's version is derived mostly from the Julian calendar, developed by the Greek astronomer Sosigenes in Caesar's employ (Taub 2017, 81). Pliny devotes a substantial section of Book 18, the longest in the *HN,* to his agrarian calendar, quoting earlier authors extensively on the timing of astronomical events and their meteorological correlates, particularly the heliacal rising and setting of certain stars, solstices, and equinoxes. Taken together, Pliny's calendar and its source materials can be used to tease out phenological relationships in the first century CE and some of their changes over time. The following section will examine those relationships and the different ways—some quite novel—in which Pliny proposes to measure them. In addition to phenological data points and more significant from a humanistic perspective, Pliny's description of seasonal change provides a place-based approach, relying on local knowledge based in diachronic experience, with which we can begin to contextualize a Roman understanding of climate change.

IV. METEOROLOGY AND THE ROMAN EXPERIENCE OF CLIMATE

Due to Pliny's extensive use of references and quotations, modern scholars generally characterize the *HN* as based upon reading rather than observation (e.g. Lloyd 1983, 135-49). On the topic of seasonal changes, as we have already seen with reference to bees and grapevines, there is tension between the two methodologies, as Pliny considers the relative merits of astronomical science and attention to terrestrial signs. In this field of practical meteorology—focused on its utility for agriculture—Pliny proves his originality, combining the parallel traditions of explanation (Book 2) and prediction (Book 18) to bring together new and traditional forms of knowledge (Murphy 2004, 15). Before the farmer's almanac can begin, Pliny forces readers to "submit to the difficulties of astronomy (*sideralis difficultas)*, which even experts undergo" (18.206) and cautions readers that his conclusions are not straightforward—a similar disclaimer as is so often found in today's articles on paleoclimate reconstruction. Still, a practical understanding of climate and the seasons was essential to farmers around the Mediterranean, whose plentiful sunshine and generally equitable temperatures make rainfall the limiting factor, strained further by high rates of summer evaporation and interannual variability (Garnsey 1988, 10). Farming depends on climate, a factor over which individuals have no control, except to some extent when they choose to plow, to sow, and to harvest. Making the necessary adjustments for seasonal variability and change over time required close attention to local conditions in addition to a working knowledge of astronomy.

Initially, Pliny continues the tradition of astrometeorological texts that Hesiod began with the final section of his *Works and Days* (ca. 700 BCE) by correlating cosmic

phenomena with seasons and weather events. Pliny acknowledges that "the proper times for sowing depend to a very great degree upon the stars" (18.201), and for that reason the exact dates of their rising and setting are of great importance (18.202). But astronomers in the same region do not always agree on those exact dates, and Pliny lists several who give different dates for the Pleiades' setting, when Greek farmers were in the habit of plowing and sowing:[28]

> Eorum qui in eadem regione dissedere, unam discordiam ponemus exempli gratia: occasum matutinum Vergiliarum Hesiodus — nam huius quoque nomine exstat astrologia — tradidit fieri, cum aequinoctium autumni conficeretur, Thales XXV die ab aequinoctio, Anaximander XXXI, Euctemon <XLIIII, Eudoxus> XLVIII (18.213).
>
> But with reference to those who, in the same country, disagree, we shall mention one remarkable example of discrepancy: Hesiod—for his *Science of the Stars* also survives[29]—has stated the morning setting of the Vergiliæ [Pleiades] takes place when the autumnal equinox is complete; but Thales [makes it] the twenty-fifth day after the equinox, Anaximander the twenty-ninth, Euctemon the forty-fourth, and Eudoxus the forty-eighth.

Pliny acknowledges that differences in the appearance or disappearance of significant constellations varied geographically, citing examples in Egypt, Italy, Rhodes, and Pontus (2.178). Indeed, when multiple authors do agree on the date of a given celestial event, it is worthy of comment (*rarum*, 18.312). Part of the explanation for the difference lies with a phenomenon that was never fully understood in antiquity, the precession of the equinoxes (Evans 1998, 262).[30] Orbital precession wobbles the earth on its rotational axis, tracing a

[28] "At the rising of Atlas-born Pleiades, begin the harvest, and you should plough when they set" (Hes. *Op.* 383-4).
[29] This work no longer survives.
[30] The Greek astronomer and mathematician Hipparchus (ca. 190-120 BCE) did author a treatise *On the Precession of the Equinoxes*, which is now lost, though preserved in part in the *Almagest* of Claudius Ptolemy (ca. 100-170 CE).

cone over intervals of about 26,000 years. At the same time, orbital tilt oscillates between 22 and 24.5 degrees on a 41,000 year cycle. Based on recent computer modeling of these synchronous effects, Elio Antonello (2016, 7) estimates that the date of the autumn setting of the Pleiades changed by about eleven days between the eighth century BCE and first century CE. Given the far removal in time as well as geography, then, it is only to be expected that Pliny should have some differences with Hesiod, the pre-Socratic philosophers Thales and Anaximander, the fifth-century Athenian astronomer Euctemon, and the fourth-century Eudoxus of Knidos. The fact that he observes those differences is to his credit; by late antiquity, farmer's almanacs had become more rhetorical exercises than practical handbooks. The tenth-century *Geoponika,* for example, showcases the author's knowledge of classical authors on agricultural subjects, including Pliny, but in reproducing their dates and recommendations to the letter, shows itself to be indifferent to contemporary farming practices (Antonello 2016, 9).

Looking to the Roman agronomists as closer contemporaries, Pliny provides examples from Vergil (*G.* 1.208, 1.227), Columella (*Rust.* 2.8), and Favonius (2.47) on varying sowing dates depending on soil quality, climate, and the crop in question (18.202-3). He shares with them the traditional 'ideology of the soil' which holds farming as an honorable occupation recalling the old Roman statesmen personally involved in the working of their own lands (Beagon 1992, 161-4).[31] Pliny suggests that farms prosper with the most attentive farmers (*diligentia… curiosius*, 18.19), quoting the old adage that "the

[31] e.g. Cic. *Off.* 1.42.150-1; Cato, *De* Agri. pref.; Columella, *Rust*. 1, pref. 12-17; Varro, *Rust.* 2, pref. 3, Virgil, *G*. 2.458-74, 2.513-42.

best fertilizer is the master's eye" (18.43). He even adopts the style of agronomists, assuming the didactic habit of using imperative verbs, which appear only in Book 18 (Hine 2011, 646-9). Literary self-consciousness seems to affect Pliny most acutely in the agricultural sphere, and he apparently felt the need to justify his account against other Roman agronomic writings (Bruère 1966; Beagon 1995, 121). Understandably skeptical of calendrical dates with their myriad and inevitable inconsistences, he rejects as impractical Virgil's designation of tasks by numbered days on the lunar calendar (18.205-206).

Pliny also departs from his contemporary Columella with regards to the accessibility and exclusivity of knowledge (Martin 1971, 376). In his handbook, Columella describes a farmer who had to be "*rerum naturae sagicissimus,"* but true mastery required astrological and meteorological knowledge, "which I cannot believe any man can know without the light of intelligence and the most expert instruction" (*Rust.* 1, pref. 22-23). By contrast, Pliny offers the observation of nature as a perfectly acceptable substitute for astronomical calculations for the uneducated rustic, and he advocates that the learned reader combines it with astronomy. His advice moves towards a mean: rustics should use knowledge more subtly, the learned more practically (Beagon 1992, 172). To that end, Pliny proposes an approach based more on local knowledge and close observation, to some extent ignoring the largely Greek astronomical literature and relying on seasonal changes visible to the attentive observer.

Pliny argues that seasonal events like leaf emergence—closely linked with temperature—were a better indicator of weather and proper agricultural activities than the

constellations.[32] Rather than giving calendrical dates for the solstices, he notes their associated phenological events: “the turning leaves of olive, white poplar, and willow mark the summer solstice, blooming pennyroyal (*pulei*) the winter solstice” (2.108). He marks the time for plowing by the appearance of the fruit of the lentisk (or mastic)[33] and the blossoming of the pear, squill, and narcissus (*ergo haec aratio has habebit notas,* 18.244). He tells us that the Roman peasant (*vulgus agreste*) knew not to sow after the departure of the stork (18.314). In some cases, his advice is refreshingly pragmatic: the farmer “ought to start spring tasks not when the west wind ought to blow, but when it does blow” (18.238). On the topic of winter sowing, after faithfully listing the celestial markers recommended by Xenophon and Cicero, he informs the reader that the true method to be adopted is not to sow until the leaves begin to fall (*cum sit vera ratio non prius serendi quam folia coeperint decidere*, 18.224). Throughout, Pliny encourages the independent farmer to look for terrestrial signs and make his own observations rather than relying on the word of authorities and astronomers.[34] It is impossible to know to what extent Pliny followed his own advice. He does claim to have personally examined all but a very few (*exceptis admodum paucis,* 25.9) medicinal plants—albeit in the garden of Antonius Castor, rather than out in the countryside—and even offers some new botanical facts believably gleaned

[32] This is scientifically valid (Keenan 2015, 48). Other pieces of advice Pliny passes down—like burying a frog in a new pot in the middle of a field as a safeguard against storms (18.94)—have not aged so well.
[33] In reference to Cicero: "The lentisk, ever green and ever bent / beneath its fruits, affords a threefold crop: / Thrice teeming, thrice it warns us when to plough." (*De Div.* 1.15, itself a translation from Aratus). Theophrastus also describes the mastic as bearing three crops of berries (*Hist. pl.* 7.13.6).
[34] Looking beyond Pliny’s agricultural books, this exhortation proves to be part of a broader rhetorical point, appearing again on the subject on medicinal plants. Pliny laments the degeneration of medicine—like astronomy, largely in the hands of Greeks—now that its would-be practitioners preferred listening to lectures to learning from experience and seeking herbal remedies in the wild in their proper season (26.11).

from his own observations during military service as procurator in Spain and Gaul (70-76 CE).[35] He does seem genuinely interested in agriculture and its improvements, discussed in the following section, and the acquaintance with agricultural practice in different provinces during his military and administrative postings could account for his keen awareness of geographical variability.

Returning to the agrarian calendar, in one of his most picturesque examples, Pliny recommends watching for the appearance of glowworms (*cicindelae*) as a sign for sowing panic and millet (18.250). Alluding again to the Pleiades, called Vergiliæ by the Romans, he compares the inconvenience of staying up to watch the stars with the ease of noticing the seasonal changes on the ground, comparing the lights of bioluminescent beetles winking on at twilight to constellations scattered in the grass:

> Iam Vergilias in caelo notabiles caterva fecerat; non tamen his contenta terrestres fecit alias veluti vociferans: 'Cur caelum intuearis, agricola? Cur sidera quaeras, rustice? Iam te breviore somno fessum premunt noctes. Ecce tibi inter herbas tuas spargo peculiares stellas easque vespera et ab opere disiungenti ostendo ac, ne possis praeterire, miraculo sollicito… Cur etiamnum altius spectes ipsumque caelum scrutere? Habes ante pedes tuos ecce vergilias (18.251-3).'
>
> Nature had already formed the Vergiliæ, a noble group of stars, in the heavens; but not content with these, she made others for the earth, as if crying aloud: "Why do you contemplate the heavens, farmer? Why look up at the stars, rustic? Already the nights oppress you, wearied, with sleep too brief. Look! For you I scatter stars amid the grass and reveal them to you in the evening, unyoked from your work, and lest you disregard them, I call your attention to this marvel… Why then do you still look and scan the sky? See, you have before your feet your Vergiliæ."

On this passage commentaries defer to Sillig (1853), who attributes the prosopopoeia to an unknown poet. Personification is not unusual in Pliny, however, as seen in his

[35] According to Morton (1986, 91), Pliny is the first to mention the exclusively maritime pea (*Pisum maritimum*, 17.30.121) and to distinguish the two plants used for rope-making in Spain (19.26, 24.65).

characterization of *divina Natura* (e.g. 2.157, Section V), so it could well be an original composition. The takeaway from this exhortation is that, for those who truly understood how to look, the countryside contributed to knowledge of the heavens no less than astronomy contributed to agriculture.

Suggesting that the writings of Roman agronomic authors reflect the views of the population as a whole has long been out of fashion, so we need not do so for Pliny's meteorology. Still, it is probably safe to assume the pragmatic meteorology in Book 18 would have been more widely relevant to the lives of ordinary Romans than his admittedly somewhat half-hearted philosophical attempts in Book 2. I propose that the inadequacy of a purely philosophical perspective is a useful analog to the purely scientific definition of climate modern scholars have lately found unsatisfactory. Climate is not merely the aggregate temperature and precipitation data for a given region; it is also a historically and culturally constructed idea, one which mediates what people expect of their surroundings (Hulme 2015; Barnes and Dove 2015). By codifying those expectations in his own particular—and particularly Roman—way, Pliny's agrarian calendar offers a unique perspective on Roman climate awareness. On the subject of terrestrial signs, a final key passage is worth quoting in its entirety:

> Sed ille indocilis caeli agricola hoc signum habeat inter suos vepres humumque suam aspiciens: cum folia viderit decidua. Sic iudicetur anni temperies, alibi tardius, alibi maturius. Ita enim sentitur ut caeli locique adficit natura idque in hac ratione praecellit, quod eadem et in mundo publica est et unicuique loco peculiaris… Adeo nihil occultum esse natura voluit (18.226-7).
>
> But that farmer unschooled in astronomy may find this sign [for sowing] among his brambles, looking at his own land: when he has seen the leaves fall. In that way the year's weather may be estimated, since they fall earlier in one place, later in another; for so [the weather] is understood as the nature of climate and locality

> affects it, and this method excels in this regard, because it is both common to the whole earth and peculiar to each place… so strongly has nature willed that nothing shall remain concealed from us.

What does all this have to do with climate change? By being both universal (*in mundo publica*) and particular (*unicuique loco peculiaris*), Pliny's method allows room for interannual and geographical variability. The farmer experienced climate as weather, and weather events "disturb the regularity of our expectations" (18.208). Nevertheless, Pliny understood climate and geography to affect (*adficit*) those unpredictable expressions, allowing local knowledge and attentive observation—his *ratio* of choice—to fill in the gaps.

Nature supplies humankind with signs of seasonal change in what Pliny calls "quite marvelous foresight" (*mirabiliore naturae providentia,* 18.228). The statement that nature wishes for nothing to be concealed from human intellect (*adeo nihil occultum esse natura voluit*) could be a programmatic sentence for the entire *HN,* since it expresses perhaps the only truly unifying theme of this diverse and multivalent work—that all of Nature is capable of being encompassed by the human intellect, and not just by the educated elite. There is a conscious effort in the *HN* to make such knowledge accessible and applicable, in keeping with Pliny's principle of universality, which emphasizes mankind as a body and his encyclopedia as all-embracing work (pref. 13, 15). In the final section, we will see whether his reach extends to the issues facing modern interdisciplinary studies of past climate change and its societal effects, as we move towards an archaeology of Roman climate awareness.

V. PLINY AND THE ANTHROPOCENE

I have thus far discussed climate change as governed by entirely exogenous factors—that is, changes to orbital and solar forcings that altered climatic conditions on a global scale. However, any contemporary discussion of the climate would be incomplete without mention of anthropogenic (human-caused) changes, whose accelerating rate has drawn such widespread scholarly and public attention in recent years. The current period, in which human activity acts as the dominant process modifying the global environment, has come under the conceptual moniker of the Anthropocene epoch, though its parameters and acceptance as a geological and historiographical period remain contested.[36] Most of the Anthropocene debate surrounds its *terminus post quem*, with possible starting-dates ranging from the atomic bomb detonations of the mid-twentieth century to the Neolithic origins of agriculture.[37] Soil scientists Certini and Scalenghe (2011) propose a start date around 2000 years ago based on the widespread appearance of anthropogenic soil horizons, arguing that by the mid-Roman period organized civilizations had altered much of the earth's surface. Recently, the archaeologist Catherine Kearns (2017) has further developed the implications of a Roman Anthropocene for Mediterranean history and archaeology. With the environmental impacts of empire, Pliny may well have been writing in an Anthropocene epoch in the Mediterranean, if not yet throughout the world.

[36] Originally proposed by the atmospheric chemist Paul Crutzen and ecologist Eugene Stoermer (2000). See Butzer (2015) and Crumley et al. (2015) for further definition and discussion of the Anthropocene.
[37] Paleoclimatologist William Ruddiman (2016) is the most vocal proponent of a Neolithic Anthropocene, caused by high agricultural greenhouse gas emissions (CO_2 and CH_4) detectible in ice cores (Brooke 2014, 286-7).

Anthropogenic Environmental Change: Mining and Agriculture

Pliny was acutely aware of alterations to the landscape and climate wrought by human action. These figure into both philosophical and practical passages in the *HN,* offering concrete examples of the scale and persistence of Roman-period environmental change, especially through mining and agriculture. Mining is the focus of Pliny's final books (33 and 34 on metals, 36 and 37 on stones and gems) and the target of some of his harshest invective. The chemical signatures of Roman mining and metallurgy appear in Greenland ice cores and European peat sediments, marking spikes in silver, lead, and copper pollution in the first century CE unmatched until the industrial expansion of early modern Europe.[38] Heavy-metal sediments deposited in mining and smelting regions like Wadi Faynan, Jordan, devastated local ecologies and continue to impact human health in our own time (Barker et al. 1999; Barker 2002, 496-504). Pliny's preface to Book 33 names the motivations behind mining as riches, luxury, and war, lamenting that humankind should find the earth's surface bounty so insufficient as to "penetrate into her entrails" (33.2). In Book 2, he supposes we would mine even the Underworld, "if such a realm existed!" (2.158). This secularizing exclamation is part of his by now familiar philosophical inconsistency, since in the same passage he refers to the earth as *dea*, and "sacred inasmuch as she renders us likewise" (2.154).[39]

[38] Brooke 2014, 331-332 and Wilson 2002, 26-28, citing earlier isotopic analyses e.g. Rosman et al. 1997.
[39] On the beneficence of Natura, see also Beagon (1992, 37-42; 222-7) and French (1994, 203-4), discussing mostly Pliny's introductory paragraphs, e.g. 2.14-27, 154-7, 7.7, 11.1-4, 18.1-5, 251-3, 266-7, 20.1, 21.1, 22.1, 25.1-3, 27.-19.

In passages like these, what Andrew Wallace-Hadrill (1990) recognized as proto-environmentalism is rooted in the traditional moral censure against elite *luxus.*[40] With his old-fashioned *mores* Pliny is to some extent a product of his time, having lived through the excesses of the emperor Nero, who provides a ready target for most of his attacks on luxury (Beagon 1992, 17-8; Wallace-Hadrill 1990, 80-96). On the luxuries of garden products and ice available year-round, he grouses: "indeed, there is nothing that pleases man in the fashion in which Nature originally made it" (*nihil utique homini sic, quomodo rerum naturae, placet.* 19.55).[41] Pliny was no naturalist in *sensu stricto*, since his interest in the natural world was still predicated upon what man could do with it. Nature was generally well-disposed to human use and described primarily in those terms, but responsible use required understanding and close attention to the particularities of place. Pliny attributes ignorance of nature, generous despite exploitation, to the "evil of an ungrateful mind" (*inter crimina ingrati animi et hoc duxerim quod naturam eius ignoramus*, 2.159). *Luxus* and local knowledge both play a role in Pliny's accounts of the environmental impacts of agricultural activities and the resulting climate change.

Pliny's attitudes towards environmental change due to agriculture are both rhetorical and practical. His expressed antipathy towards *luxus* accounts in part for his approval of smallholdings as opposed to large estates cultivated by slaves, the *latifundia* he famously accuses of ruining Italy (*perdidere Italiam,* 18.35). But Pliny might also have

[40] Thommen (2012, 78) connects Roman *mores* and environmental ethics in this way: 'here it is not protection of nature, but rather fitting in sensibly with the existing world order, with the goal of moral fortification." See also Marchetti 1991 on the Roman moral tradition in Pliny more generally.
[41] Further examples at 9.139, 33.1-4, and 34.138.

practical reasons for his condemnation of *latifundia,* possibly in response to the large tracts of neglected or abandoned land in contemporary southern Italy, already noted south of Apulia by Cicero (*Att.* 8.3.4) (Beagon 1992, 163).

Agriculture wrought significant environmental changes, even to the climate. The decline in woodland which generally characterizes the Roman period has been largely attributed to agricultural intensification (Di Rita and Magri 2009). As early as 1864, George Perkins Marsh's seminal *Man and Nature* linked destructive Roman practices to deforestation, erosion, and land abandonment (9-12). Pliny describes some remarkable transformations to agricultural landscapes in Book 17, in a passage on the effect of local climate and soils on trees:

> Quid quod mutantur saepe iudicata quoque et diu comperta? in Thessalia circa Larisam emisso lacu frigidior facta ea regio est, oleaeque desierunt, quae prius fuerant, item vites aduri, quod non antea… et circa Philippos cultura siccata regio mutavit caeli habitum (17.30).
>
> Do we not find that [soils] appraised over a long period are often changed? In Thessaly, in the vicinity of Larisa, after the lake was drained, the district became much colder, and the olive-trees which had been there formerly perished, and likewise the vines were frost-bitten, which never happened before… and in the vicinity of Philippi, after the country was drained for cultivation, the nature of the climate changed.

Here Pliny is quoting Theophrastus on the creation of frost-hollows in Larisa (*Caus. pl.* 5.14.2-3) and Philippi (*Caus. pl.* 5.14.5), passages which show that the effects of human agency on climate were understood as early as the fourth century BCE. Frost-hollows testify to the powerful effects of microclimates. They form when the local geography—in these cases, depressions left by drained lakes—accumulate cold air in sinks (Grove and Rackham 2001, 142). The passage continues: "In Syracusan territory, an immigrant farmer

(advena cultor) lost his crops to mud after clearing the soil of stones, until he put the stones back again (*donec regessit lapides,* 17.30)." Regional changes to the environment like these, caused by clearance and drainage for agriculture, were probably more dramatic and immediately relevant to the lives of Roman agriculturalists than long-term global change, but also had some far-reaching effects. Atmospheric circulation models suggest that widespread deforestation increased surface albedo—the proportion of solar radiation reflected by the earth's surface—throughout the entire Roman world (Reale et al. 2000). Higher albedo would have suppressed Mediterranean precipitation by reducing surface evaporation to limit the amount of moisture in the air, contributing to the more arid climate of today (Gaertner et al. 2001; Kaplan et al. 2009, 3017).

Pessimistic readings of Mediterranean environmental history take Roman-period degradation for granted, the direct result of social and technologically empowered overexploitation that left successors with an impoverished environment (e.g. Hughes 2014, esp. 68-150). Pliny offers a more positive view, worth highlighting now that interdisciplinary studies are revising long-lived assumptions about exploited landscapes. Mensing et al. (2015) analyzed pollen, paleomagnetism, geochemistry, and historical data to find limited evidence for degradation in a 2700-year lacustrine sediment core taken near Rome—perhaps owing to the capital's reliance on and access to imported resources—compared to significant deforestation and erosion during the Medieval Warm Period. The environmental legacy of the Roman Empire remains contested, and further close regional studies are needed. Pliny's encyclopedia, like the agronomic writings of his contemporaries, provides context to land-use intensification with narratives of cumulative

technological change and scientific understanding (Butzer 2005). After criticizing the abusive agricultural practices on Italian *latifundia* (18.4, 18.36), Pliny goes on to mention still larger estates in Gaul without censure, praising their improved farming technology and greater efficiency (18.261, 286). Though critical of the destructive effects of human greed, Pliny also offers a counterpoint to the Roman elite's generally primitivistic attitude towards cultural change, wherein society is in a state of unremitting decline. Unlike the poetic depections by Hesiod and Virgil of farmers struggling in the wake of a long-past Golden Age, on the subject of agricultural labor Pliny is "positive as well as practical" (Beagon 1992, 164). Unlike Lucretius' battle between *vis naturae* and *vis humana,* Pliny's depiction of man and nature is largely characterized by harmonious relations (e.g. 17.58, 17.96, 32.1, 32.41; Beagon 1995, 129). His farmer was not necessarily lacking in *cura* or *diligentia*, but local knowledge took work and attention to develop, and the health of the landscape reflected the relationship between cultivator and soil. Whether it was practiced poorly or well, Pliny was a close observer of agriculture's effects on the landscape.

The nature of environmental knowledge is one realm in which the literary record stands to greatly enhance our understanding of Roman responses to environmental change. Thus far, past climate research has centered on causal links between deteriorating climate and resource stress, thus tending towards grand narratives of decline, collapse, or societal resilience. Arguments for metastability of the Mediterranean network operate over the *longue durée*, sometimes obscuring spatial and temporal scales to present human agents as an anonymous, nebulous group (Walsh 2014, 27, on Horden and Purcell 2000). Whereas climate viewed as an exogenous mechanism driving social change maintains and reifies

the separation of natural and social processes, questioning historical ecologies holistically opens up the disorderly interfaces between human actions, social change, and the material world (Kearns 2017, 4). Climate changes have varying effects depending on a society's environmental setting, its social, economic, and political structures, and those of its neighbors. Any correlation between climate change and human history is complex, multifaceted, multi-scalar, and contingent on social context and human agency. Macro-scale narratives miss the Italian farmer watching for the first leaves to emerge and adjusting his planting schedule. They miss the newcomer to the hinterland of Syracuse realizing his mistake, putting back the stones, and dealing daily with erosional processes and climatic effects. A major challenge facing future climate history studies is how to allow the individual back into the picture. The final discussion will consider Pliny's contribution in two areas, human agency and local knowledge, and explore some ways forward.

The Importance of Human Agency

Historians studying the societal impact of climate change rarely aim to establish general laws that govern how people respond to it (Izdebski et al. 2016, 7). Reviewing recent progress towards an environmental history of antiquity, Harris (2013, 7) concludes: "We need more data, obviously, but more importantly still, we need better thinking about the possible range of differences between local climates within the same region and within the Roman Empire (Mediterranean and otherwise) as a whole; and we also need better thinking about the likely effects of climatic change on human, or rather Roman, behavior." I will address the latter concern first and propose that Pliny's *HN* offers valuable insights

into the behavioral effects of climate change and perceptions thereof. Rather than framing the subject simply as the effect of humankind and climate on landscape, Pliny offers insights into the "vital interactions" between man and nature which are now demanding scholarly attention (Harris 2013, 7). Pliny provides enthusiastic and occasionally eloquent witness to pre-scientific ways of thinking about these interactions.

The global domestication implied by the Anthropocene corresponds with Pliny's anthropocentric view of nature. However geologists settle the question of pre-industrial starting-points, the Anthropocene will probably continue to be debated in humanistic circles, for its implications for human collective agency and impact (Heise 2017, 3). The question of perspective is an important one, sometimes lost in the eagerness of historians to connect climate trends to imperial fortunes. As Harris (2013, 4) remarks candidly on the depression of Nile floods in the second and third centuries CE: "Whether this had any impact on the grain supply of the city of Rome is unknown, but it must certainly have made life more difficult for the Egyptian poor."[42] At the same time, archaeological theory is facing calls for greater contextuality and individuality, "an increased focus on regional and local diversity in the archaeological record and the ideas and intentions of the people that created it" (Izdebski et al. 2016, 11). This may seem to downplay the importance of climate at first glance, but in seeking to avoid monocausal explanations, Mediterranean archaeologists are now engaging more actively with climate archives to consider multivariate models for cultural change (Izdebski et al. 2016, 11-12). Though texts have

[42] The effects of eastern Mediterranean social and political strife are well attested in the first quarter of the second century CE, when the unrest severely impacted productivity along the Nile and threatened the grain supply of Rome (Taylor 2004, 251-2).

had their own deterministic effect on classical archaeology over the discipline's long history, reading for ideas and intentions behind human engagement with landscapes has the potential to revitalize interdisciplinary discussion.

The Importance of Local Knowledge

Returning to Pliny's passage on anthropogenic landscape change (17.30), the detail that the farmer who destabilized his slopes by removing the stones was a newcomer (*advena*) seems to have been offered by way of explanation for his misuse of the land. Local environmental knowledge developed over generations, tended towards sustainability, and was lost at the landscape's peril. Working from ethnographic analogy from rural Valencia, Karl Butzer (2011, 12-13) characterized the local engagement with the landscape as "a constantly shifting repertoire of agricultural strategies in response to market opportunities, demographic growth, finite resources, and environmental problems… predicated on values, prescribed social behavior, cumulative experience, and ongoing information exchange." Butzer's description gets at the complexity of ancient responses to environmental change, compounded by the general inaccessibility of authentic rural voices in the literary record, which makes these passages in Pliny all the more valuable.

That Pliny describes climate in local terms limits his utility for the identification of empire-wide trends, but not to his detriment as a source. His perspective serves to remind us that climate was experienced locally, as weather and the patterns of seasonal change. Large-scale syntheses have drawn considerable attention to the study of past Mediterranean

climates for their contribution to grand social and historical narratives, but their utility is limited. The way forward lies in fine-grained regional studies, where multiple lines of evidence and tight chronologies can begin to untangle the dynamic feedback loops of society and environment (Walsh 2014). Most regions of the Mediterranean are highly sensitive to climate changes, and the relationship between climate and environment varies from place to place (Luterbacher et al. 2012). Interregional variability has created a mosaic of habitats across the Mediterranean, all subject to some degree of transformation by humans along with climate changes (Mercuri et al. 2014). Looking for ways "towards the historical problem of societal response to climate change," McCormick (2013, 82-83) puts forth two research goals: 1) specific, securely demonstrated high-resolution climate change in particular regions; and 2) the impact of those changes on farming practices, as gleaned from written records, the archaeology of farm technology, food storage, archaeobotany, and agrarian calendars.[43] Geoarchaeology offers another way forward. Focused and multidisciplinary archaeological investigations can help to resolve chronologies for comparison with increasingly refined environmental data and distinguish between anticipatory and reactive human responses to environmental change.

As we have seen, Pliny brings together a vast range of information from two different traditions of Greco-Roman meteorology in the interest of making the material accessible, retrievable, and useable. Taub (2017, 85) identifies two important epistemological claims here: that "specialist 'expert' theory-laden knowledge may be of

[43] On archaeobotany, Anna-Maria Mercuri and colleagues (2014) have published a synthesis of all archaeobotanical studies in Italy. Agricultural implements have a longer history of study, and K.D. White's volume (1967) refers to over thirty different passages of Pliny.

limited value, and reliance on one type of knowledge, for example astrometeorological knowledge, is not sufficient." Pliny expects his farmer to be encyclopedic in his study of nature, gathering whatever information might be useful from his immediate environs. In this way Pliny's farmer provides a model not only for the Roman agriculturalist, but for the modern scholar seeking to reconstruct the Roman experience of climate change. We are expected to be likewise encyclopedic, drawing on a wide array of source material and knowledge, combining and presenting them in novel ways. Through the inclusiveness and interconnectedness of the *HN*, Pliny created a new genre by synthesizing previously disparate elements and traditions into a single coherent work. An achievement of this scale is now the goal of natural scientists, historians, and archaeologists studying the ancient climate of the Mediterranean.

VI. CONCLUSIONS

Let us revisit the threefold goal of the *HN* as Roger French described it: moral instruction on man's right relationship with nature, entertainment through its strange and wonderful aspects, and utility as a large-scale reference work (French 1994, 231). Focusing on Pliny merely as an encyclopedia misses the first two; misinterpreting him as a scientist eludes all three. It is not any particular scientific sophistication that makes Pliny a good source on ancient climate; quite the contrary. The evidence of Roman climate he offers, which is largely but not entirely consistent with the equanimous conditions of the RCO, comes from a respect for local knowledge rather than the advancement of any particular overarching theory. As a curious and omnivorous compiler—and not a *mere* compiler, but one with a rhetorical point to make—he also offers uniquely insightful evidence for climate change and Roman perceptions of it.

The proliferation of interdisciplinary studies on the past Mediterranean environment will continue to challenge and reprise the roles of authors like Pliny. E. O. Wilson (1998) argued for the fundamental unity of human knowledge, and his idea of consilience has become a popular byword for collaborations between the humanities and sciences, though his account entirely omits the study of society and nature in the past (Izdebski et al. 2016). Now with a growing interest in climate change past and present, classical authors even in the traditionally more privileged tiers of poetry are becoming targets of the same sort of data mining as Pliny's work has been for centuries, to the understandable chagrin of some of their dedicated scholars.[44] I am not arguing that

[44] e.g. McCormick's (2013) treatment of Ausonius.

archaeologists, historians, and natural scientists should use literary sources merely as checks on paleoclimatic data, nor do I believe—as some have argued—that investigating past climate change is a misplaced retrojection of modern anxieties about planetary crisis. Climate change and its scientific validity remain politically and geographically contested and an understanding of climate change is still to some extent both privileged and politicized.[45] Ongoing debates and uncertainty due to the differential impacts, perceptions, and challenges of modern global warming complicate the development of any single narrative. Acknowledgement of similar complexity in the Roman world need not preclude its investigation. Instead, viewing Mediterranean environmental history through the lens of the Anthropocene epoch invites critical inquiry into the study of human-environmental relationships across disciplines, even those as diverse as classics and climatology (Kearns 2017, 9).

To conclude, scholars of historical and contemporary climate change may have something to learn from Pliny's advice to the Roman farmer. While our reading of ancient authors and established scholarship is indispensable, our potential to make new observations about ancient climate is rapidly exceeding expectations. Focused and fine-grained multi-proxy studies are sharpening our ability to distinguish between local, regional, and global trends, along with the responses to them. While he may not always follow his own advice, Pliny urges the farmer to be attentive to the local conditions, and

[45] Texas, where this report was written, is among the states most affected by shifting weather patterns, rising temperatures, droughts, and hurricanes associated with modern climate change. According to the Yale Program on Climate Change Communication (Popovich et al. 2017), only 57% of Texans are concerned about global warming, corresponding with political views and median population age as much as regional vulnerability to climate change (i.e. places already dealing with its effects).

this rings true for paleoclimate studies. Historians and archaeologists must be sensitive in turn, and not too hasty to attribute local changes to empire-wide trends. As humanists and scientists together work towards pairing close readings of ancient literature with advances in climate science, archaeological research, and the increasing resolution of paleoclimate data, we have before our feet our Vergiliæ. Now we must learn to look.

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