Between the Calendar and the Clock
An Environmental History of American Timekeeping in the Nineteenth Century

By

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We understand the meaning and measure of time through the patterns of our everyday lives and landscapes. For the past eight years writing and researching this dissertation has been the foremost pattern in my life. All experiences I've had during this time bear some relation to it. And so, for those who know how to read it, this manuscript contains within it a hidden record of those whose ideas and generosity have contributed to its creation. I am deeply grateful to my friends here in Madison I have been lucky enough to find on this graduate school journey, and equally thankful for my chosen family members elsewhere that supported me during this process. I am also profoundly grateful to my parents and brother and sister as well as my Barker-family in-laws and nieces and nephews for their support, patience, and bottomless enthusiasm for talking through the minutia of nineteenth century millwork. And, of course, to Rick and Amy for providing me and Nathan with a refuge in the heart of Madison. My Bubbeh, Bernice, died just as I finished the first draft of the first chapter, and my Grandmom, Tommie, left us just after I defended the final manuscript. Along the way there have been births and weddings, epiphanies, jokes, and deep conversations. I hope those of you who have had a part in the creation of this dissertation, will enjoy each subtle moments of rondure when you recognize your own ideas, questions, or interests reflected in the text that follows.

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An Infinite Index of Change

The history of timekeeping runs through American histories of modernity and the Enlightenment, the impact of capitalism, changes in business management, and changing perceptions of the natural world. In classic works by E.P. Thompson, Michel Foucault, Jacques le Goff, and David Harvey the broad transformation in Western time-consciousness from the Enlightenment to modernity appears as the slow death of natural time and seasonal rhythms, the subduing of calendrical or liturgical measures of time, and the enforcement of abstract measures, ticked-off by machines in ever smaller and more reliable units. In this way, "for better or worse (usually for worse)," historian Michael J. Sauter explained, "Western capitalists compelled the next reluctant population – be they rural European peasants or non-Western peoples—to submit to the clock."[1] Mechanical time, and with it the clock, is implied in our very definitions of modernity. For instance, in *The Idea of Wilderness,* Max Oelschlaeger defines modernism as "that combination of the power of science and technology with political and economic ideas modeled on the machine metaphor."[2]

If modernism and modernity exist under the machine metaphor, it seems reasonable to assume that modern time is mechanical.[3] But the clock has never been the only way to know and

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[1] Michael J. Sauter, "Clockwatchers and Stargazers: Time Discipline in Early Modern Berlin," *The American Historical Review* 112, no. 3 (2007): 685-709, 687.

[2] Max Oelschlaeger, *The Idea of Wilderness, From Prehistory to the Age of Ecology,* (New Haven: Yale University Press, 1991), 97.

[3] In this dissertation modernity is defined a bit loosely as a set of taken-for-granted cultural assumptions about "how things fit together… and how they ought to fit" matched with a progressive sense of time. Sheila Jasonoff and Sang-Hyun Kim, *Dreamscapes of Modernity, Sociotechnical Imaginaries and the Fabrication of Power,* (Chicago: The University of Chicago

note time, and the history of modern timekeeping is not only a history of mechanical time. This other history—the history of how non-clock-based ways of tracking time changed over the course of the long nineteenth century—is the subject of my dissertation: "Between the Calendar and the Clock: An Environmental History of American Timekeeping Practices in the Long-Nineteenth Century."

Although Americans turned increasingly to the clock in the eighteenth and nineteenth centuries, they continued to pay attention to the rhythms of the natural world. Moreover, as environmental historians and historians of science argue, during this period American perceptions of nature were hardly static: new instruments, new ideologies, and new identities shaped and reshaped everyday engagement with forests, fields, and factory yards. In keeping with such rapidly changing perceptions of nature and technology, the non-clock timekeeping technologies that fascinated Europeans and Americans during this era were surprising and eclectic. These included practices such as growing unusual fruit out of season in colonial gardens, organizing elaborate water-powered factory clocks at Lowell, and creating compendious tables correlating tree-leafing and harvests in the American interior.

Histories of technology often follow the routes of the most widely adopted practices, ignoring those proposals that did not seem to work in the way intended or were not adopted.[4] The

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Press, 2015), 4. Historians of time often define modernity at least partially in relation to mechanical timekeeping, something that I hope my dissertation will help modify in the future. Mark Rifkin, for example, argues that modernity "entail[s] the creation and extension of capitalism, the self-reflexive rejection of tradition as such in potentially freeing ways, and a struggle around forms of mechanized standardization." Mark Rifkin, *Beyond Settler Time: Temporal Sovereignty and Indigenous Self-Determination,* (Duke University Press, 2017)*,* 10. Alexis McCrossen explains that "I refer to the set of conditions that required constant, precise, and standardized timekeeping, and to the consequential emphasis on speed, urgency, contingency, and simultaneity, as 'modernity.'" Alexis McCrossen, *Marking Modern Times: A History of Clocks, Watches, and Other Timekeepers in American Life,* (Chicago: The University of Chicago Press, 2013), 17.

[4] I think my dissertation aligns in important ways with Jessica Riskin's arguments in *The Restless Clock* however my study tends to examine a practical and lay response to the changes Riskin chronicles within scientific circles. We arrive at a similar point by examining different groups of individuals motivated by different sets of problems; "The people involved in this competition have been ambivalent in their commitments, and the losing principle has not disappeared from science. Instead, it has remained, obscured from view by the winning principle, but still active." Jessica Riskin, *The Restless Clock: A History of the Centuries-*

historiography of time, for instance, until recently, has been almost exclusively preoccupied with understanding the spread and development of clock-time and mechanical timekeepers and the secularization of time.[5] Looking backwards from a present seemingly dominated by the clock and by an abstracted, neutral time, this focus makes sense. It has also generated many important insights into the complexities of time-consciousness, the politics of time-discipline, and the ways that time-schedules bind communities and nations together—and work to exclude or regulate others.[6] Collectively, these studies demonstrate the ways in which timekeeping is a practice of making one's self legible to a group and, in turn, reading a social landscape or given community.[7] "In this way," historian Michael J. Sauter argues, "time awareness became our modern compulsion."[8]

Long Argument about What Makes Living Things Tick (Chicago: The University of Chicago Press, 2016), 9. Helen Curry makes a case for the necessity of following un-chosen paths forward as well, Helen Anne Curry, *Evolution Made to Order: Plant Breeding and Technological Innovation in Twentieth-Century America* (Chicago: The University of Chicago Press, 2016).

[5] See David Landes, *Revolution in Time* (Cambridge: Harvard Belknap Press of Harvard University Press, 1983); Gerhard Dohrn-van Rossum, *The History of the Hour: Clocks and Modern Temporal Hours*. ed. Thomas Dunlap (Chicago: The University of Chicago Press, 1996), Jacque le Goff, *Time, Work, & Culture in the Middle Ages.* trans Arthur Goldhammer (Chicago: The University of Chicago Press, 1980).

[6] Historian Thomas Allen argues that national temporal experience is political but necessarily layered, while anthropologist Margaret Paxson uses the landscape as a way to explain the layered temporal rhythms encoded in the performance of the calendar year. Thomas Allen, *A Republic in Time: Temporality & Social Imagination in Nineteenth-Century America* (Chapel Hill: University of North Carolina Press, 2008). Margaret Paxson, *Solovyovo: The Story of Memory in a Russian* Village (Bloomington: Indiana University Press, 2005), 269; Doreen Massey argues that the present moment must be seen as the "simultaneity" of "all moments, together, in their histories. This is no spatial surface; it is a contemporaneity of trajectories." Doreen Massey, "Traveling Thoughts," in *Without Guarantees: In Honor of Stuart Hall,* eds. Paul Gilroy, Lawrence Grossberg, and Angela McRobbie (New York: Verso, 2000), *228*; on time-discipline see E. P. Thompson, "Time, Work-Discipline and Industrial Capitalism," *Past &* Present 38 (December 1967)<pages>, Mark M. Smith, *Mastered by the Clock; Time, Slavery, and Freedom in the American South* (The University of North Carolina Press, 1997), Mark M. Smith, "Old South Time in Comparative Perspective," *The American Historical Review,* Vol. 101, No. 5 (Dec., 1996)<pages>. Martin Breugel, "Time that can be Relied Upon,' The Evolution of Time Consciousness in the Mid-Hudson Valley, 1790-1860," *Journal of Social History* 28, no. 3 (1995)<pages>; Michael O'Malley, "Time, Work, and Task Orientation; A Critique of American Historiography," *Time & Society* 1, no. 3 (1992): 341-358, 342.; Michael O'Malley, *Keeping Watch: A History of American Time* (New York: Viking Penguin, 1990).

[7] See James Scott and Benedict Anderson on temporal legibility and the state, James Scott, *Seeing like a State* (New Haven, Yale University Press, 1998); Benedict Anderson, *Imagined Communities: Reflections on the Origins and Spread of Nationalism (*New York: Verso, 1983); Mark Rifkin on temporal order and legal and political legibility, Rifkin, *Beyond Settler Time*; Foucault on temporality and order, Michael Foucault, *Discipline and Punish: The Birth of the Prison,* trans. Alan Sheridan (New York: Vintage Books, 1979).

[8] Sauter, "Clockwatchers and Stargazers," 686.

Yet, looking forward from the eighteenth century, the notion that the history of improved Western timekeepers would converge on mechanical clocks and their relatives might have been somewhat surprising.[9] In 1773 London watchmaker Thomas Hatton, for example, could speak of the improvement of mechanical timekeeping while at the same time imagining the improvement and even perfection of other non-clock timekeepers. "[Any] motions causing parts of time, being shown in an index how oft it has happened, form what may be properly called a time-piece, or time-keeper," Hatton explained, "and as the motions of bodies are infinitely varied, consequently there are infinite ways of measuring time."[10] Hatton pursued the improvement of his art, horology, while listing a range of mechanical and non-mechanical ways of registering change which also might be considered as part of improved timekeeping: "time-keepers may be made as various as the genius of man is inventive."[11]

Hatton granted his readers the freedom to choose, invent, and cultivate timekeepers of all forms, calibrated to an infinite set of needs. Many histories of time chronicle the ways in which it became harder to choose against the clock, but this history does not help us understand as fully how people in the past *aspired* for time to be kept, or how they hoped to organize overlapping temporal patterns in their daily lives. We have not yet asked why, of all of the possible ways to improve timekeeping, Westerners settled on the mechanical clock and its regular units—and as this

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[9] Taking this approach I was particularly inspired by Stephen Harrison, Steve Pile and Nigel Thrift's work in *Patterned Ground,* that looking forward is "an attempt to backtrack from familiar and obvious ways of seeing patterns in the world, and to attempt to discover the world anew. […] a cosmology that hasn't yet figured out the cosmos." Stephen Harrison, Steve Pile, and Nigel Thrift, *Patterned Ground: Entanglements of Nature and Culture* (London: Reaktion Books, 2004), 7.

[10] Thomas Hatton, *An Introduction to the Mechanical Part of Clock and Watch Work. In Two Parts. Containing all the Arithmetic and Geometry Necessary, with their Particular Application in the said Branches, a Work very useful for the Working Mechanic or Gentleman Mechanically Inclined.* (London, 1773), 286.

[11] Hatton, *An Introduction,* 289.

dissertation will show, in the long nineteenth century there were many alternative proposals for ways to improve timekeeping that were not based on the clock. The mechanical clock was a choice made over and over across the nineteenth century, in different industries, for different reasons, and to organize schedules at different scales. But settling on the mechanical clock is not an argument for its historical necessity in organizing modern industry or society. Modern time could be kept in other ways – and often was.

In fact, for many of Hatton's contemporaries, the perfection of the art of timekeeping seemed to lie entirely outside mechanics, and instead resided in the realm of perception. While horologists like Hatton sought the improvement of clock-time through mechanics, others, like the authors of nautical manuals or the inventors of cotton mill machinery, sought the improvement of organic time— time registered by changes in observable environmental phenomena— through a combination of mathematics, physics, and the natural science. As I will explain, the timekeepers these authors, operators, and inventors created can be found within garden calendars, horticultural encyclopedias, navigation charts, logbooks, phenological records, and even the design of factory buildings. From the late eighteenth century through the beginning of the twentieth, members of this second group imagined the local environments as an expression of a rationally organized, mathematically derivable, and ultimately stable nature, and so they proposed that the landscape itself, or at least elements of it, would be the face of the most perfect and most universal clock— if only it could be read.

Reading a Timekeeper

It is a commonplace almost beyond mentioning that different kinds of timekeepers must be read in different ways. To read a sundial, one studies the angle and movement of a shadow; to read a sandglass, one considers the quantity of sand remaining. A calendar is a paper technology; a clock is a mechanical technology. They produce information in different ways, and so that information must be read differently. These are only a few examples of an important insight from the history of timekeeping: time is hybrid, heterogeneous, and layered.[12] Not only do human beings live according to a number of layered temporal schedules, but different ways of telling time also create different kinds of time. Take for example the clock and the calendar, archetypes that stand here for two important approaches to organizing temporal information I examine throughout my dissertation.

Both the clock and the calendar work to stabilize human perceptions within the moving planes of space and time. To interpret distance—to stabilize perception—the observer needs at least two reference points. From 1680 to 1920, mechanical time-keepers, like clocks, created fixed points by recording regularized and standardized units that, when combined, could be associated with larger astronomical periods like the year. During the same period, non-clock timekeepers, like calendars, not only reached towards the stars as fixed points, but they also attempted to ground the periods they recorded within points formed by observable relationships in the terrestrial environment. For instance, an *English Lady's Almanack* published in 1706 offers its readers methods for calibrating their sense of time by referring to the relationships between clocks, seasons, astronomical events, climate, and the agricultural year.[13] Such calibrating moves can be seen in the very first month where the author observes that on January

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12 Many authors take very different perspectives on the concept of hybridity and heterogeneity, see Rifkin on the politics of hybrid time, Mark Rifkin, *Beyond Settler Time;* see Thomas Allen for an in depth discussion of the heterogenous time of the early republic, Thomas Allen, *A Republic in Time;* see Adam Barrows for a summary of other perspectives on layered time, Adam Barrows, *Time, Literature, and Cartography after the Spatial Turn: the Chronometric Imaginary* (New York: Palgrave MacMillan, 2016).

13 "January," *English Lady's Almanack* (1706) in *Women Advising Women.* (Marlborough: Adam Matthew Publications, 1992), pt. 2, reel 7-9, 15.

2nd, "*Good Watches should be 9 minutes too fast for the Sun.*" In addition to commenting on the relationship between clocks and the sun, the author suggests the environmental conditions attending this period of time,

> No Grass the Fields, no Leaves the Trees now shew
> The Frozen Earth lies buried deep in Snow
> Swift Rivers are with sudden Ice constrain'd
> And studded Wheels are on its back sustain'd[14]

Though the relationships that calendars attempted to fix changed over time, the way that calendars kept time continued to emphasize eclectic and complicated matrices of relationships between natural phenomena and across time and space. A systematized calendar, therefore, was not necessarily a regularized calendar, nor did it organize relationships only within the containers of year, months, week, or day alone.

The calendar and the clock required different technologies to be accurate, reliable, and portable. Clockmakers needed to refine the mechanisms that allowed machines to count ever-more regularized units ever-more consistently and reliably, while calendar authors needed to refine their representation and interpretations of observable and reproducible phenomenological relationships. In 1660, when my dissertation begins, the clock and the calendar were recognizably different approaches to keeping time, and often seemed to track different forms of time—the clock was a method of reliably counting units of time, while the calendar was a method for establishing and tracking relationships between natural phenomena. Both kept different types of time. A factory foreman in the first decades of the nineteenth century needed to coordinate labor on the factory floor not only within the regularized cycles of clock-time but also against periodic but nonregularized rhythms of drought, cold, health, and light.

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14 *English Lady's Almanack*, "January," 15.

More than simply good examples of how timekeepers create different temporal orders, I chose the clock and the calendar because they have come to stand, for some theorists, as exemplars of two categories of temporal experience: cyclical and linear.[15] Evolutionary biologist Stephen J. Gould famously explored these "eternal" divisions in his work *Time's Arrow, Time's Cycle* (1987). In this work Gould demonstrated the ways that conceptions of the geologic past and future hinged on the ways that historical actors like Charles Lyell and James Hutton conceptualized time and the cosmos. There is good reason to see time divided in this way not just on geologic scales, but in the more everyday encounters with time. Even our literary metaphors support it: "the cycle of seasons," "the daily round" cast against "counting the minutes until…" or living through "numbered days."

As Gould showed with Hutton and Lyell, the metaphors we hold for time influence how we see the world and act in it. Spatial theorist Henri Lefebvre delved into the consequences and conundrums of these two approaches to time in the third work in his series on the social production of space, *Rhythmanalysis* (1992). Cyclical processes, according to Lefebvre, "originate in the cosmos, in the world, in nature," and these "processes and movements, undulations, vibrations, returns and rotations" can be seen in the passage of day and night, heat and cold, seasons and tides.[16] Linear time, by contrast, Lefebvre defines as "a series of identical facts separated by long or short periods of time."[17] When considering the abstractions of deep time, it is possible to imagine how these categories might be intellectually sifted apart, and for men like Lyell and Hutton much was at stake in which metaphor they chose. But the divisions

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[15] Stephen Jay Gould, *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time* (Cambridge: Harvard University Press, 1988); Samuel L. Macey, *Patriarchs of Time: Dualism in Saturn-Cronus, Father Time, the Watchmaker God, and Father Christmas* (Athens: The University of Georgia Press, 2010).

[16] Henri Lefebvre, *Rhythmanalysis: Space, Time and Everyday Life* (Bloomsbury Academic, 2013), 85.

[17] Lefebvre, *Rhythmanalysis,* 85.

between cyclical and linear time are hazy in practice. Waking in the morning, for instance, I mark the start of a new day, which in one sense locates me in a new position as the earth travels relentlessly around the sun, but that same instant adds one more tally to the number of days, hours, and seconds I have been alive; one more point in an unknowable but steadily unfolding line of days leading from my birth to death. I am moving forward through my life and through historical processes constantly unfolding. I am also moving around the sun, on a perpetually spinning planet. To simply reckon the day, I encounter both cyclical and linear time; I cannot separate them. “Time and space, the cyclical and the linear, exert a reciprocal action,” Lefebvre explained, “they measure themselves against one another; each one makes itself and is made a measuring-measure; everything is cyclical repetition through linear repetitions.”[18]

In this dissertation I examine the creative tension between Euro-Americans’ desire to measure experience in the world through regular units and their desire to measure time through periodic-but-not-fully-predictable phenomena. These orientations towards timekeeping generally align with the categories of linear and cyclical, however the timekeepers I examine live more clearly in the terrain between the two definitions, and so I use different language to draw-out the nuances between them. For example, ships’ logbooks balance the regular units of the chronometer against astronomical sightings, bodily experience, and environmental observations, all within the format of an hour-by-hour log, kept on a daily cycle. As a timekeeper that integrates multiple temporal rhythms in order to arrive at a more accurate sense of time, a ship’s logbook is one example of what I call an “organic timekeeper”—it constructs itself out of temporal orders primarily (but not exclusively) based in the observable periodic phenomena of the natural environment. Organic timekeepers can be mechanical, as we will see, but they take

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[18] Lefebvre, *Rhythmanalysis,* 18

many other forms too, like garden beds, buildings, or even analog computers. By contrast, the opposite of an organic timekeeper keeps time by measuring change in regular units whose meaning and quantity is abstracted from the "stuff" being measured. Non-organic timekeepers do not have to be mechanical, but they often are, and clocks are the most ubiquitous form they take. If there is one thing you take away from this dissertation, I hope you will close these pages better able to identify and interpret organic timekeepers at work in your everyday life. Please note, however, that because this dissertation explores the hazy territory outside frequently-used definitions of time, I will occasionally shift the terms I use to identify and describe organic time in order to more accurately reflect historical processes. In the chapters that follows, I will use terms such as placebased time, natural time, non-regularized time, non-clock, or analog time as synonyms for organic time.

Close scrutiny of the non-clock timekeeping practices promoted by Americans between 1660 and 1920 offers three nested contributions to American history. First, it critiques and expands the historical narrative of time-consciousness as it has been told during this period. Second, this method-driven critique demonstrates that when the histories of "clocks" and "calendars" are considered in tandem, the disjunctures and divergences between their histories will expose crucial gaps within the history of time and American time-consciousness. Finally, by focusing on the phenomenology of time-keeping practices, I will challenge the scale at which the histories of time are told and tested, inviting a reconsideration of the fields of both environmental and temporal history.

I argue that when we put the environmental and cultural history of long-nineteenth century timekeeping practices together, amplifying the history of nonmechanical timekeepers to make the wide range of time management technologies more visible, we encounter a far richer and more nuanced history of time, environmental perception, and American culture. These timekeeping technologies influenced the changing ways that Euro-Americans thought about the nature of time, but they also reflected major trends in the way Americans perceived the natural world. My research reveals unexpected coalitions of Americans working to find new ways of organizing and representing time, and in the process attempting to articulate and live in accordance with something I'm calling modern organic time.

By mixing environmental history with the cultural history of science and technology, my project also calls attention to one of the features of American history that tends to be obscured or overlooked in the clock-centered historiography of American time-consciousness and modernity. In the long-nineteenth century, rationalists as well as romantics, engineers as well as 'luddites,' urban jewelers as well as country farmers, and many others, all defended something imagined as universal and organic time against the clock. Though opponents of clock-time, this diverse array of Americans did not desire to return to a premodern world. Their contestation of the clock was itself an expression of their modernity.

A Short History of Histories of Time

Tracing the history of time-consciousness from the Enlightenment to modernity, the historiography of time attempts to understand in what ways Europeans and Americans were modern and what has been gained or lost in the process of becoming modern. Its evolving conclusions suggest that what was lost in the transition to an urban, mechanical, capitalist, abstracted, clock-based time was something termed natural time, task-time (and with it self-determination), and a seemingly instinctive relationship to the natural environment. In the historiography, the broad transformation in time-consciousness from the Enlightenment to modernity natural time and task-time slowly die—though not without protest—and are replaced by abstract measures of time, ticked-off by machines in ever smaller units. By the end of World War I, Americans lived within the confines of time made fully abstract and artificial. Though many opposed this form of timekeeping, as I will explain, historians have primarily explored this opposition as emanating either from an anti-modern or counter modern impulse, or as a visage of pre-modern social or economic lifestyles.

For some of these historians, the transition away from peasant/agrarian time and towards urban/mechanical time has been interpreted as a triumph; for others it was a fall from grace. One line of interpretation, anchored by Karl Marx and his efforts to historicize mid-nineteenth century British industrialization and labor rationalization, argued that the transition to a world dominated by the clock was imposed from above by the logic of industrial labor.[19] To Marx, organizing labor by the clock was a Faustian bargain on the part of capital, a process that robbed the worker of the power to control his own labor while also exposing for the attentive critic the inherent contradictions of capitalism. Against this bleak view of a European peasantry dragged into modernity, Max Weber's work on the self-discipline of pietistic reformed religion argued that "this sober bourgeois capitalism," was self-chosen and individually maintained, rather than imposed. Europeans and especially Americans had made themselves ready for industrial labor and modernity.[20] Between Marx and Weber a rough narrative of the history of time-consciousness began to emerge, a story with an origin in the monasteries, an intensification either in the Protestant Reformation or in the English industrial revolution, and an end point in a clock-conscious working class.

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[19] Karl Marx, "Economic and Philosophic Manuscripts of 1844" and "The *Grundrisse,"* in *The Marx-Engels Reader,* ed. Robert C. Tucker (New York: W.W. Norton & Company, Inc., 1978), 66-125, 221-293.

[20] Max Weber, *The Protestant Ethic and the Spirit of Capitalism*, trans. Talcott Parsons (New York: Routledge, 1930, 1992).

Whether chosen or imposed, both threads of the historiography agreed that the transition towards time-consciousness occurred in urban settings, and Georg Simmel's turn of the century sociological research on the metropolis exemplifies this claim. Cities, for Simmel, represented concentrated value, and that concentrated capital accelerated the pace of the money economy.[21] Where money circulated quickly, time seemed to accelerate and people lived fast-paced lives; where capital was tied up in slow-changing or predictable routines, people lived slow-paced even lethargic lives.[22] In all of this, the clock was necessary to regulate and coordinate the accelerating pace of life. Simmel's conclusion aligned urbanization and the money economy with the clock, implying that without the clock neither would be possible.

Simmel proposed that however arrived at, the condition of being modern and urban necessitated clock-consciousness. He did not, however, suggest when this transition to a clock-enabled modernity took place. Where Marx and Weber help us see the rift within the historiography over questions about how Westerners came to be modern and capitalistic, Simmel and later Jacques le Goff illustrate a parallel search in the historiography for the transition to modernity. In this way, the history of clock-consciousness came to be wedded to the historiography of modernity.

Building on the work of Marc Bloch and the Annales school, in the nineteen fifties French historian Jacques le Goff used the history of time-consciousness in the Middle Ages to support an argument for a slower transition to modernity.[23] In doing so he pushed back against

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[21] Georg Simmel, "The Metropolis and Mental Life," *The Sociology of Georg Simmel*, trans. Kurt Wolff (New York: Free Press, 1950), 409-424.

[22] John Allen helped me clarify this point in Simmel: John Allan, "On Georg Simmel: Proximity, Distance, and Movement" *Thinking Space*, eds. Nigel Thrift and Mike Crang (London: Routledge, 2000), 65, Kindle.

[23] Jacque le Goff, *Time, Work, & Culture in the Middle Ages,* trans. Arthur Goldhammer (Chicago: The University of Chicago Press, 1980).

the idea that modernity should be understood as an abrupt break with the past. To do this, le Goff focused on the idea of time as a disciplining tool, as capital, and as a process that, though it did not begin with the clock, ended with a clock-conscious urban population. Much like Simmel's study of the late nineteenth century metropolis, le Goff argued that urban life in the Middle Ages was complicated and required coordination, and it was not only bells that needed to be coordinated in the short and long term, but also credit, labor, and capital.[24] This required the technology of subdivision, an emerging specialty of urban merchants who learned to break the sanctity and "unity" of time by dividing it into ever-smaller units.[25] Finally, alongside these urban changes of the fifteenth and sixteenth centuries came the technology of thinking in terms of time.[26] For later historians, le Goff's work on histories of "temporal organization" in sixteenth-century urban centers seemed to argue that as early as the Middle Ages Europeans were learning to manipulate the temporal orders that structured their lives, and that this "state of affairs" must be understood as "modernizing."[27] Work in this vein reified the beginnings of mechanical time as the beginning of time-consciousness as well as the beginnings of modernity. By the middle of the twentieth century, clock-consciousness had become a historical litmus test for modernity.

Where le Goff looked to the Middle Ages to find the roots of modern society, E. P. Thompson looked only as far the late eighteenth and early nineteenth century English working class. Writing in the 1960s, Thompson brought to his study a romantic nostalgia for the

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[24] Gerhard Dohrn-van Rossum builds considerably on this point in his later work on the history of European temporal orders. Gerhard Dohrn-van Rossum, *The History of the Hour: Clocks and Modern Temporal Hours*, ed. Thomas Dunlap (Chicago: The University of Chicago Press, 1996).

[25] le Goff, *Time, Work, & Culture in the Middle Ages*, 36.

[26] This interpretation of le Goff comes from Dohrn-van Rossum, *History of the Hour,* 272.

[27] For instance, "Temporal order can thus be understood as the process of the modernization and increasing density of regulations concerning the organization of time." Dorhn-van Rossum, *History of the Hour*, 272.

vanishing English peasantry and a respect for his conservative rural subjects that Marx never shared.[28] Indeed, where Marx naturalized the loss of peasant lifestyles and mentalities, Thompson chronicled what seemed to be a painful and patchwork imposition of industrial urban discipline, and in the process offering an updated interpretation of the argument for imposition.

In Thompson's famous essay "Time, Work-Discipline and Industrial Capitalism," the entwined processes of enclosure, industrialization, and the transition to capitalism, pushed peasants off the land and into the city. There they were forced to abandon self-directed, task-oriented agricultural lifestyles in favor of a time-regime dominated by capitalists and organized by the rigors of the clock. Exogenous power in the form of factory owners and foremen demanded workers internalize the clock, forcing laborers to discipline themselves to live by the great metronome. Yet Thompson diverged in important ways from Marx's more narrow interpretation of how changes in time-consciousness occurred. Thompson's study showed English men and women at first resisting the regularized time of their employers, but eventually using the manufacturing time as a tool to articulate class-consciousness and argue for their own time.[29] In Thompson's work the association of clock-time with capitalism, and capitalism with modernity, was explicit. To escape the injustices enabled by capitalism and its time-discipline, Thompson called for a return to some forms of "pre-modern" temporal perception.[30] This call

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[28] For comparison, Marx on the bourgeoisie, "It has created enormous cities, has greatly increased the urban population as compared with the rural, and has thus rescued a considerable part of the population from the idiocy of rural life." Karl Marx, "Manifesto of the Communist Party," *The Marx-Engels Reader,* ed. Robert C. Tucker (New York: W.W. Norton & Company, Inc., 1978), 477.

[29] Thompson, "Time, Work-Discipline and Industrial Capitalism," 38, 73, 85-6.

[30] Thompson, "Time, Work-Discipline and Industrial Capitalism," 95.

reinforced the idea, by suggesting the inverse was true as well: to be pre-modern and non-industrial was to follow non-clock schedules.[31]

Just as Thompson modified Marx in the late 1960s, in the next decade French philosopher Michael Foucault modified the Weberian interpretation of time-discipline as an individual choice. Foucault's work suggested that though time-consciousness may on the surface seem to be an individual choice, that choice was still conditioned by systems of control. Using the history of the French military and prison systems, Foucault explored processes of rationalization, standardization, and bodily discipline. He argued that the Enlightenment catalyzed systems of control where time-keeping methods, primarily embodied in the clock, exerted "a subtle coercion" over the individual, "obtaining holds upon [the body] at the level of the mechanism itself—movement, gestures, attitudes, rapidity: an infinitesimal power over the active body."[32] Unlike Thompson's laborers who encountered time-discipline in the material world around them, Foucault's subjects' bodies unconsciously adopted the time-regimes encoded in institutions.[33] Modern institutions constructed modern time—and it was taken for granted that modern time meant the regularized units of the clock.

Between Foucault, Thompson, and le Goff, theories of the history of time entered the 1980s having assigned to clocks the role of harbinger of institutional power, class division and wage labor. Their authors added considerable scope to the earlier interpretations of time-consciousness as either imposed or chosen by suggesting the range of social and individual

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[31] For a critical re-evaluation of Thompson see Paul Glennie and Nigel Thrift, "Reworking E.P. Thompson's 'Time, Work-discipline and Industrial Capitalism,'" *Time & Society* 5, no. 3 (1996): 275-299; and Michael O'Malley, "Time, Work, and Task Orientation; A Critique of American Historiography," 341-358.

[32] Foucault, *Discipline and Punish: The Birth of the Prison*, 137.

[33] Through the timetable, for instance, "time penetrates the body and with it all the meticulous controls of power." Foucault, *Discipline and Punish,* 152.

contexts that conditioned how time-regimes might be encountered, enforced, and employed. Additionally, these theories build on Simmel in identifying time as the medium of economic integration and acceleration, which allied them with emerging literature on the creation of the nation state, national markets, and nationalism.[34]

David Harvey, a geographer and spatial theorist, welded these threads together in the 1980s, and used his synthetic history of time to define post-modernity. In *The Condition of Post-Modernity*, Harvey argued that a sharp break must be marked in the early 1970s after which "postmodern cultural forms" seem to correlate strongly with "a new round of 'time-space compression' in the organization of capitalism."[35] More to the point, Harvey claimed ideas about time and space were material because they were "necessarily created through material practices and processes which serve to reproduce social life."[36] Thus, if social life seemed to have different material expressions and formations in different periods, spatial and temporal conceptions must therefore be assumed to change. "Each distinctive mode of production or social formation," he explained, "will, in short, embody a distinctive bundle of time and space practices and concepts."[37] With this claim, Harvey laid the groundwork for later literature of heterogeneous temporalities, particularly those defined by distinctions between different modes of production and consumption.

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34 See for instance, Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business (*Cambridge: Belknap Press, 1977); Wolfgang Schivelbusch, *The Railway Journey: The Industrialization of Time and Space in the 19th Century* (University of California Press, 1986); Anderson, *Imagined Communities*; Eviatar Zerubavel, *Hidden Rhythms: Schedules and Calendars in Social Life* (London: University of California Press, 1981).

35 David Harvey, "The Argument," *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change* (New York: Wiley-Blackwell, 1991), vii.

36 Harvey, *The Condition of Postmodernity,* 204.

37 *Ibid.*.

Following Harvey, histories of time focused on the claim that time-regimes and temporalities had material effects and could be identified and defined through their material history. While offering useful modifications and subtle critiques of the earlier literature, these studies primarily explored the production and consumption of time-keeping technologies and authority.[38] For instance, Michael O'Malley made a compelling argument that the clock was not so incompatible with agrarian lifestyles as an earlier literature had made it out to be.[39] Carlene Stephens and Alexis McCrossen disputed the interpretive weight historians like David Landes had placed on the presence of time-keepers as indicators of time-consciousness.[40] Incorporating the argument that distinct material cultures indicate distinct temporal-cultures, Thomas Allen used the decoration, production, and circulation of clocks in the Early Republic as the basis for his history of heterogeneous national temporalities, calling into question the supposed unity of clock-time.[41] Considering temporal standardization on a global scale, Vanessa Ogle likewise argued that "up until the 1940s and 1950s, the concept of a worldwide grid of standardized, uniform mean times, and coherent notions of social time, was largely a fiction in the heads of a few mainly Euro-American railway engineers and scienstists."[42] Given that the presence of clocks could no longer be taken by historians to imply their use, much less authority, Alexis

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[38] One important exception to this trend towards production and consumption is Mark Smith's work on the clock and plantation work-discipline. Smith continues to frame time-consciousness within the earlier conversation over chosen/imposed. Mark M. Smith, *Mastered by the Clock; Time, Slavery, and Freedom in the American South* (The University of North Carolina Press, 1997).

[39] He claims there are "remarkable congruencies between a sense of time derived entirely from the natural world and the impulse to discipline, tightly schedules, unstinting work, the kind of work that we usually ascribe to industrial, capitalist, clock-based time." Michael O'Malley, "Time, Work, and Task Orientation; A Critique of American Historiography," 342; Michael O'Malley, *Keeping Watch: A History of American Time* (New York: Viking Penguin, 1990).

[40] Carlene Stephens, "'The Most Reliable Time': William Bond, the New England Railroads, and Time Awareness in 19th-Century America," *Technology and Culture* 30, no. 1 (January 1989) <pages>; Alexis McCrossen, "The 'Very Delicate Construction' Of Pocket Watches and Time Consciousness in the Nineteenth-Century United States," *Winterthur Portfolio* 44, no. 1 (Spring 2010), 1-30; David Landes, *Revolution in Time.*

[41] Thomas Allen, *A Republic in Time.*

[42] Vanessa Ogle, "Whose Time Is It? The Pluralization of Time and the Global Condition, 1870s-1940s," *American Historical Review* 120, no. 5 (December 2013): 1376-1402, 1377.

McCrossen, Ian Bartky, and Vanessa Ogle's recent monographs interpret the paths through which public clocks and national or international standards gained authority, the ways that time-producing institutions competed to sell credible time-signals to the public, and the global context for temporal standardization.[43] Finally, Michael J. Sauter and Peter Galison read the landscapes of Berlin and Bern in order to draw nuanced connections between the material environment of German and Swiss social and intellectual life and the history of temporal standardization.[44] Sauter, for instance, argued that "time-discipline began as an urban product and emerged not from the factory floor but from the streets, where most people in the early modern world would have encountered clocks."[45]

Despite these fruitful new avenues and revisions, in this historiography modernity still lives under the sign of the clock, and the association of these two seem to be over-determined. It is taken for granted, for instance, that a cotton mill could only maximize production through the imposition of clock-time, and could not have, for instance, increased production through other forms of timekeeping not composed of regular units mechanically counted. Histories of timekeeping in Japan, Australia, and South Africa that illustrate the blindspots in the dominant histories of time perception and timekeeping have not been fully incorporated into the larger historiography, and historical conceptions of Western modernity still seem to require a mechanical metronome ticking-away regular units.[46] As a consequence, insightful as the

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[43] Alexis McCrossen, *Marking Modern Times*; Ian Bartky, *Selling the Time True: Nineteenth Century Timekeeping in America* (Redwood City: Stanford University Press, 2000); Vanessa Ogle, *The Global Transformation of Time: 1870–1950* (Cambridge: Harvard University Press, October 2015).

[44] Michael J. Sauter, "Clockwatchers and Stargazers"; Peter Galison, "Einstein's Clocks: The Place of Time," *Critical Inquiry* 26, no. 2 (2000): 355-389.

[45] Sauter, 688.

[46] See for instance Giodanao Nanni, *The Colonisation of Time; Ritual, Routine, and Resistance in the British Empire* (Manchester: Manchester University Press, 2012); Keya Ganguly, "Temporality and Postcolonial Critique," in *The Cambridge Companion to Postcolonial Literary Studies*, ed. Neil Lazarus (Cambridge: Cambridge University Press, 2004).

historiography of Western time-consciousness is, we have barely scratched the surface of the history of temporal perception and time-keeping, and we are long overdue for a reconsideration.

To address this gap, I examine four American industries that sought greater efficiency and increased production by attempting to align the patterns of their labor more closely with the rhythms of the natural world, inventing and employing a wide range of organic timekeepers to do so. Embracing the idea that time should be universal, standardized, and rationalized, the groups of gardeners, sailors, captains, mill owners, mill operatives, bureaucrats, scientists, and industrialists I consider in this dissertation all consider the clock insufficiently precise, accurate, or universal enough to fit the conditions of their labor. Their rejection of the clock was not a rejection of modernity, rather, it was an expression of their commitment to it.

The history of time is not simply the history of clock-consciousness, but the historiography of Western time-consciousness has become a history of the clock. Despite repeated efforts to shift the perspective, this tendency has not yet changed. Observing the same feature of the literature more than twenty years ago, historian Michael O'Malley composed a stinging and thorough critique of the historiography, focusing on the supposed division between mechanical and natural time.[47] The literature on clock-time has always pivoted against an idea, often quite vague, about what "natural" or "premodern" time was.[48] In early works by Marx, Weber, or le Goff this earlier sense of time is bracketed within romantic and pastoral ideals. This ideal of pastoral natural time was famously anchored by anthropological research carried out by Pierre Bourdieu among the Kabyle in northern Algeria. For Bourdieu this way of noting—or *not*

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47 O'Malley's brief historiographical essay makes one of the points I will elaborate upon in my dissertation. He claims there are "remarkable congruencies between a sense of time derived entirely from the natural world and the impulse to discipline, tightly schedules, unstinting work, the kind of work that we usually ascribe to industrial, capitalist, clock-based time." Michael O'Malley, "Time, Work, and Task Orientation," 342.

48 See O'Malley, "Time, Work, and Task Orientation," and Mark Rifkin, *Beyond Settler Time.*

noting as he saw it—time was called "task-time" and this freedom to organize one's day around the labor that must be accomplished, at whatever rate one wished, is what was then lost in the transition to capitalism and commodified clock-time.[49] For the most part, historians have heard O'Malley's call to reconsider the historiography, but reconsidering it and contesting its claims has led back to a literature focused on clocks—now doubly so since the substance of both the core historiography and its revision traverse the same territory.[50]

To get out of this rut, we need to set the clock aside and amplify the history of non-clock timekeeping. It also means bringing the same openness to the history of time that Hatton brought to his definition of time: time keepers can take infinite forms. Timekeeping is "composed of everyday stuff" and it is about environmental perception. We must refocus our scholarship on the processes of systematizing and universalizing perceptions of nature, and then consider some of the technologies Americans employed to accomplish these goals. Many of them—many more than most of us would expect—were organic timekeepers.

Perception

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49 Most scholars agree with Mark Rifkin when he argues in *Beyond Settler Time,* for the necessity of uncoupling studies of indigenous temporalities from the implicit assumptions of Western historiography and conceptions of modern timekeeping. Rifkin argues that when applied to temporalities, the concept of hybrid modernities encourages scholars to present indigenous temporalities as "epiphenomenal variations in the face of a presumed temporal linkage within modernity." However, by subsuming the diversity of Indigenous temporalities into a universal background marked otherwise by Euroamerican referents, this approach ultimately obscures Indigenous temporal experience, history, and the extension of settler colonialism into the intimacies of temporal perception. Rifkin, *Beyond Settler Time,* 10.

50 One prominent example of how revision tended to lead back to the clock is the conversation that arose among American and British historians over Weber and Thompson's interpretation of Protestant and especially Puritan time-discipline. See for instance, T.H. Breen, "The Non-Existent Controversy: Puritan and Anglican Attitudes on Work and Wealth, 1600-1640," *Church History* 35, no. 3 (September 1966): 273; Robert Poole, "'Give Us Our Eleven Days!': Calendar Reform in Eighteenth-Century England," *Past& Present,* no. 149 (November 1995): <pages>; Paul Hensley, "Time, Work, and Social Context in New England," *The New England Quarterly* 65, no.4 (December 1992): 533-537; James P. Walsh, "Holy Time and Sacred Space in Puritan New England," *American Quarterly* 32, no. 1 (Spring, 1980): 7-83; David Hackett Fischer, *Albion's Seed; Four British Folkways in America* (Oxford: Oxford University Press, 1989), 158-166.

Reflecting on metaphors for temporal experience, French philosopher Maurice Merleau-Ponty argued that "time is … not a real process, not an actual succession that I am content to record. It arises from *my* relation to things."[51] I am not concerned in this dissertation with what time is ontologically. Rather, I agree with Merlau-Ponty: time is best understood and investigated phenomenologically—through the "things" that the human mind uses to stabilize relationships within the fluid landscape of duration. In this dissertation, I refer to this ongoing unfolding of the phenomena of universe as "organic time." Bird calls, church bells, hungry stomachs, and the angle of the light might be some of those "things" that can be woven together to create a sense of time, or that can be assembled to mark changes in time. "Organic timekeeping" practices are composed from the patterns we develop to interpret the phenomenal universe's unfolding and the systems we use to track those patterns. For this reason, organic timekeeping technologies can be found anywhere that the human conception of time touches the world, because it is through these technologies that we make the dynamic unfolding of the universe as it occurs in specific places and specific environments legible and meaningful.

Organic timekeeping happens when and where place and time are inextricably linked. In these circumstances, organic timekeeping technology acts as a kind of decoder ring, translating the chaotic phenomenal universe into patterns that are culturally legible and enabling more abstract timekeeping and spatial systems constructed and employed. The territory between the abstractions of time and space, most commonly associated in the West with clock time and Cartesian space, and the unassembled phenomena of the universe is the province of organic timekeeping technology. We can see an example of organic timekeeping in action in the pages of *The English Lady's Almanack*'s entry for January, 2nd. On that day the author explained that

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[51] Maurice Merleau-Ponty, *Phenomenology of Perception* (New York: Routeledge, 1962), 478

"Good watches should be 9 minutes too fast for the Sun."[52] Doing so, the author reconnected the abstraction of clock time to the observable material world, to the unfolding of the seasons, the length and angle of the shadows, and passage of the stars, making it possible for the clock's ticking could continue to be meaningful in the Lady's everyday life.

By specifying that this dissertation addresses the phenomena from which particular nineteenth-century American time-regimes were constructed, I am necessarily framing my work within two fields whose members compose my primary audience. First, this approach assumes that the history of time *is* environmental history, and proposes that environmental historians must be more attentive to temporal history in their research and writing. Second, this approach assumes that the history of time is also, inescapably, sensory history. This dissertation asserts that by acknowledging this connection to sensory history, historians who do write about temporal history must more fully address the subtle and idiosyncratic changes in human perception over time and from place to place.

Time-keeping is the practice of perceiving, interpreting, and fixing the fluid relationships between phenomena in the world into a matrix that is replicable, portable, and meaningful.[53] Individuals construct this matrix in different ways, influenced by the existing time-cultures they occupy.[54] The history of time is, at base, formed by the myriad ways human cultures have

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[52] *English Lady's Almanack*, 15.

[53] This definition draws from: *TimeSpace: Geographies of Temporality*, eds. Nigel Thrift and Jon May (London: Routledge, 2001); Doreen Massey, "The Politics of Space/Time," *Space, Place and Gender* (Minneapolis: University of Minnesota Press, 1994), 249-272; John Bender and David Wellbery, eds., *Chronotopes: The Construction of Time* (Redwood City: Stanford University Press, 1991); Henri Lefebvre, *Rhythmanalysis*.

[54] Mark Rifkin refers to these such time-cultures as "perceptual traditions" and has a wonderful section on the idea in *Beyond Settler Time:* "The process of contextualizing, or orienting, new sensations within an already active set of tendencies, memories, and histories (themselves based not simply on beliefs about the world but on the accretion of material interactions in it with all sorts of entities, human and otherwise) extends beyond the present into the future." (28). However Rifkin emphasizes the role of "long-standing inhabitance" as the first among many ways that perceptual traditions are formed. I would argue that this approach still assumes a kind of "common sense" about encounters with environments that we should not assume and cannot help explain the experience of mobility or displacement. Rifkin, *Beyond Settler Time,* 28-29.

attempted to stabilize and replicate relations within the fluidity of duration in the physical environments that they occupy. The history of time is additionally composed of individual and group efforts to communicate, perceive, and contest those relationships. In short, historians of time must see their work as deeply involved in environmental history, since the history of time is a history of noticing and giving meaning to human environments. For the same reason, environmental historians must develop a far more sophisticated literature on the subject.

Ideas about time provide an architecture of subtle cause-and-effect relationships that enable the human senses to be integrated and refined. The human senses interpret the world *in time*. For instance, ideas about time undergird human interpretation of what phenomena precede, co-occur, or followed another, what phenomena or entities could plausibly have *caused* an event to occur, could *not* have caused something to occur, what the consequences of an event might have been, or the likelihood of something occurring again. When the leaves rustle on that tree over there and the hair on my head is disturbed, it is an idea about time that tells me these two phenomena are related and have meaning as a unit: I am sensing the passage of the wind.[55] Histories of time are, therefore, also histories of what can be perceived in environments by whom, how, and to what end. As ideas about time change, and as cultures change, so too do the boundaries of what it is possible to perceive. The history of time is necessarily a history of the human senses.[56]

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55 Harrison, Pile and Thrift explore some of this process in their introduction by quoting from theoretical physicist J. M. Juach's work, *Are Quanta Real? A Galilean Dialogue*. "Segredo: This is a marvelous idea! It suggests that when we try to understand nature, we should look at the phenomena as if they were messages to be understood. Except that each message appears to be random until we establish a code to read it. This code takes the form of an abstraction, that is, we choose to ignore certain things as irrelevant and we thus partially select the content of the message by a free choice. These irrelevant signals form the 'background noise,' which will limit the accuracy of our message. But since the code is not absolute there may be several messages in the same raw material of the data, so changing the code will result in a message of equally deep significance in something that was merely noise before [….] Thus a code presupposes a free choice among different, complementary aspects, each of which has equal claim to reality." J. M. Juach*, Are Quanta Real? A Galilean Dialogue* (Bloomington: Indiana University Press, 1989), 64.

56 In offering my revision to American temporal history, I hope to be in dialog with the flourishing new methodologies of historians whose work focuses on changes in American sensory history and perceptions of the natural world. I am particularly

Time is composed from the "stuff of everyday life," as John Bender ad David Wellbury put it, and the patterns those in the past sought to find within the proliferation of possible "stuff" mattered (and matter still). Though this "stuff" may be as humble as a lettuce plant, or the twist of a cotton thread, or as lofty as a passing comet, bird migrations, or sun spots, it is through these phenomena and their associations that the human mind constructs the meaning and measure of duration. "The everyday is simultaneously the site of, the theatre for, and what is at stake," Henri Lefebvre reminds his readers, "between great indestructible rhythms and the processes imposed by the socio-economic organization of production, consumption, circulation, and habitat." Many histories have considered how changes in the production, consumption or circulation of capital and goods changed temporal perception and bound Americans closer to a clock-centered modernity. The steady ticking of a clock is one way of making the social patterns within a given landscape or community legible and portable, but a clock is just one way of rendering the natural world legible and predictable. And not all phenomena occur at regular intervals. Depending on the scale at which they are considered, many phenomena slide between regular and irregular rhythms. Reflecting on the ways that the human mind codifies and categorizes environmental

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inspired by histories attentive to exploring the history of what could be understood through individual senses. This includes Leigh Eric Schmidt's work on hearing and religious belief, Mark Smith's research into the social landscape of smell and sound, and Vladimir Jankovic's insights into the limits of enlightenment thought in the context of heat, cold, and damp. Some historians of time have already begun this work, most notably in the context of sound, but I think the phenomenological and affective history of time requires greater investigation. Leigh Eric Schmidt, *Hearing Things: Religion, Illusion, and the American Enlightenment* (Cambridge: Harvard University Press, 2002); Mark M. Smith, *The Smell of Battle, the Taste of Siege,* (Oxford: Oxford University Press, 2014); Vladimir Jankovic, *Reading the Skies: a Cultural History of English Weather, 1650-1820* (Chicago: University of Chicago Press, 2000).

56 Mark M. Smith has previously written about the history of time in *Mastered by the Clock* but has moved on to study sensory history as well. Mark M. Smith, *Sensing the Past: Seeing, Hearing, Smelling, Tasting and Touching in History*. (Berkeley: University of California Press, 2008); Mark Smith, "Coming to 'Our' Senses: an Introduction," *The Journal of American History* 95, no. 2 (September 2008): 378-380. Thomas Allen, "Clockwork Nation: Modern Time, Moral Perfectionism and American Identity in Catherine Beecher and Henry Thoreau," *Journal of American Studies* 39, no. 1 (April 2005): 65-86.

phenomena, Harrison, Pile and Thrift are blunt in their assessment of its consequence: “what is at stake […] is the multi-layered structure of reality.”[57]

For this reason, the history of American time-consciousness and time-keeping must be examined at a much closer scale than it has been previously.[58] The synthetic history of time, with its dichotomies between natural and mechanical time, chosen or imposed, relies on histories told at a macro scale, often in the frame of the longue durée or on a class-level. In this dissertation I want to disrupt taken-for-granted assumptions about the history of time, and illustrate the fragility of those claims when applied to lived experience in everyday settings.

Such close attention is necessary in part because the history of American non-clocked time is taken for granted by most historians, and too generally simplified or overlooked by temporal historians. Attending to scale allows me to demonstrate in a series of carefully chosen case-studies that there were changes in American conceptions of non-regularized time, and those changes had real (and visible) consequences in the lived experience of the past, effects that nevertheless were not always visible from all scales. Such a tight focus, methodologically, calls for close case-studies, that account for different geographies, from the kitchen garden to the globe. Secondarily, attending to scale serves my purposes because it calls into question historians’ often sweeping claims about American time-consciousness. It is my belief that histories that closely examine the lived experience of time-keeping and time-consciousness in everyday life, and particularly histories that reveal the messy relationship between ideas and

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57 Harrison, Pile and Thrift, *Patterned Ground*, 28

58 Foucault partially pointed the way when he declared that in time-discipline “the mystique of the everyday is joined here with the discipline of the minute,” and later when he called Enlightenment methods for rationalizing space and time a “micro-physics of what might be called a ‘cellular’ power.” Foucault, *Discipline and Punish,* 140, 149

practice, will trouble the categories (modern and premodern, natural and artificial, cyclical and linear) that have until now stabilized the historiography of time-consciousness.

For historians to overlook the environmental and sensory histories of time is not trivial. Temporalities constitute not only our most basic subjectivities; they are also the foundation of an ongoing effort to construct individual and group cosmologies and identities.[59] "Temporalization," as Merleau-Ponty puts it, is the medium through which "we find our bodily being, our social being, and the pre-existence of the world, that is, the starting point of all 'explanations'…" [60] Historical debates about how to keep time or proposals for how to change time-keeping practices strike at the heart of how individuals in the past perceived, constructed, and communicated the contents of their cosmologies. This dissertation, a history of the non-clock timekeeping practices from the Enlightenment to modernity, is therefore an exploration of what people in the past thought was at stake in the ways that they knew and noted time. It is also a history of the ways they aspired to keep time and organize society—temporal regimes that did not always come to fruition, but nevertheless tell us a great deal about how some nineteenth century Americans *wanted* modern society to be organized.[61]

Whether debating how Western culture experienced modernity or questioning when modernity and capitalism began, the historiography of time can be easily summarized as a extended conversation over what verb must be appended to time-consciousness. Was time-

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[59] See for instance, Michael Hanchard, "Afro-Modernity: Temporality, Politics, and the African Diaspora," *Public Culture* 11, no. 1 (December 1999): 245-268; Neferti Tadier, "Life-Times of Dispossability within Global Neoliberalism," *Social Text 115* 31, no. 2 (Summer 2013): 19-48; Sara Ahmed, *Queer Phenomenology: Orientations, Objects, Others* (Durham: Duke University Press, 2006).

[60] Merleau-Ponty, *Phenomenology of Perception,* 503.

[61] Karl Mannheim has claimed that "the collective structure of the mentality of a group can never be as clearly grasped as when we attempt to understand its conception of time in the light of its hopes, yearnings, and purposes." Karl Mannheim quoted in Michael D. Gordin, Helen Tilley, and Gyan Prakash, "Utopia and Dystopia beyond Space and Time," *Utopia/Dystopia: Conditions of Historical Possibility* (Princeton University Press, 2010).

consciousness *imposed?* Was it *chosen?* Was it *produced*? Perhaps *consumed?* Clearly, the history of time cannot be interpreted without considering time-consciousness to be all of these. And yet, all of these ways of considering time-consciousness imagine time as a finished product, something contained and understood, clearly delimited: a *product, an ethic, a timetable, a watch*. Clock-time may be learned, but few of these histories consider how non-clock time is learned or imposed, and fewer still how non-clock timekeeping practices changed over time or were systematized or standardized. Thinking of time, clock-based or otherwise, as a known quantity, leads histories away from understanding time as a constantly changing phenomenological experience. With this in mind, my dissertation offers one more verb to this list. Time-consciousness is constantly *cultivated*.

Chapter Descriptions

The four chapters of my dissertation follow four different proposals for non-clock organic timekeepers, each proposal increasing in scale and complexity. I begin on the scale of the kitchen garden and then move to the deck of an American merchant ship, showing how seemingly different timekeeping technologies designed to be carried from place to place—like garden books and ships' logbooks—addressed the problems of universal and standardized timekeeping in surprisingly similar ways. I use these similarities to support the contention that there was a broad and inventive cohort of Americans who thought the regular units of clock-time were insufficient to meet the conditions of their labor in particular environments where experiences of place and time were inextricably linked. Building from there, in my third chapter I examine organic timekeepers that operated on the scale of the watershed powering a mid-nineteenth-century water-powered cotton factory. My final chapter analyzes several connected projects among scientists and bureaucrats at the Patent Office, USDA, Coast Survey, and Smithsonian Institution to create and follow national temporal orders using organic timekeeping technologies. In this chapter I argue that the creation of a national clock-based time standard was integrally linked to associated projects in national organic timekeeping.

The cases I examine in each of these chapters are independent of each other, however some historical actors and institutions appear in multiple chapters. Figures like Benjamin Pierce and Henry David Thoreau appear in multiple locations in the text, applying organic timekeeping practices to many different projects. The fact that organic timekeeping practices surface in the work of such a wide array of people, I take to indicate the ubiquity of this approach to timekeeping. Organic timekeeping can be considered a heuristic practice whose historical existence we can trace for at least one hundred and fifty years. People operating with this perspective looked for ways to interpret the unfolding of temporal patterns in specific times and places for practical reasons connected to material practices of daily life. We can find certain congruences between some of the people in this tradition, but it would be a mistake to assume that the cases I lay out in this dissertation, or the figures I examine, are all part of a single linear evolution of organic timekeeping practices. By tracing its manifestations within four industries, through several scales and intensities, these chapters tell a common story of change and continuity within the practices of modern organic timekeeping across the long-nineteenth century. Collectively they demonstrate that timekeeping practices based in the rhythms of the natural world did not diminish with the expanded influence of mechanical timekeeping. Rather, organic timekeeping practices became instrumental to the development of modern timekeeping, and continue to play influential roles in the temporality of American culture even now.

CHAPTER 2:

The first case study begins on the scale of an eighteenth-century kitchen garden, and examines the problem of coordinating temporal perception in local environments with globe-spanning imperial schedules. While the British Parliament poured money into the search for a chronometer that could go to sea, other Englishmen, like the authors of gardening guidebooks and colonial nurserymen, struggled with the question of how to make time portable in ways unconnected to clock-time and its regular units. In this chapter I demonstrate how ideas of nature are also, inherently, ideas about the nature of time and the ways it should be kept. To illustrate this claim I use the debates within seventeenth- and eighteenth-century horticultural literature over how to keep time in a garden to show the ways in which available timekeeping technologies, like the garden calendar, garden almanac, and garden dictionary, could not adequately reflect the gardener's empirical experience or his cosmology. As a consequence, British and, later, American gardeners developed a technique that used seeds as timekeepers in order to better situate the more abstract temporal schedules offered in guidebooks with the conditions of local environment.

Chapter one focuses on the ways that gardeners used specific seeds grown in very specific ways as timekeepers. It also introduces the idea that, by the mid-nineteenth century, the newly-minted fields of ecology and phenology had been invested with great significance by horticulturalists. The idea that ecology and phenology might reveal the Arcadian clock, returns in chapter five as bureaucrats and scientists at the USDA and Smithsonian Institution attempt to use phenological surveys to develop national crop schedules and predictions.

CHAPTER 3:

In my second case study, I continue to trace the history of travelling instruction manuals, but in this example I follow American polymath Nathaniel Bowditch (1773-1838) out to sea as he composes his famous navigation guide, *The American Practical Navigator*. During this era, clocks were capable of travelling aboard a ship without gaining or losing too much time, but they were not reliable or accurate enough to be the sole timekeeping instrument on board. Well into the nineteenth century, marine chronometers were, in the words of one instruction manual on nautical routine, "liable to jump one or two seconds in the daily rate without any apparent cause, and then reassume their former rate in a few days."[62] Since four seconds variation in the chronometer was equivalent to one mile in longitude, even for those who owned this expensive instrument, relying solely on the time kept by the marine chronometer could be risky. Though the marine chronometer plays an important role in the history of timekeeping, the obvious limitations to marine chronometers inspired additional proposals for improved and systematized timekeeping at sea.

The most widely-employed and systematized method for finding position at sea developed at the end of the eighteenth century was the ship's logbook. As an "index of change," the logbook began as a timekeeping technology in the fifteenth century, however, during the decades between 1790 and 1840, American navigators and captains, inspired by proposals from Bowditch and other nautical authors, pushed for the logbook to become more standardized and systematized in its uses, contents, and format. Overtime, the logbook became a cutting-edge tool for determining longitude and, by extension, a timekeeper. Longitude, after all, is defined as a specific position in space and time. This timekeeping technology offered a method for weighing and calibrating multiple forms of timekeeping against each other, using mechanical, mathematical, and qualitative methods of telling time to reduce uncertainty. The logbook was a tool to help sailors and navigators translate bodily experience into numbers and compare calculations, observations, and estimations. During the first decades of the nineteenth century, nautical manuals emphasized the importance of

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[62] James McLeod Murphy, *Nautical Routine and Stowage, with Short Rules in Navigation* (New York, 1849), 4.

systematizing logbook entries and touted the scientific mysteries that would be resolved with the principled investigation of "scientific sailors."

CHAPTER 4:

In the fourth chapter, I employ foremen's manuals, practical engineering guides, and the self-published papers of factory operatives to examine the ways that cotton mills in the mid-nineteenth century channeled and integrated the multiple temporal structures that flowed through and around their walls. From these sources, I argue that worker's may have been forced to notice timetables, but the conditions of their jobs also forced them to feel the power of the river in the tension of a thread, the heat rising from floor upon floor of belts and drive shafts, the whine of gears and winches and cogs overhead. In this sense, the line of cotton running from skutching room to spinning room, offered a carefully calibrated report on environmental conditions within the factory. If they wanted, operatives and managers could interpret the humidity of the carding room in the twist of the thread, or the height of the river in pace of the machines. The factory itself was an organic timekeeper, registering regional and local environmental conditions in a range of ways that the operatives learned to read and respond to.

The water-powered factory was not only a place of timetables and mechanical clocks. Though workers may have been leaving an agricultural landscape behind, they were leaving the countryside only to plunge into a deeper relationship with the river. The factory walls thrummed with the life of the river, where the viscosity of the water due to cold, or its level due to drought or flood, entered worker's bodies through the vibrations of the floor. Worker's may have been forced to notice timetables, but the conditions of their jobs also forced workers to feel the power of the river in the tension of a thread, the heat rising from floor upon floor of belts and drive shafts, the whine of gears and winches and cogs overhead. Their annual pay reflected the health of the cotton crop, the humidity of the air, height of the river, and amount of sunlight as much as it did fluctuations in national or global markets. In chapter three I argue that this sensory experience—and the knowledge it produced—was instrumental in the practical work of the factory, since it influenced actual performance of labor, the safety of the workers, and the output of the mill.

CHAPTER 5:

The final case study follows Isaac Newton, the first head of the USDA, from his early days as a master gardener advocating for a weather service, to his work during the Civil War to collect, compare, organize, and systematize national crop and weather reports into Agricultural Reports.[63] These reports were first published in 1863. Newton seemed convinced that beneath the disorder of subjective reporting, confused weather correspondents, and improper agricultural practice, he could recover enough order to issue agricultural predictions and to shape a more regularized national credit cycle.[64] In this conviction and the publications that it inspired, Newton offers a chance to examine changing ideas of organic time. Imagining a transcendent temporal order in nature anchored in growing cycles and weather patterns, Newton aspired to use the USDA's Agricultural Reports and statistics to uncover that order and thereby render agriculture more predictable and more controllable.

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63 In his history of English almanacs, Bernard Capp suggests by the seventeenth century almanacs had become a method for manipulating grain prices. "Contemporaries realized," he claims, "that [weather and crop] prophecies could be self-fulfilling, as farmers hoarded supplied and waited for prices to rise." He cites at least one example of an almanac author who withheld crop predictions in an effort to foil hoarders. Bernard Capp, *English Almanacs 1500-1800; Astrology and the Popular Press*. (Ithaca, Cornell University Press, 1979), 64.

64 "These columns of dry figures are eloquent." One of the Agriculture Report's boosters cheered, "they are going to exert a tremendous influence. Just see what they have done this season. When your last monthly came out corn was selling her at $1 10[sic]; straitaway it rose to $1 30 [sic], and no one wants to sell at that. Those little bulletins are going to regulate the markets." *Agriculture Report,* January, 1865, 3

The changes Newton undertook at the USDA were mirrored in overlapping projects undertaken by several other bureaucrats working for the Smithsonian meteorological and phenological survey, the Coast Survey, and the US Patent Office. These allied projects relied on a faith in the ultimate consilience of temporal orders. Phenological surveys would support and confirm crop predictions, tide predictions would support and confirm meteorological findings, sun-spot charts could explain the wheat crop. Through expanded scientific surveys and the new tools within statistics and probability, these scientists and bureaucrats sought to draw together information about the periodic occurrence of the disparate local phenomena, and from these enormous tables of information draw forward a rational and systematized national temporal order. This national temporal order, based in the observable conditions of the natural world, would achieve in time what was so-hard won with space: confirm national synthesis. By the middle of the 1870s, however, many of these projects had encountered the limits of either funding or feasibility. Their supporters began to grapple, too, with questions about "fit" and uncertainty. Motivated by changing views of the limits of statistics as well as changing understandings of the scope of the project, by the early 1880s the push for national temporal integration fractured. The result was a series of smaller-scale and less ecologically-based "zones," which continue to structure American understandings of mechanical and organic time: life zones, crop zones, and time zones.

This chapter also establishes a set of problems related to the collection and interpretation of data. If timekeepers are registers of change, certain types of change—certain patterns—only emerge from the computation of large sets of numbers. One of the limits the USDA and meteorological survey faced was the problem of how slow it was to compute large tables. An organic timekeeper for national schedules might be possible, but perhaps not with the technologies available at mid-century. For these scientists and bureaucrats, settling for zones based on regular and abstract units was partially a compromise forced by expediency. It was not impossible to compute other patterns, and computing them, render the national landscape legible and more predictable. Rather, it was time-intensive to do so, and projects like the USDA crop report could not sustain the man-power or funding to carry those projects out in the time Congressional demands allowed.

Five decades ago, E.P. Thompson opened historians' eyes to systems of organic timekeeping operating within English peasant life and challenged by industrial time discipline, a revelation from which generations of scholars have drawn important inspiration. However, far from dying at the hands of a clock-driven modern industrial world, those systems of organic timekeeping persisted far longer than Thompson credited, and continue to shape our lives and environmental perception today. The modern world is built on the foundation of modern organic timekeeping.

Although we often consider the close of the nineteenth century an era when the mechanical clock triumphed over other ways of knowing and noting time, the modern organic timekeeping practices I describe in my dissertation persisted and even flourished during this period. They persisted because in many facets of American life and commerce—such as horticulture, navigation, cotton factory production, and crop reporting—place and time remained inextricably linked. In each of these cases, Americans continued to employ modern organic timekeepers because they could not overcome the ways in which their industries were entangled with the place-based patterns of their local and regional environments. In these cases, Americans needed organic timekeepers to make meaning at the juncture where the human conception of time touched the world. To the extent that layers of abstraction, represented by the mechanical clock and later the digital computer, seem to become important to these industries, we should not read their presence as a total replacement for organic timekeeping practices. As I show in my conclusion, the presence of abstraction within these industries illustrates the success of organic timekeeping technologies in translating the periodic but not fully predictable patterns of local environments into systems so legible and reliable that a layer of abstractions could be built upon them. In my conclusion, I argue that modern organic timekeeping technologies have become only more necessary with the expansion of digital technology.

Timekeeping is fundamentally a practice of environmental perception. Climate change is already shifting many of the temporal patterns of human life, and the scale of those changes will only accelerate. For this reason, climate change is a challenge to our existing timekeeping systems, and I believe that we will be able to more consciously and conscientiously respond to the challenge if we keep track of those cultural systems of our own making that shape our sense of time. Modern organic timekeepers still touch the world. They are still necessary for our interpretation of the ongoing unfolding of the phenomenal universe, and they are still integral to our construction of reality. Histories of timekeeping that focus on the clock tempt us to forget that the way organic timekeepers touched the world mattered, and it matters still. A great deal depends on our ability to recognize their work.

2

Melon Time and the Mechanical Gardener

Introduction

Timekeeping is the practice of perceiving, interpreting, and situating the fluid relationships between phenomena in the world as they change over time into a matrix that is replicable, portable, and meaningful.[1] As Europeans and Euro-Americans turned increasingly to mechanical time measured by the clock in the eighteenth and nineteenth centuries, they also continued to pay attention to placebased organic time, measured through the rhythms of the natural world. More than simply attending to these rhythms, horticulturalists developed surprising non-clock timekeeping technologies to make natural patterns more legible and easier to follow. These methods surface first in an eighteenth-century British debate over the ideal format for composing garden books, next in an unexpected obsession on both sides of the Atlantic with growing melons out of season, and finally in elaborate proposals to create compendious tables correlating tree-leafing and crop harvests in the American interior. This history reveals garden book authors from 1660 through 1820 working to find new ways of representing time in the pages of their books, and in the process attempting to articulate and live in accordance with a concept I call "modern organic time."

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1 This definition draws from: *TimeSpace: Geographies of Temporality*, eds. Nigel Thrift and Jon May (London: Routledge, 2001); Doreen Massey, "The Politics of Space/Time," *Space, Place and Gender* (Minneapolis: University of Minnesota Press, 1994), 249-272; John Bender and David Wellbery, eds., *Chronotopes: The Construction of Time* (Stanford: Stanford University Press, 1991); Henri Lefebvre, *Rhythmanalysis: Space, Time and Everyday Life*, Stuart Elden and Gerald Moore, trans. (New York: Bloomsbury, 1992, 2013).

The experience of time is at once universal and placebased. And it often seems as though a choice must be made between these two ways of knowing time: universal or particular, mechanical or organic, artificial or natural. Attempting to modernize organic timekeeping methods, however, the horticultural authors I examine rejected this dichotomy between universal and particular. They insisted that there must be some technology capable of mediating between both empirical experiences of time. Precisely because time and place intersect, eighteenth-century horticultural authors argued that only by becoming keenly aware of local environments could readers transcend the limitations of all available timekeepers—whether clock, calendar, or almanac. These authors promised readers that through careful observation of the natural world they would be able to discover the most perfect timekeeper of all, one that was fully universal and also fully placebased. Surprisingly, melons, and the specific practices required to grow them out of season, became the key to finding this universal timekeeper in nature. Ultimately, this horticultural history shows that technologies like garden books and acclimated seeds influenced the way gardeners perceived the natural world, while they also reflected the changing ways that Europeans and Euro-Americans thought about the nature of time.

The popularizers of the debate over organic timekeeping are well known to the history of science, horticulture, and botany. Their attempts to modernize organic timekeeping developed in creative tension with regularized clock and calendar time, and in conversation with the emerging natural sciences. John Evelyn (1620-1706), patriarch of the British horticultural press, was a fellow of the Royal Society in company with his contemporaries, Isaac Newton and John Ray. Stephen Switzer (1682-1745) was an early adopter of Alexander Pope's and Joseph Addison's arguments in favor of a more naturalistic style of gardening. He applied these critiques most famously in his designs for Blenheim Palace. Phillip Miller (1691-1771), also a fellow of the

Royal Society, was chief gardener at the Chelsea Physic Garden and a noted opponent (though ultimate convert) to the Linneaen botanical system. John Abercrombie (1726-1806) was one of the most prolific and respected British horticultural authors of his period. He was considered, along with Miller, the authority on kitchen gardening on both sides of the Atlantic through the 1820s. Finally, Philadelphia nurseryman Bernard M'Mahon (~1775-1816) wrote the first national gardening book for the United States, and was charged with acclimating half of the seeds collected by Lewis and Clark's expedition.[2]

In the pages of their garden almanacs, dictionaries, calendars, and encyclopedias, each of these scientifically minded, practical gardeners wrote against mechanical and regularized time, instead proposing different methods to find a more accurate and portable organic timekeeper. The ideas they proposed, and the solutions they found, did not consciously aim for something called modern time. However, their proposals did emphasize the need for portability, universal application, mobility, and standardization in timekeeping technology—all features associated with modern timekeeping. And, curiously, they argued that modern organic time could be found through a technology that has rarely, if ever, featured in a history of timekeeping: a melon seedling grown in winter in a box of dung, known as an early melon.

Each of these authors faced a common, fundamental dilemma: how to teach readers to perceive organic time in the pages of a book alone. Each sought tools to fit their advice to the

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[2] For more on these authors: Margaret Willes, *The Gardens of the British Working Class* (New Haven: Yale University Press, 2014); Blanche Henrey, *British Botanical and Horticultural Literature before 1800; Compiling a History and Bibliography of Botanical and Horticultural Books Printed in England, Scotland, and Ireland from the Earliest Times until 1800* (London: Oxford University Press, 1975); Andrea Wulf, *The Brother Gardeners: A Generation of Gentlemen Naturalists and the Birth of an Obsession* (New York: Vintage, 2008); Richard Drayton, *Nature's Government: Science, Imperial Britain, and the "Improvement" of the World* (New Haven: Yale University Press, 2000); U. P. Hedrick, *History of Horticulture in America to 1860: With an Addendum of Books Published from 1861-1920* (Timber Press, 1988); Sara Gronim, *Everyday Nature: Knowledge of the Natural World in Colonial New York* (New Jersey: Rutgers University Press, 2009); James E. McWilliams, "'To Forward Well-Flavored Productions': The Kitchen Garden in Early New England," *The New England Quarterly* 77, no. 1 (March 2004), 25-50.

relative forwardness of the season and the particulars of local conditions. In this context, the difficult art of growing melons out of season become a widely used method for testing and calibrating horticultural advice. Several stages in the practice of growing early melons can be seen in an illustration from Richard Bradley's *New Improvements of Planting and Gardening* (1739) (see figure 1). In this image, several gardeners at work in a "melonrie" on a large estate. In the center of the foreground, a row of melons or cucumbers grows under bell-glasses, partially exposed to the elements but still protected from the cold and wind. Just to the left the next crop of melons or cucumbers has sprouted in a hot-bed warmed from below by rotting manure and insulated from changeable spring weather by glass-lidded wooden boxes.

From the earliest days of North American colonization, until the first decade of the nineteenth century, English-speaking American gardeners relied on garden books published in the British Isles and calibrated specifically for British climatic conditions. American publishers began producing garden books written for a national audience in 1806, extending the British horticultural debate about timekeeping. Importantly, a melon grown in winter, which in Britain was already a tool to calibrate garden book advice to local conditions, gained new and surprising meaning in the United States. American books promoted the early melon as a tool capable of revealing, standardizing, and teaching organic time. The melon would teach a gardener to perceive the unfolding of organic time. Together, these two stories of books and melons bring environmental history and temporal history into closer conversation. In the process, they show practical gardeners in the long-nineteenth century searching for more supple and subtle ways of reading time than those typically investigated within a clock-centric history of time.

Horticulture: A Place-bound Art

In 1760, eight years after he began recording the progress of his garden in a book, a middle-aged parson and avid naturalist in rural England named Gilbert White introduced a new type of melon into his garden.[3] White would go on to publish *The Natural History and Antiquities of Selborne* in 1789 and become one of the intellectual founders of the field of ecology, however in the summer of 1760, judging by the entries in his *Garden Kalendar*, White's intellectual energies were focused primarily on growing melons.

Melons are not native to England and gardeners like White pursued not only the sweetest fruit, but also types that might more reliably produce in a cooler English climate. In 1760 White's *Garden Kalendar* records that he had purchased eighty Armenian melon seeds from Phillip Miller, chief gardener of London's Chelsea Physic Garden.[4] After a spring of strong sunshine that threatened to scald the melons, White traveled to Chelsea to observe how Miller cultivated the Armenian melons.[5] Unfortunately, despite careful observation and assiduous attention, success eluded White. "On my return … I found my Cantaloupes in very bad plight indeed," White wrote, "one of the Armenians, the day after I came home, withered away, tho perfectly sound; & dyed as if eaten off at the root; tho up on search no grub could be found in the mould."[6] By the end of the season, he curtly noted, "All the Cantaloupes cut. Not one in perfection."[7] The hoped-for acclimation of the Armenian melon seeds had failed along with much of the rest of White's melon crop, but it was not clear whether the trouble was with the

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[3] Gilbert White, *Garden Kalendar, 1751-1771*. Reproduced in facsimile from the manuscript in the British Library. Introduction and notes by John Clegg (Yorkshire: The Scholar Press, 1875).

[4] Please note that White's entries follow both old style and new style dating. For simplicity, I have modified the dates to the new style. White, "February 17, 1760," *Kalendar,* 76.

[5] White, "June 23, 1760," *Kalendar,* 91

[6] *Ibid.*.

[7] White, "August 15, 1760," *Kalendar,* 95.

imported seeds, Miller's instructions, the timing of White's activities in the garden, the season, or some combination of all four. It was a puzzle that White spent the next twelve years of his *Kalendar* resolving.

Gardening is an art that demands its practitioners be attentive to time and place. A gardener must know when to plant, when to harvest, when to prune. Some plants grow quickly, like lettuce, others slowly, like an apple tree. An eighteenth century gardener needed to perceive all these patterns, coordinate them, and through manual labor produce a space recognizable as a garden landscape. As plants grew and died, as weather and seasons changed, as labor-time grew and shrunk, the space designated as a garden was hardly the same constellation of plants or phenomena one day to the next. And while the gardener coordinated growth cycles in time, he also considered the space of the garden, as its productive territory expanded and contracted in each season or with intercropping and succession planting.

Good gardening is also a deeply place-bound art, highly contingent on unique local conditions. British horticultural guidebooks written in the long eighteenth century, however, travelled considerable distances and were used in a wide variety of climates and conditions.[8] Imagined as accessible and portable guides written for men of leisure as well as professional gardeners and middleclass amateurs, these encyclopedias, almanacs, and calendars circulated around the Atlantic World attempting to teach gardeners in disparate regions how to interpret and transform their local environments.[9] These circulating books made the already complex

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[8] U.P. Hedrick argues "colonial gardeners had to rely almost wholly on English works." Hedrick, *History of Horticulture,* 467. Also, MacWilliams, "'To Forward Well-Flavored Productions'," 25- 50, 30. On the mobility of seeds and horticultural books: Andrea Wulf, *The Brother Gardeners*; Richard Drayton, *Nature's Government;* U. P. Hedrick, *History of Horticulture in America to 1860*; Sarah Gronim, *Everyday Nature;* Philip J. Pauly, *Fruits and Plains, The Horticultural Transformation of America* (Cambridge: Harvard University Press, 2008).

[9] The audience for these books was broad, for readership and circulation see: Willes, *The Gardens of the British Working Class,* 81.

relationship between the gardener, his place, and time fraught. George Washington, for instance, consulted the 1731 edition of Philip Miller's English garden dictionary every morning before surveying his estate in Virginia.[10]

Books not only crossed the seas; seeds did as well. Phillip Miller, for instance, stocked his famous London garden with seeds shipped from the American colonies and beyond.[11] And to complete the circuit, while seeds and books travelled, so too did professional gardeners.[12] Gardeners like Miller travelled regionally from job to job, between gardens and nurseries for better training, and between smaller estates and larger ones for better prospects. These books not only travelled widely, but they were widely read. Remembering that each of these authors wrote multiple books—calendars, dictionaries, and encyclopedias— it is possible to compile a sense of their reach through its sheer volume. Philip Miller's *Gardener's Dictionary,* for example, went through eight editions in his lifetime alone; John Abercromie's *Every Man His Own Gardener* saw twelve editions before his death and was in constant publication until the end of the nineteenth century. Even less well-known authors like Richard Bradley published six editions of his *New Improvements* during his lifetime. Bernard M'Mahon died shortly after his *Calendar* was published, but over the next forty years his sons published fifteen editions of their father's work.

Throughout the long-eighteenth century, the wide circulation of these books—and the resulting errors of the gardening advice they contained—encouraged horticultural authors to question how best to represent space and time on the pages of a book and to question what the

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10 Andrea Wulf, *Founding Gardeners: The Revolutionary Generation, Nature, and the Shaping of the American Nation* (New York: Vintage, 2012), 23-34.

11 Wulf, *Brother Gardeners,* 34-47.

12 Willes, *The Gardens of the British Working Class,* 87.

most portable, most universal, and most accessible form of timekeeping might be. Likewise, it influenced amateur gardeners like Gilbert White to create records of their own to experiment with calibrating garden book advice to the particulars of their place and season. By attempting to systematize and render more portable gardening advice, authors were experimenting with rationalizing and standardizing perceptions of time and place. Assiduously following that advice over several years, gardeners like White trained in a new way of perceiving organic time—a method for telling time in nature which was standardized across a transatlantic readership and yet still place-specific.

The British Search For An Organic Timekeeper

Gilbert White's early melons were most threatened by unseasonable weather. White could anticipate, to some degree, what might be needed to acclimate an Armenian melon to a Hampshire kitchen garden under normal circumstances, but he frequently expressed frustration over days that refused to comply with expected weather for the season. What was White to do for his cucumbers on a day in February when the weather was "Perfect summer: the air full of Gnats,… as in a fine day in August"?[13] Equally perplexing was the day in March 1758, which White described as "Great snow all the day, & most part of the night; which went off the next day in a stinking, wet fog…. more like Jan. than March."[14] The most confusing season in White's *Kalendar* may have been the winter of 1755. "A terrible winter for Earthquakes, Innundations, Tempests, & continual Rains," White lamented, "no frost worth mentioning except on the 11th; &

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13 White, "February 12, 1859," *Kalendar,* 75.

14 White, "March 21, 1858," *Kalendar*, 58.

the 12th of November."[15] These were days out of place: an August day in February, a January week in March, spring in November.

Garden calendars and other guidebooks assumed a certain level of stability in seasons. The precision of garden book advice, whether calendrical or otherwise, could be called into question by unseasonable weather. Phillip Miller's instructions for growing early melons

Figure 1: the frontispiece in Philip Miller's Gardener's Kalendar *promises to reveal the clock of nature, with angels, cherubs, and gardeners all at work in the garden. Here the gardeners are in the background. Their placement implies they are helpmeets in creating an Edenic landscape, but not yet fully literate in the arcadian clock looming in the clouds over their heads. It is the angels in the foreground that seem to order and direct the landscape. The image also advertises that Miller's book will offer lessons in growing fragile plants under bell-glasses (foreground) and in hot-houses (behind the angels) – two methods 18th century gardeners used to render space and time more plastic.*

Philip Miller, The Gardener's Kalendar (London, 1769), frontispiece

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[15] White, undated, *Kalendar,* 26.

assumed that February was cool, that by March the weather would be growing more mild and sunny, and that the winter would include more than two hard frosts. When the season was either ahead of or behind expectations, how was his advice to be followed? Inversely, how could a garden book author like Miller write a guidebook capable of anticipating all the changing conditions a gardener like White might experience? And if Miller tried to write instructions for all of those myriad conditions, what format would those instructions take—an encyclopedia, an almanac, a calendar? That Miller wrote garden books in each of those genres suggest his dissatisfaction with any of the available formats for a universal horticultural guidebook.

British horticultural literature expanded dramatically in the mid seventeenth century and by the end of the eighteenth century had developed a cumulative commentary on the landscapes and timescapes of gardening. Though they increasingly agreed on the purpose of an improved organic timekeeper for horticulture, by the end of the eighteenth century horticultural authors grew frustrated in their attempts to realize that timekeeper in the pages of a book. By 1824, when J.C. Loudon published his famous encyclopedia, British garden book authors had concluded it was not possible. This debate was most clearly visible in authors' commentary about the relative merits of different formats or genres of advice manuals.[16]

Horticultural calendars, almanacs, and dictionaries, as well as their methods for representing organic time, developed in the shadow of the clockwork universe, Isaac Newton's mathematical publications, and John Ray's natural theology. The concept of a clockwork universe grew out of medieval physics, and developed around the idea that the universe was the expression of divine will, rationally organized and mathematically derivable. In the seventeenth

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[16] Lloyd Pratt usefully examines the formal structure of literature as a temporal tool: Lloyd Pratt, *Archives of America Time: Literature and Modernity in the Nineteenth Century* (Philadelphia: University of Pennsylvania Press, 2010).

century, supporters of the New Science, including Isaac Newton, described the universe as a machine composed of inert matter set in motion by a divine hand.[17] Meanwhile, in cultivating the concept of natural theology, John Ray began to argue that "just as the watch implied the watchmaker," in the clockwork universe the complexity of nature necessitated a divine creator.[18] In combination, these ideas shaped many assumptions about how a gardener should be instructed, what time was, and what an improved horticultural timekeeper should reveal. Yet, the regularity of Newton's clockwork universe depended on absolute time and the reversibility of time—two features of a new physics possible on paper but not practicable in the everyday world of a kitchen garden. In the preface to the first edition of his *Mathematical Principles of Natural Philosophy*, Newton points to a disjuncture.. **"**To the practical mechanics all the manual arts belong, from which mechanics took its name," Newton explains, "But as artificers do not work with perfect accuracy, … mechanics is so distinguished from geometry that what is perfectly accurate is called geometry; what is less so, is called mechanical."[19] In the seventeenth and eighteenth centuries, mechanical clocks were, demonstrably and by definition, inaccurate and imperfect. But an art like horticulture offered the opportunity to encounter a more accurate and more perfect timekeeper through nature, one created and calibrated by God's own hand.

When John Evelyn composed his major treatises on horticulture and silviculture in the 1660s he struggled with that dichotomy: the perfected art and the imperfect artist. On the one hand, natural theology and the new physics indicated that there was a discernable, stable, and

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17 Jessica Riskin, *The Restless Clock: A History of the Centuries-Long Argument about what Makes Living Things Tick* (Chicago: The University of Chicago Press, 2016), 3.

18 Max Oelschlaeger, *The Idea of Wilderness, From Prehistory to the Age of Ecology* (New Haven: Yale University Press, 1991), 102. For more on Ray see Riskin, *The Restless Clock,* 81.

19 Isaac Newton, *Sir Isaac Newton's Mathematical Principles of Natural Philosophy and His System of the World; Translated into English by Andrew Mottee in 1729.* Trans. Florian Cajori (Berkeley: University of California Press, 1934), xvii.

rational order in nature, one that rational man could access through empirical study. On the other, empirical study in the garden suggested that the clock was an imperfect metaphor of natural time, that the best measures of time in nature resisted regularity, and that the place-bound art of gardening could not be reduced to any universally applicable equation. Contemplating this disjuncture between belief and experience, Evelyn and his successors concluded that good instruction manuals should assist gardeners to find and forward that more perfect order.

The core of this horticultural tradition included Evelyn, publishing in the 1660s and 1690s; Stephen Switzer, writing in the early eighteenth century; Philip Miller, writing in the 1720s to 1760s; John Abercrombie, writing in the late eighteenth century; and, finally, Bernard M'Mahon and Walter Nicol, writing in the United States and Scotland, respectively, in the first decades of the nineteenth century.[20] Newton argued that "the errors are not in the art, but in the artificers," and garden book authors seemed to agree.[21] By the end of the eighteenth century, though still convinced of the ultimate order of the universe, authors grew less confident in the idea that such order could be represented in the pages of a book. Rather, as the reverend James Justice explained in his garden calendar of 1771, by teaching readers how to give themselves fully over to the needs of their plants, guidebooks might "raise to us a Number of *mechanical Gardeners*."[22]

To represent time in the garden and teach readers like Gilbert White how to follow it, authors like Phillip Miller turned to three genres to organize their advice: the calendar, the encyclopedia, and the almanac. The first genre authors employed was the almanac, though it fell

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[20] For their popularity see: Henrey, *British Botanical and Horticultural Literature before 1800.*

[21] Newton, *Mathematical Principles of Natural Philosophy*, xvii.

[22] Italics original. James Justice, *The British Gardener's New Director, Chiefly Adapted to the Climate of the Northern Countries,* (1771), iv, v.

out of popularity through the eighteenth century. The calendar was an equally ancient format for garden advice, but English notions of the calendar were changing in the eighteenth century, and the purpose and contents of English garden calendars changed over the course of that century as well. Finally, after the mid-eighteenth century, garden book authors turned with great frequency to the classic Enlightenment formats of the dictionary or encyclopedia. Some authors, like Miller, wrote in all three genres and liberally critiqued each.

Regardless of genre, these books illustrate a broad change in the way British horticultural authors between 1660 and 1820 approached the problem of representing organic time in a book. Though their subject was placebound and particular, they responded to the mobility of their instruction manuals by attempting to render their advice more universal and more standardized. The debate emerged in an early eighteenth century push for some common standardizing mechanism within the text, something that could fix in place representations of time and space. In the intervening decades, British authors experimented with versions of these three formats and instructions, attempting to resolve the problem of portability while critiquing fellow authors' methods. Frustrated, horticultural authors grew increasingly dissatisfied with the abilities of any genre—whether almanac, calendar, or encyclopedia—to teach readers to find organic time in their gardens. By the end of the century, seeking ever more universal applicability, the authors of garden books began to look beyond format and towards practice for methods to stabilize and standardize representations of time contained within their books.

Competing Timekeepers

"The almanac was everything," historian Molly McCarthy argues in her history of the daily planner, "it told [men] the time, calculated the interest on his loans, directed him to the nearest inns, and entertained him with poetry."[23] As guidebooks, British gardening almanacs were often little more than twelve one-page tables listing activities for each month. Almanacs organized and interpreted perceptions of the natural world according to a common set of contrasts, attempting to help readers choose agricultural activities by integrating bodily experience, astrology, theology, and the natural world.[24] To ordinary readers of the era, "the human body and the surrounding natural world were constituted similarly," historian Sara Gronim explains, "and the balance and flow of heat and cold, dryness and moisture were the sources of change in body and world alike."[25] This deeper level of instruction came from an image included in the almanac called the "man of signs," which showed the human body and certain bodily conditions correlated with the signs of the zodiac. In combination with almanac pages for each month constructed using latitude dependent astronomical sightings, the man of signs offered a method for interpreting and even predicting environmental conditions through bodily experience, and vice versa.

Garden almanacs coordinated myriad schedules on each page: civil and commercial schedules, religious calendars, meteorological information, navigation charts, astronomical calendars, solar and lunar schedules, and more. The *English Lady's Almanack* (1706), for instance, offered advice on the raising of children, recipes for broth, and explanations for an eclipse, in addition to suggestions on what plants would be in season.[26] Because they coordinated so many timekeeping regimes and stabilized that matrix against astronomical sightings, almanacs

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23 Molly McCarthy, *The Accidental Diarist: A History of the Daily Planner in America* (Chicago: University of Chicago Press, 2013), 14.

24 Gronim, *Everyday Nature,* 39.

25 *Ibid.*.

26 *English Lady's Almanack* (1706) in *Women Advising Women.* (Marlborough, Wiltshire, England: Adam Matthew Publications, 1992), pt. 2, reel 7-9, 15.

lost reliability outside of the cultural and geographical settings in which they were produced.[27] If the reader knew how to garden already and lived within the specified zone of the almanac, it could be a useful guide suggesting when to plant, hire labor, and harvest. It could even instruct you on how to reset your clock, get married, or pay your taxes. But if you were too far north or south of the specified range, or didn't know much about the practices briefly mentioned in the text, the instructions became threadbare. Monthly instructions offered in complicated tables could be time-consuming to decode.[28] Planting advice, intended for a different latitude, diverged from the observed conditions.[29] Almanacs tied themselves to place because they were portable along lines of latitude, but not longitude, and they calibrated time by showing the interrelationship between different social methods of telling time. Almanacs were most useful within of the social contexts where they were created, as guides to local place and time.

In contrast, British gardening calendars did not seek to coordinate multiple time regimes as almanacs attempted to do. Instead, organized around the twelve months of a year, they offered more detailed garden-specific lists each month divided by the section of the garden. They also began to offer more comprehensive advice. Doing so, British garden calendars sought to depict the whole art of horticulture, as well as the whole garden, in time and space.

Evelyn's *Kalendar* was appended to his larger work on silviculture, but as the broader cultural definition of a calendar began to settle in England, the standalone calendar became a

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[27] Bernard Capp, *English Almanacs 1500-1800; Astrology and the Popular Press* (Ithaca: Cornell University Press, 1979).

[28] McCarthy, *The Accidental Diarist,* 23.

[29] Careful authors like Charles Marshall specified the useful range of their texts: "The *time* mentioned in this *calendar* is, that which the authors judges will be found most *generally* right in the midland counties, as the extremes of *north* and *south* necessarily make a difference in this business." Charles Marshall, *An Introduction to the Knowledge and Practice of Gardening, First American from the Second London Edition, Considerably Enlarged and Improved to which is added An Essay on Quick-Lime as a Cement and as a Manure.* (1799), 101.

more popular format for garden book authors.[30] Eighteenth century garden calendars, written by men like Stephen Switzer, Philip Miller, James Justice, and John Abercrombie, organized the work of the garden by month, dividing instructions to the cultivation of each plant across the growing season. Many of these works claimed lengthy personal experience as the basis of their authority. Phillip Miller, for example, insisted, "the calculations here made, are not taken from any one particular season, but by comparing a diary which the author has kept many years; and from a medium of Several years observation, the whole has been compiled."[31] Within each month, tasks appeared in the order in which they needed to be addressed, but often special sections on particularly popular topics appeared as appendices. For instance, Evelyn and Switzer both dedicated special sections to growing early melons and cucumbers.

By the 1720s, garden calendar authors offered some of the strongest rebuttals to almanacs, focusing on two major critiques. First, they took issue with prescriptions to plant according to the astrological signs, arguing that this approach to time was too inflexible. "We are yet far from imposing […] those nice and hypercritical Punctilios," Evelyn explained in his critique of almanacs, "which some Astrologers, and such as pursue their Rules, seem to oblige our Gardners to."[32] He argued that almanac writers gave the impression that gardening must occur according to fixed and inflexible timelines, "as if, forsooth, all were lost, and our Pains to no purpose, unless the Sowing and the Planting, the Cutting and the Pruning, were perform'd in such and such an exact Minute of the Moon."[33]

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30 G. L. Whitrow, *Time in History: Views of Time from Prehistory to the Present Day* (Oxford: Oxford University Press, 1988), 110.

31 Miller, *The Gardener's Kalendar,* (1769), xii.

32 Evelyn, *Kalendarium Hortense*, (1699) 5.

33 *Ibid.,* 5.

The next generation of garden book authors, such as Philip Miller, emphasized the physical portability of their own work in contrast to both almanacs and dictionaries. They praised calendars for being small enough to slip into a pocket, or compendious enough to be accurate everywhere.[34] Later still, in 1799, Samuel Etheridge reprinted Charles Marshall's *An Introduction to the Knowledge and Practice of Gardening* in the United States with a preface that boasted that the book was even smaller than the first printing and therefore more portable. This economy of page space, Marshall specified, was accomplished through the format of a calendar.[35] In these cases, portability aspired to universality.

John Abercrombie described the type of time represented by garden calendars as a "medium period, calculated from the careful observation of different seasons."[36] Though Abercrombie made his name publishing a highly reputed gardening calendar in the 1760s, later he began to write against the format. In this, Abercrombie reflected the popularity and confidence of elite Enlightenment rationalists, but he also reflected the serious concerns about the particularities of good gardening that occupied the minds of his non-elite readers. Abercrombie warned that a calendrical format that only depicted medium-period activities and elided long-term practices and instantaneous action, was not sufficient for good gardening—it misled amateurs into thinking activities of the garden were too regularized. Additionally, the "forwardness, or lateness, of the seasons," Abercrombie observed, could not be accounted for in garden calendars. As a consequence, "this fluctuation of our climate, subverting the stationary precision of the *Calendar*, may carry the proper time in one year as far backward as it may in

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34 Miller, *The Gardeners Kalendar (*1751), vi

35 Marshall, "Preface, "*An Introduction to the Knowledge and Practice of Gardening* (1799).

36 John Ambercrombie, *The Practical Gardener, or Improved System of Modern Horticulture.* 2nd edition. (1817) DO Rare Books I-2-4 ABER.

another forward … a person unacquainted with the principle upon which the operation is founded, will either act wrong in following the directions, or, if aware of their UNSEASONABLE character, be uncertain when to proceed."[37] The calendar, its detractors argued, distorted and regularized the many rhythms of organic time in order to represent the whole landscape of a garden as a unit.

Authors like Abercrombie turned to encyclopedias as another possible way to represent organic time. These books were substantially larger in size and more expensive than most almanacs and calendars. They organized information alphabetically and dedicated as much page space as needed to the whole growing cycle of each plant. Separating individual plants and facets of the garden allowed authors to give detailed guidance on fast-growing or slower-growing plants whose growth patterns were distorted by the more regularized calendrical format. Likewise, some tasks, like pruning, should not occur every year, though an annual calendar would be remiss if it did not include instructions on how to prune. Moreover, some spaces in the garden, like a hot house, were understood by eighteenth-century gardeners as technologies that bent time and space in ways that were intended to deliberately manipulate the progression of the calendar year or effects of climate.

"In this case," explained Abercrombie, "the culture for the subsequent years is apt to be lost sight of in the *Monthly Method*, all the parts of which make up but one year…."[38] In short, many of the temporal patterns of gardening did not fit into the annual format of a calendar or almanac. The dictionary or encyclopedia did not distort time to fit the format of a year and so could also teach readers how to follow more subtle time scales. However, in order to more

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37 Abercrombie, *The Practical Gardener*, viii

38 *Ibid.,* viii-ix.

accurately show scales of time, dictionaries pulled the landscape of the garden apart, addressing each plant individually rather than in context.

If neither the calendar nor the encyclopedia were an ideal format for garden work, and if the almanac had only limited portability, the mechanical clock, the emerging tool of industry, was little better. We have already encountered garden book authors writing against presenting organic time either as fixed schedules (like an almanac) or as too regularized or uniform (like a calendar). In addition to these concerns, garden book authors also worried that gardeners needed to think about time in ways that were incommensurate with the units of a clock because gardeners needed to be attentive to both very small time periods, like minutes, and very long time frames like decades—and they needed to see those two timescales as interconnected. This bifocal sense of time, where the very small was juxtaposed against the very large, appears early in eighteenth century horticultural literature. For example, "a Gard'ner is not only to [w]reck upon the loss of bare twelve hours," Evelyn reminded his readers, "but of an whole Year, unless he perform what is at the present requisite in its due Period."[39] Miller echoed this sentiment in his advice on tree planting, contrasting the labor of several hours against the results in thirty years.[40] The vehemence of this caution did not dwindle as clocks became more reliable or common. In 1812, Scottish horticultural author Walter Nicol reminded "the young gardener" that "his situation is different from that [of] the mechanic, the operations of whose business revolve daily or weekly, who have frequent opportunities to correct mistakes."[41] A gardener, Nicol explained, must think about time in far more vigilant terms. In the garden, mistakes could not be corrected in the next minute or hour, "the operations in gardening revolve more seldom; many of them but

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[39] Evelyn, *Kalendarium Hortense* (1683), 11.

[40] Miller quoted in Marshall, *An Introduction to the Knowledge and Practice of Gardening,* 126.

[41] Walter Nicol, *The Gardener's Kalendar* (1812), 4.

once a-year."[42] A gardener needed to be highly conscious of time, but a mechanical clock was not the right instrument to guide his labor.

Despite continuing disagreements over format, the popularity of garden guides only grew during the eighteenth century as gardening became a mark of refinement, a middle class pastime, and an avenue of social mobility. This popularity had a material impact on the garden book trade since, as Richard Weston argued in his *Gardener's Pocket-Calendar* (1779), increased demand differentiated the genres still further: "a gardener's calendar is become almost as necessary, in every family, as an almanac."[43] In the starkest terms, the difference between genres was this: some formats for writing gardening books deconstructed space in a garden in order to more accurately represent time, while some distorted time in order to more accurately represent the whole space of a garden. Others gave a generally good account of both space and time for knowledgeable readers but could not travel very far north or south of their specified ranges. None were fully portable. If these methods were all imperfect in one way or another, where else could authors turn?

Finding Time in a Garden Landscape: Early Melons

These limitations posed practical, not just theoretical, problems for authors like Phillip Miller. Many authors—Evelyn being a notable exception—were working men who gained fame first as gardeners on famous estates, then as seedsmen or nurserymen writing in their spare time, and only later as authors. These men developed the genre in part as a way to avoid having to rewrite instructions for every seed packet sent from their nurseries.[44] Likewise, running

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[42] Nicol, *The Gardener's Kalendar,* 4.

[43] Weston, *Gardener's Pocket-Calendar,* 469.

[44] Henrey, *British Botanical and Horticultural Literature,* 396-409.

comments about the limitations of each genre likely grew out of a practical need to choose one format or another for their guidebooks and explain their choice to readers. Despite waning assurance that some book format might be perfected, these authors continued to stress the Arcadian ideal that there was still a higher order in nature, that a universal guide to organic time could be found and followed, and that doing so would allow gardeners to harmonize their labor with the rhythms of the natural world.

To follow organic time, gardeners like Gilbert White needed to learn how to read an organic timekeeper and garden book authors like Phillip Miller needed to figure out how to make that timekeeper visible and legible. By the final decades of the eighteenth century, British horticultural authors had sketched a general set of expectations for what this most accurate of organic timekeepers should be. It should be universally portable and generalizable (precluding almanacs), it should reflect multiple growth cycles and time-scales (precluding the calendar and the clock), and it should represent how all the parts of a garden operated together (precluding an encyclopedia).

John Claudius Loudon's *Encyclopedia Of Gardening* (1824) might be considered the apogee of the debate over genre. Louden's encyclopedia was "systematically instead of alphabetically arranged" and included several subject indexes, multiple calendars for all the parts of a garden, instructions for calculating the "*almanac time* in this kalendar," and essays on topics of particular interest.[45] Aspiring to full comprehensiveness, Louden's encyclopedia was enormous and expensive: one of its two volumes held over a thousand pages alone. Figure 2 illustrates the multiple genres of timekeeping technologies Louden tried to incorporate in his

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45 J.C. Louden, *An Encyclopedia of Gardening; Comprising the Theory and Practice of Horticulture, Floriculture, Arboriculture, and Landscape-Gardening, Including All the Latest Improvements; A General History of Gardening in All Countries, and a Statistical View of Its Present State, With Suggestions for Its Future Progress in the British Isles.* 2nd edition (1824), 1147.

Encyclopedia. In the table at top, for instance, Louden demonstrates what a hypothetical "Weather book" entry might look like, listing temperatures by the thermometer, barometric readings, and wind speeds, leaving space for phenological observations about the flowering or leafing of trees. The last column, however, connects the methods of temporal and environmental perception used in almanacs, encouraging gardeners to correlate bodily sensation ("dull and sleepy" reads one) with the conditions of the garden. Annexing another format for temporal perception, in the next paragraph Louden then directs his readers to Gilbert White's *Naturalist's Kalendar* as another model for observing the natural world supported by his instructions. Finally, in the graph at the bottom, Louden shows how readers should measure the interior temperatures of the hot-bed, the hot-house, and the green-house, contextually implying that such close observation will likewise reveal larger patterns in the natural world. In August, the hot-bed (third line from the top) would not have had any melons, but Louden suggests that a graph like this could be used both to learn to anticipate changes and patterns in temperature, and to measure success across several years.

Despite all his efforts to incorporate methods from all horticultural genres, Louden doubted the utility of any guidebook, however compendious. "Even if such books are made as perfect as their nature admits of," he lamented, "still they are only calculated to aid the memory."[46] Louden insisted, instead, that "the natural and therefore the best indications for the operations of sowing and reaping, […] are given by the plants themselves, or by the progress of

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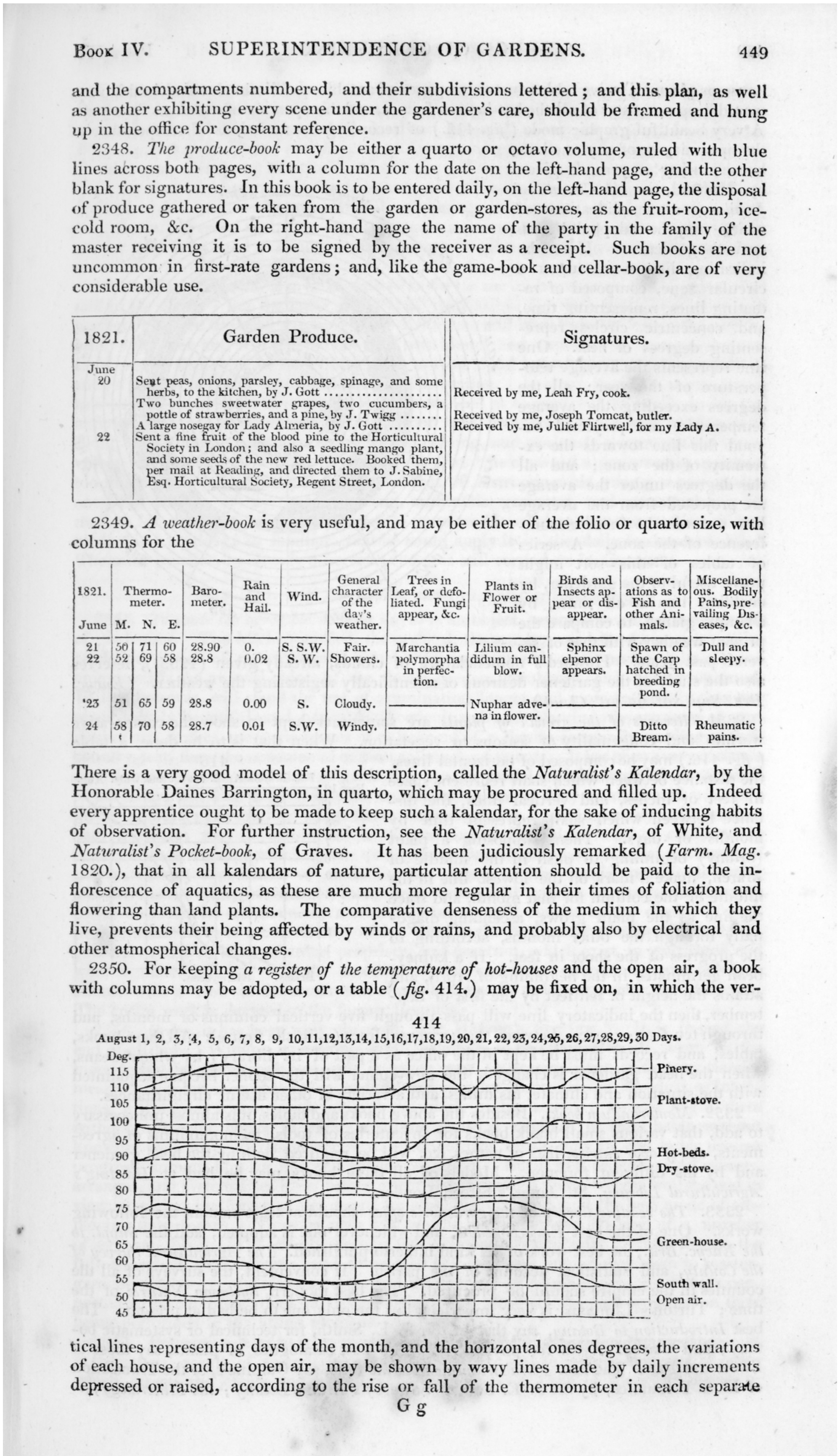
[46] Louden, *An Encyclopedia of Gardening*, 452.



and the compartments numbered, and their subdivisions lettered; and this plan, as well as another exhibiting every scene under the gardener's care, should be framed and hung up in the office for constant reference.

2348. *The produce-book* may be either a quarto or octavo volume, ruled with blue lines across both pages, with a column for the date on the left-hand page, and the other blank for signatures. In this book is to be entered daily, on the left-hand page, the disposal of produce gathered or taken from the garden or garden-stores, as the fruit-room, ice-cold room, &c. On the right-hand page the name of the party in the family of the master receiving it is to be signed by the receiver as a receipt. Such books are not uncommon in first-rate gardens; and, like the game-book and cellar-book, are of very considerable use.

1821.	Garden Produce.	Signatures.
June 20	Sent peas, onions, parsley, cabbage, spinage, and some herbs, to the kitchen, by J. Gott	Received by me, Leah Fry, cook.
	Two bunches sweetwater grapes, two cucumbers, a pottle of strawberries, and a pine, by J. Twigg	Received by me, Joseph Tomcat, butler.
	A large nosegay for Lady Almeria, by J. Gott	Received by me, Juliet Flirtwell, for my Lady A.
22	Sent a fine fruit of the blood pine to the Horticultural Society in London; and also a seedling mango plant, and some seeds of the new red lettuce. Booked them, per mail at Reading, and directed them to J. Sabine, Esq. Horticultural Society, Regent Street, London.	

2349. *A weather-book* is very useful, and may be either of the folio or quarto size, with columns for the

1821. June	Thermometer. M.	 N.	 E.	Barometer.	Rain and Hail.	Wind.	General character of the day's weather.	Trees in Leaf, or defoliated. Fungi appear, &c.	Plants in Flower or Fruit.	Birds and Insects appear or disappear.	Observations as to Fish and other Animals.	Miscellaneous. Bodily Pains, prevailing Diseases, &c.
21	50	71	60	28.90	0.	S. S.W.	Fair.	Marchantia polymorpha in perfection.	Lilium candidum in full blow.	Sphinx elpenor appears.	Spawn of the Carp hatched in breeding pond.	Dull and sleepy.
22	52	69	58	28.8	0.02	S. W.	Showers.					
23	51	65	59	28.8	0.00	S.	Cloudy.	————	Nuphar advena in flower.	————	————	————
24	58	70	58	28.7	0.01	S.W.	Windy.	————		————	Ditto Bream.	Rheumatic pains.

There is a very good model of this description, called the *Naturalist's Kalendar*, by the Honorable Daines Barrington, in quarto, which may be procured and filled up. Indeed every apprentice ought to be made to keep such a kalendar, for the sake of inducing habits of observation. For further instruction, see the *Naturalist's Kalendar*, of White, and *Naturalist's Pocket-book*, of Graves. It has been judiciously remarked (*Farm. Mag.* 1820.), that in all kalendars of nature, particular attention should be paid to the inflorescence of aquatics, as these are much more regular in their times of foliation and flowering than land plants. The comparative denseness of the medium in which they live, prevents their being affected by winds or rains, and probably also by electrical and other atmospherical changes.

2350. For keeping *a register of the temperature of hot-houses* and the open air, a book with columns may be adopted, or a table (*fig.* 414.) may be fixed on, in which the vertical lines representing days of the month, and the horizontal ones degrees, the variations of each house, and the open air, may be shown by wavy lines made by daily increments depressed or raised, according to the rise or fall of the thermometer in each separate

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Figure 2: This page from Louden's Encyclopedia of Gardening *brings many of the themes in this chapter together in one place. In the middle of the page Louden demonstrates what a "weather book" entry might look like, listing temperatures by the thermometer, barometric readings, and wind speeds, but also leaving space for phenological observations about flowering or leafing of trees, and even bodily sensation ("dull and sleepy" reads one entry). For the model on which this weather book was based, Louden directs readers to none other than Gilbert White's* Naturalist Kalendar. *In the figure at the bottom, Louden shows how to graph the interior temperatures of the various time-and-space bending (season-extending, ecosystem simulating etc.) technologies of the garden: the hot-bed, the hot-house, green-house, and so forth. In august, the hot-bed (third line from the top) would not have had any melons, but Louden suggests that a graph like this could be used both to learn to anticipate changes and patterns in temperature, and to measure success across several years.*

Louden, *An Encyclopedia of Gardening*, 449.

the season as indicated by other plants."[47] Since natural theology, the new calculus, and the Arcadian ideal all agreed that ultimate order could be found in nature, then the perfect horticultural guide was the landscape itself. What was needed was not a guide*book*, but a universal *guide* to render any local landscape a gardener might encounter temporally legible. What was needed was a method to reveal an Arcadian clock.

After twenty winters of growing melons in boxes heated by dung and covered by glass, Gilbert White's *Kalendar* suggests that success could not be counted in braces of melons alone. Successful crops like that of 1759 were rare and mediocre years were more common. Even when the fruit ripened, the result was not always edible. What White gained from this practice was something more than a few bland melons. In his earliest entries, White tended simply to list types of seeds planted and jot abbreviated memos about quantities of dung for hot beds or the success of different pollinating practices. He avoided broad conjectures about why crops failed or succeeded. By the end of the *Kalendar,* however, White's entries begin to draw correlations between the success of each melon crop and the condition of the soil, weather, or pollinators. "Upon digging into the melon bed…, I found that the [hot-bed] maintained an heat equal to what is usual in a mild bed at first planting," White explained in an entry from August 1765, "from whence I conclude that the heat was too powerful this sunny scorching summer for the fruit by forcing them into ripeness before they were full fleshed: in common summers, when there is a good deal of shady wet weather no doubt the use often is of excellent service for Cantaloupes, as I have experienced."[48] Other entries use the familiar space of the melon beds as a point of departure to examine broader ecological relationships. "Since my melon frames have been taken

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47 Louden, *An Encyclopedia of Gardening, 452.*

48 White, "August 22, 1865," *Kalendar,* 194.

in, & before the rains fell […] there grew up at once a very singular appearance of the fungus kind that seems rather to be poured over the ground than to vegetate: it was soft and pappy, & about the consistence of thick milk of a very ill savor. […] I have had them on beds before the frames have been taken off; when they have crept in part up the sides of the frame. To the best of my remembrance they have never appeared on any beds that have not been covered with tan….”[49] In the final years White juxtaposes labor in his garden with the arrival of natural phenomena: “The nightingale, *mosacilla luscinia*, sings. The blackcap, *mostilla asticapilla*, sings. The redstart, *mosacilla Phanicaurus* appear. Raised, & earthed-out the large Cucumber bed to the full; & mossed it.”[50] By listing the birds first, White’s entry suggests that the earthing-out of the cucumbers might have been cued by the seasonal arrival of the birds, an attempt to begin drawing instructions for kitchen gardening from the landscape itself.

The practice of using an early melon as a timekeeping lesson began in part because, just as garden books travelled, seeds also travelled. Some imported seeds, like the melon, were so difficult to grow in England and simultaneously so popular among elites that garden guides devoted considerable page space to instructing English gardeners in their cultivation.[51] In the fifteenth century, vegetables were the food of the poor and animals, but by the seventeenth century, imported varieties and newly introduced vegetables and fruit made their way into elite cuisine, and melons became the favorite delicacy of kings. The “melonrie” became one of the most prized portions of elite as well as humble gardens.[52] Reflecting on the broad appeal of growing melons as well as the wide variety of gardens in which the fruit was grown, John Evelyn

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49 White, “September 5, 1865,” *Kalendar,* 196.

50 White, “April 10, 1867,” *Kalendar,* 217; in the original White did not italicize the latin names.

51 George W. Johnson, *A History of English Gardening, Chronological, Biographical, Literary, and Critical Tracing the Progress of the Art in this Country from the Invasion of the Romans to the Present Time* (London, 1829), 177.

52 See Willes, *The Gardens of the British Working Class,* 12, 31.

remarked, "every Gard'ner now-a-days, knows how to raise *Melons,* but very few to Govern them."[53] Anyone could grow a melon, but horticultural authors warned that growing a melon early in the season was the test of a skilled, *English* gardener.[54] Melons, and their close relatives cucumbers, will sprout and flourish only within a narrow range of warm and constant temperatures, conditions that were understandability difficult to maintain in the January cold of a kitchen garden.[55] Only someone with a deep knowledge of his local climate, seasons, and weather could successfully cultivate a fragile melon seedling through the rigors of early spring. "There is no Vegetable," Thomas Ellis explained in his 1776 garden guide, "in which the art and skill of a gardener are so much required, as in raising of early cucumbers, and on which they so much value themselves."[56]

Though an unlikely pre-occupation, English gardeners in the long-eighteenth century dedicated a great deal of time and effort to raising this finicky crop. By the 1760s it had become so popular to produce an early melon that Philip Miller complained that gardeners threw themselves too enthusiastically at the project, despite his estimation that the fruit was "fitter for the dunghill than the table…"[57] Thirty years later the fad had not let up. In 1794 James MacPhail claimed that early melons and cucumbers were ubiquitous: "not only gentlemen, but almost every tradesman who has a garden and dung, have their cucumber frame."[58] By 1829, in his

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53 Evelyn, *Kalendarium Hortense*, 5.

54 Switzer, *The Practical Kitchen Gardener* (1727), iv, v, 49-50.

55Michael D. Orzolek, Steven M. Bogash, Lynn F. Kime, and Jayson K. Harper, "Agricultural Alternatives: Cantaloupe Production" (Publication Distribution Center: The Pennsylvania State University, 2006), 2. Available online: agalternatives.aers.psu.edu.

56 Thomas Ellis, *The Gardener's Pocket-Calendar, Containing the Most Approved Methods of Cultivating the Useful and Ornamental Plants for the Kitchen-Garden, Flower-Garden, and flowering-in Shrubs; Arranged in Alphabetical Order, to Which are added, Directions of What is Necessary to be Done in Every Month of the Year* (London, 1776), 34-35; also Justice, "January," *The British Gardener's New Director*, 5.

57 Philip Miller, *The Abridgement of the Gardener's Dictionary* (1763) DO Rare Books Coll RBR A-1-6.

58 James MacPhail quoted in Henrey, *British Botanical and Horticultural Literature,* 487.

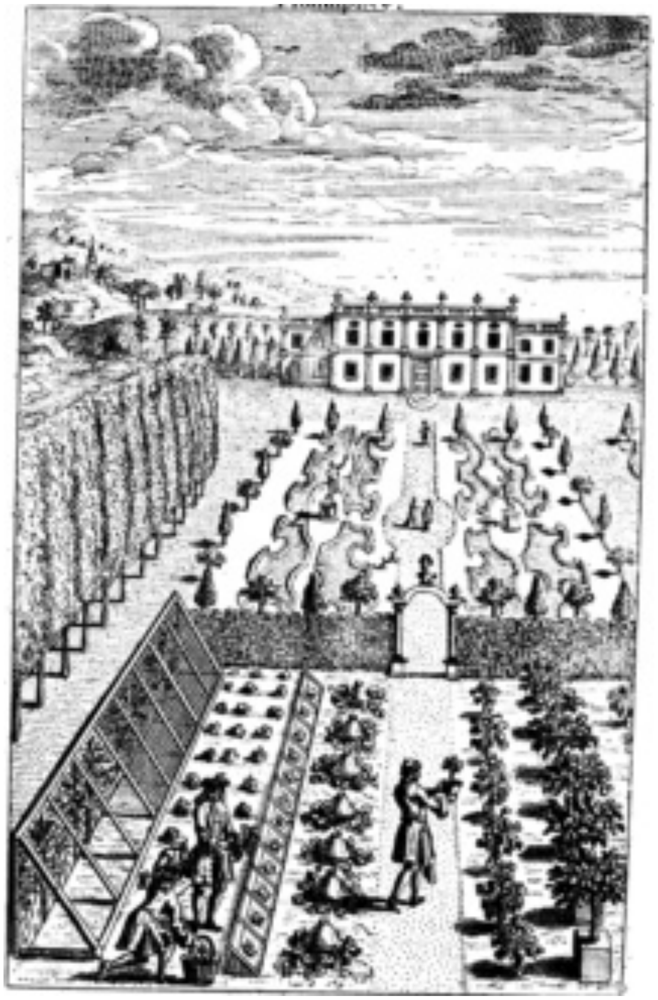

Figure 3: In this image from the Richard Bradley's New Improvements of Planting and Gardening, *several gardeners work in a "melonrie" on a large estate. In the center of the foreground, a row of melons or cucumbers grows under bell-glasses, and just to the left, a line of hot-beds incubates the next crop*.

Richard Bradley, *New Improvements of Planting and Gardening both Philosophical and Practical* (London, 1739), frontispiece.

history of English gardening, George Johnson used the earliness of the melon crop as his measure of progress over the previous century.[59]

As Gilbert White's *Kalendar* helps us understand, early-melon growing depended on a deep knowledge of place. In eighteenth century England, because they were not native to the British Isles, because they had consistent growing requirements, and because they were popular and prized by elites, the practice of growing early melons grew into a tool of calibration. With a pre-existing knowledge of place, a gardener could adapt the instructions from a garden

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[59] Johnson, *A History of English Gardening,* 177.

guidebook on growing an early melon to fit his knowledge of local conditions, and in the success of his crop he could test his skill. This message was conveyed not just in text, but also through illustrations like, for instance, the frontispiece to John Abercrombie's *Gardener's Dictionary* (1791). In this image two gardeners work in a garden, while a genteel couple strolls in the background. Evidence of assiduous activity can be seen around each gardener in the beds they are digging, the hot-bed (middle ground, left) and hot house (middle ground, right) with their lights opened to vent hot air, and the rake and watering can in the foreground. These examples of daily activity and good-order combined with images of an early melon seedlings in the hot-bed and a well-managed green-house combine to suggest to the viewer that this gardener has already mastered the fundamentals of good gardening and is attuned to an arcadian clock.

As English, Scottish, and Irish professional gardeners moved to the American colonies, and as amateur gardeners settled ever deeper into the American continent, the early melon developed further into a tool to reveal organic time. We can see this practice unfold in the pages of the first gardening guide published in the United States and intended for a national audience, Bernard M'Mahon's *American Gardener's Calendar* (1806). M'Mahon trained as a professional gardener in Ireland, and after immigrating to Philadelphia in the 1790s worked as a journalist, seedsman, and nurseryman until his death in 1816. A horticultural confidant of Thomas Jefferson, M'Mahon was widely respected as a nurseryman, and the garden guide he authored went through eleven editions before it ended its publication in 1851. The calendar M'Mahon composed offered instructions to amateur American gardeners applicable from Maine to Georgia and west to the Mississippi.[60]

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[60] Bernard M'Mahon, *American Gardener's Calendar; Adapted to the Climates and Seasons of the United States,* (Philadelphia, 1806).

Accounting for differences between England and America in soil, climate, weather, and seasons, as well as in the gardener's access to labor, finished goods, and capital, M'Mahon's instructions expressed a deep ambivalence about the portability of English garden books of all genres. "However excellent and useful these [English] works are in the regions to which they are adapted," M'Mahon argued, "they tend to mislead and disappoint the young *American* Horticulturalist…."[61] Copying large sections of John Abercrombie's English garden calendar, and yet changing key details to fit American conditions, M'Mahon translated standard English gardening practice into an American climatic, cultural, and material context. Imagining his audience as young, mobile, inexperienced, and relatively poor, and assuming those readers knew as little about local growing conditions in the interior of the country as he did, M'Mahon presented the early melon as a heuristic lesson that taught gardeners what they needed to know about local conditions. In the process, it standardized perceptions of local place so that the remainder of his *Calendar's* instructions could be usefully applied. In England, the early melon helped calibrate advice to local conditions. In the nascent United States, where local environmental conditions were less well known, the early melon helped reveal and render legible environmental patterns in order to teach gardeners when to perform more necessary tasks in the garden. Both Deane and Abercrombie warned that the relative "forwardness" of a season could undermine a calendar's utility. In M'Mahon's *Calendar,* the early melon offered gardeners an opportunity to calibrate the time schedules offered in the text against local conditions and thereby avoid this mistake. M'Mahon suggested that heuristic lessons like the early melon, when combined with meteorological observations, were themselves steps towards a complete national

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[61] M'Mahon, *American Gardener's Calendar,* 2.

planting system, perhaps based on the leafing-out times of trees.[62] The early melon would help gardeners to read an Arcadian clock, nature itself.

In M'Mahon's *Calendar*, each month's instruction for growing the early melon focused on a different lesson in interpreting heat, sunlight, weather, and plant growth patterns. The foundation on which this lesson developed was the same as in England: the melon needed a constant temperature of 69 and 1/10th degrees Fahrenheit to thrive, but in order to maintain those conditions from January to May, the gardener needed to systematically investigate the surrounding environmental conditions.[63] The melon's consistent needs functioned as a standard against which larger environmental patterns would be revealed.[64]

The lesson developed slowly, so that in January, the gardener was only responsible for creating a hotbed out of dung and piled straw and maintaining it at a constant temperature despite fluctuating external conditions. Assuming his readers did not have access to instruments like thermometers, M'Mahon instructed gardeners to estimate temperature through touch.[65] But perhaps remembering that not all bodies *feel* the world in the same way, he offered ways to calibrate the individual perceptions of heat: an egg pulled fresh from the nest, he explained, was 106 degrees, a pool of frozen water 32 degrees.[66] For even greater specificity, other household items could help gauge relative coldness: "ice or snow mixed with kitchen salt produces a degree of cold equal to *zero* or 0 of Fahrenheit. Rivers or running waters, freeze at 20 7/10; cider and

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[62] M'Mahon, *American Gardener's Calendar,* 480.

[63] *Ibid,* 480.

[64] Jessica Riskin might call a melon seed, especially one used as a standardizing timekeeping technology, as "a thing with agency," or "a thing whose activity originates inside itself rather than outside." As such, melon time and its adherents provide a lay example of the dissenting scientific tradition Riskin examines in *The Restless Clock.* Riskin, *The Restless Clock,* 3.

[65] M'Mahon, *American Gardener's Calendar*, 481.

[66] *Ibid.*.

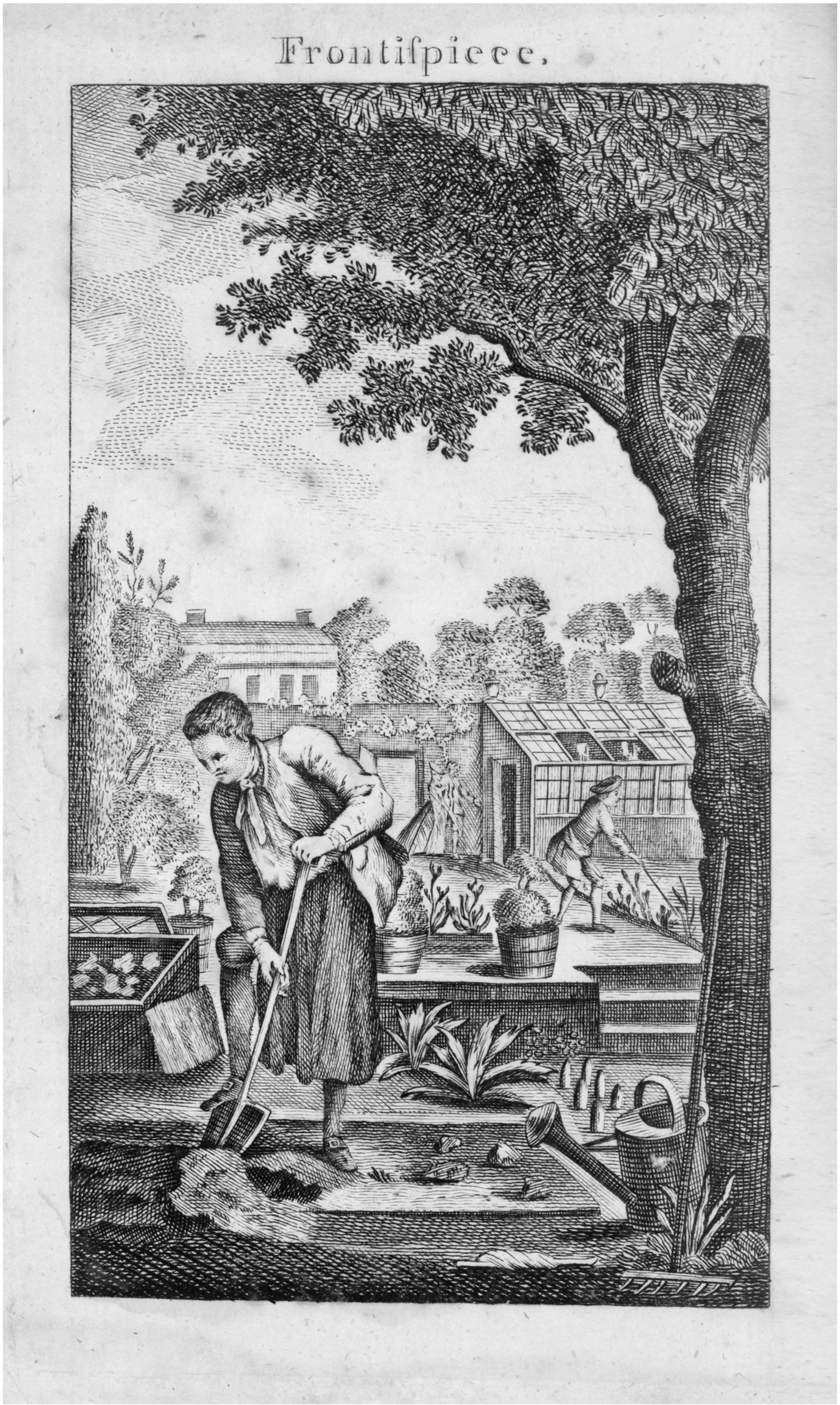

Figure 4: In the frontispiece to John Abercrombie's garden calendar, two gardeners work while a genteel couple strolls in the background. Evidence of their assiduous activity lies around the gardeners in the beds they are digging, the hot-bed (middleground, left), and hot house (middle ground right) both of which have their lights opened to vent hot air. Unlike Miller's engraving, in this well-ordered and walled garden there are no angels guiding activities and there is no zodiac in the clouds governing the season. The knowledgeable gardener has replaced the angels in the foreground, and a leafing tree takes the place of the zodiac. The evidence of daily activity, good-order, and early melon seedlings in the hot-bed, suggest to the viewer that this gardener had already mastered the fundamentals of good gardening, and is attuned to an arcadian clock.

John Abercrombie, *Everyman His Own Gardener* (London, 1791), frontispiece.

vinegar at 11 7/10, and unadulterated wine at 5 degrees."[67] For melon seedlings to germinate, the gardener needed, literally, to feel his way towards a constant temperature halfway between slushy puddle water and a fresh egg.

In the next month, once the seedling had sprouted, the gardener needed to maintain the constant temperature and learn to interpret changing weather conditions, since ice would damage the melon's tender leaves. In March, the month of the equinox, the melon began to develop leaves large enough to scorch in the sun, the melon taught the gardener to pay assiduous attention to the angle and strength of sunlight. By April, climatic differences between southern states and northern states would have grown pronounced, and the health of the early melon helped teach the gardener to attend to climatic variation not only north and south but also by elevation. Finally, in May, the remainder of the garden would begin to thrive, and M'Mahon instructed readers how best to integrate the growth cycle of the early melon with the growth cycles of more important crops like corn and squash. He suggested that once the gardener learned to grow the early melon, the melon itself could signal when it was time to plant corn and other more important staple crops because it could reveal the forwardness of the season.[68]

M'Mahon assumed gardeners would fail to grow an early melon for several years, but in failing they would systematically gain knowledge of the local environment necessary for growing more important and valuable crops in-season. The fruit of this practice, as M'Mahon explained, was not the one or two sickly melons a gardener might raise, but a cumulative lesson in environmental perception—particularly in the interconnected temporal rhythms of local environments. These lessons in perception, mediated through individual gardeners' bodies and

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67 M'Mahon, *American Gardener's Calendar*, 481.

68 *Ibid.,* 359.

standardized by the limited conditions under which a melon seedling could grow, had the effect of teaching gardeners to find and then read what M'Mahon hoped would become a national calendar of growth-cycles, climates, weather, and sunlight. That is the universal timekeeper M'Mahon's horticultural calendar aimed toward, not the awkward month-by-month guide that provides the format for his text. This was M'Mahon's solution to the problem of how to teach organic time in the pages of a travelling garden book: his version of standardized organic time.

The early melon in its bed of dung was a technology of modern timekeeping, useful for making a temporal-regime visible and legible. With its help, a good gardener could synchronize his labor to the conditions of his local environment, coming to understand through careful observation of the melon's health why certain activities needed to happen when they did. The melon could teach gardeners to perceive larger patterns in nature and, armed with that knowledge, learn to participate with that larger order. With this key in hand, a gardener could read the surrounding woods and fields like a timekeeper; the book of nature would be legible and man could begin to fit his life to its rhythm. The early melon illustrates the ways that organic timekeepers are at work where human conceptions of time touch the material world, where patterns of place and time are inextricably linked. The practice of growing an early melon mediated between abstract cultural timekeeping systems like the horticultural calendar or almanac, and the periodic but not fully predictable unfolding of patterns in the gardener's local environment.

Conclusion: Modern Organic Time

Gilbert White appears in this story as a particularly frustrated early melon grower. However, he figures in environmental histories far more frequently as the author of *A Natural*

History of Selborne and as an embodiment of Arcadian ecology.[69] In *Selborne*, White recorded his observations of the complicated and interconnected natural phenomena around his small parish of Selborne, England. In the process of describing and interpreting the natural world around him, White drew from classical literature as well as his own empirical observations to argue for the possibility of an "inward sense of harmony between man and nature" achieved "through an outward physical reconciliation."[70] Ecology—the study of the natural world as an interconnected whole—promised the possibility for man to harmonize his activities with the patterns of nature. Framed this way, we might also say that White's Arcadian ecology sought to make organic time legible, because only by making ecological relationships visible and meaningful could someone like White begin to intentionally fit his life into those patterns. Timekeeping is the practice of perceiving, interpreting, and situating the fluid relationships between phenomena in the world as they change overtime into a matrix that is replicable, portable, and meaningful. Ecology is a form of timekeeping.

Environmental historians often draw an important distinction between intellectual followers of Gilbert White's Arcadian ecology, and the ideas of Carl Linneaus and imperial ecology. Understanding nature as "a mechanism designed by a beneficent creator," imperial ecology supported the idea that "the natural world was analogous to a factory to manufacture an unending stream of products for human consumption."[71] Though published after Evelyn and Switzer died, and originally opposed by Miller, Linneaus's *Systema Naturae* (1758) and its classification system quickly became necessary material in horticultural literature. M'Mahon's

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[69] Oelschlaeger, *The Idea of Wilderness,* 104.

[70] Donald Worster, *Nature's Economy: A History of Ecological Ideas*, 2nd ed. (Cambridge: Cambridge University Press, 1977), 10.

[71] Oelschleager, *The Idea of Wilderness,* 105.

Calendar, for example, included a catalog of 3,700 plants arranged by English and Latin names.[72] M'Mahon's *Calendar* more broadly reflects Worster's interpretation that the "fundamental assumption" of imperial ecology "was that the 'economy' of nature is designed by Providence to maximize production and efficiency."[73] With references to externally imposed botanical classifications, the factory system, empire, and efficiency, such characterizations of imperial ecology suggest an implicit alliance between imperial ecology and modern industrial clock-consciousness.

Arcadian and imperial ecology seem to be opposed: organism and mechanism, organic time and the mechanical clock. In the practical horticultural literature of the period, however, that seeming opposition melts away. It dwindles because, as illustrated by the early melon, plants could be timekeeping technologies for horticulturalists of the long-eighteenth century.[74] If the purpose of an Arcadian ecology was to harmonize human activity with the natural world, then the closer man drew to nature, the fewer mistakes he would make in his garden, the less effort he would need to expend, and the more productive his fields would become. If his knowledge of nature was compendious enough, a gardener might be able to follow those patterns anywhere, to garden or farm wherever he chose. Ecology would give him tools to read time in the landscape. "Nature is so uniform in her operations," the author of a popular New England dictionary predicted in 1797 "that the farmer will be able infallibly to read the true times of sowing, by casting his eye upon the trees and shrubs that are about him."[75] When plants were understood as

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72 M'Mahon, *American Gardeners Calendar,* v.

73 Worster, *Nature's Economy,* 52.

74 Philip J. Pauly argues, "what then was culture is now biotechnology." Philip J. Pauly, "Is Environmental History a Subfield of Garden History?" *Environmental History* 10, no. 1 (January 2005): 70-71, 71.

75 Samuel Deane, *The Newengland Farmer; or, Georgical Dictionary,* 2nd ed. (1797), 185-7, DO Rare Books Coll. RBR M-3-4.

timekeepers, then harmony with nature was another name for efficiency. Because of the narrow range of conditions under which a melon seedling would flourish, the early melon became a heuristic lesson teaching gardeners how to begin harmonizing their activity in the garden with the patterns of the natural world.

British and American horticultural authors writing between 1690 and 1820 fit within a spectrum between Arcadian and imperial ecology. Switzer, perhaps, might be situated closer to White's Arcadian end; M'Mahon closer to an imperial perspective. Regardless, all of these authors shared a faith in the stability of nature. From Evelyn through Abercrombie, M'Mahon and beyond, the idea of nature as the expression of a clockwork universe was the steady metronome underlying temporal experience. Nature was the face of a perfect clock, if it could only be read. It was this understanding, rather than an argument over whether nature was an organism or a machine, that shaped horticultural ideas about the nature of time and what a perfected timekeeper should enable. Plants, they argued, were the key to modernizing organic timekeeping.

Ideas about nature are also ideas about the nature of time, but in this instance, a clockwork metaphor for nature did not inspire horticultural authors to adopt mechanical timekeepers. We must broaden our understanding of technology to understand their proposals and critiques. It was not that the mechanical clock was anathema to horticultural labor, these authors argued. Rather, as a timekeeper it was not exacting, accurate, or universal enough to fit the conditions of their labor or experience. The same could be said to different extents of a calendar, an almanac, and an encyclopedia. For horticultural authors in the long-eighteenth century, to accept any of these timekeeping technologies as the best method to interpret nature and organize human activity would have compromised their empirical understanding of the natural world as stable and rationally organized. Therefore, sciences like ecology and phenology that taught people to follow the landscape as part of an interconnected, governed whole—whether approached from an Arcadian angle or an imperial bent—were also inextricably part of the history of modern time-consciousness. Searching for the key to modern organic time, horticultural authors argued it was plant technology—the early melon—that educated gardeners to read instructions from the most accurate and reliable timekeeper, nature. For them, modernizing time keeping meant systematizing and standardizing perceptions of the natural world.

3

Global Time from the Deck of a Ship

Introduction: Accumulated Errors

In the early eighteenth century, expanded European trading routes made possible by more weatherly ships sailing farther afield with smaller crews pushed the need for more accurate methods of timekeeping at sea. Sailing longer distances out of sight of land and in less-well-known waters, the accumulated errors of navigating by dead reckoning or plain sailing increased the odds that a ship would discover itself, often suddenly, many miles off course. This hazard was compounded by fifteenth and sixteenth century changes in hull and sail design that made ships less maneuverable near shore or in shallow waters.[1] By the seventeenth century, ships that were capable of sailing long distances in deep ocean swells were far less capable of safely navigating shallow water, and even minor errors in long-distance navigation increased the chances that ships would stumble onto such dangerous circumstances. Ships were far more capable of crossing the ocean, but with this new aptitude for long-distance sailing, the acceptable margins of error in navigation diminished. A variation of four seconds in time could put a ship one mile out of its reckoning. Even in familiar waters, larger ships demanded a precision from navigation that seventeenth and eighteenth century sea captains struggled to deliver. This was

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1 For more on fifteenth- and sixteenth- century changes in hull and sail design see, Clinton R. Edwards, “The Impact of European Overseas Discoveries on Ship Design and Construction during the Sixteenth Century,” *GeoJournal* 26, no. 4 Quincentenary of the Discovery of the Americas (April 1992), 443-452; Trevor Kenchington, “The Structures of English Wooden Ships: William Southerland’s Ship, *Circa* 1710,” *The Northern Mariner/Le Marin du nord* III, no. 1 (January 1993), 1-43; For more on long distance navigation see Joyce Chaplin, *Round About the Earth: Circumnavigation from Magellan to Orbit* (New York, 2012); Joyce Chaplin, “Knowing the Ocean,” in *Science and Empire in the Atlantic World,* eds. James Delbourgo and Nicholas Dew (New York, 2008): 73-95.

famously demonstrated by the loss of a squadron of English ships and the death of 2,000 mariners off the coast of Cornwall in 1707, an accident that reputedly made the British admiralty acutely conscious of the need for better precision timekeeping methods at sea, and inspired them to offer a bounty to anyone who could produce a method capable of reliably and accurately determining the time at sea.[2]

For the most part, histories of precision timekeeping begin here and follow eighteenth-century British horologist John Harrison's legacy forward through his work on refining the marine chronometer.[3] These histories take it for granted that because the chronometer worked, it would necessarily be adopted. In his popular history of precision, *The Perfectionists,* Simon Winchester concludes his lingering portrait of Harrison and other British horological pioneers by succinctly explaining that "precise running clockwork made for precise navigation."[4] But, even if a precise clock could be made to run at sea, these histories miss the point that in the eighteenth and nineteenth century navigation itself was an imprecise art, a science of approximations. These histories leap over the roughly eighty-year gap between Harrison's invention and the first time an American nautical authority endorsed the chronometer as *one of several* possible methods for tracking time at sea. Rejecting the chronometer does not reflect a antimodern movement within nautical literature. To these highly influential experts, the chronometer was too unreliable and too delicate to be a fully universal timekeeper.

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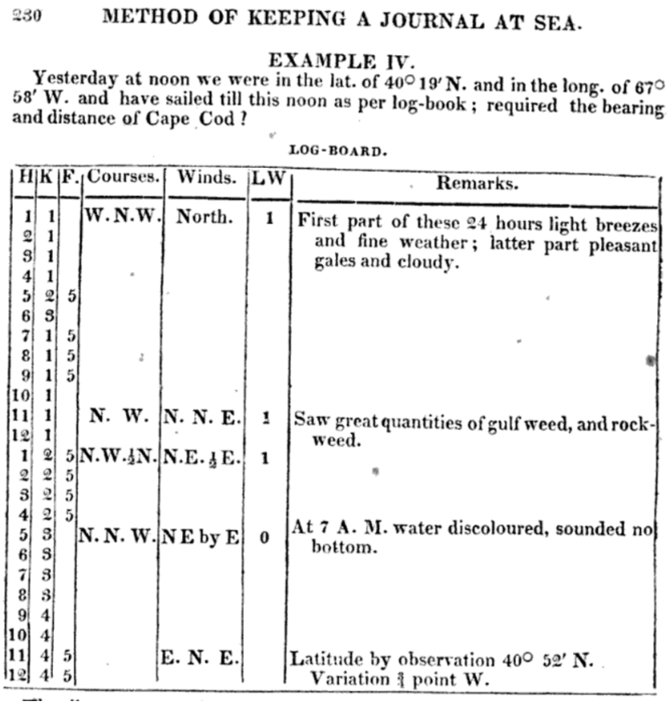
2 See, Jordan D. Marche, II, "Restoring a 'Public Standard' to Accuracy: Authority Social Class, and Utility in the American Almanac Controversy, 1814-1818," *Journal of the Early Republic* 18, no. 4 (1998): 693-710; Richard Dunn and Rebekah Higgitt, *Finding Longitude* (Royal Museums Greenwich: Collins, 2014); David Landes, *Revolution in Time* (Cambridge: Harvard Belknap Press of Harvard University Press, 1983).

3 Popular examples include Dava Sodel, *Longitude: The True Story of a Lone Genius who Solved the Greatest Scientific Problem of his Time* (New York, 2007); Simon Winchester, *The Perfectionists: How Precision Engineers Created the Modern World* (New York, 2018); Andrew K. Johnson, Roger D. Conner, Carlene E. Stephens, and Paul E. Ceruzzi, *Time and Navigation: The Untold Story of Getting from Here to There* (Smithsonian Books, 2015); Richard Dunn and Rebekah Higgitt, *Ships, Clocks, and Stars: The Quest for Longitude* (New York, 2014); Charles W. J. Withers, *Zero Degrees*: *Geographies of the Prime Meridian* (Cambridge: Harvard University Press, 2017).

4 Winchester, *The Perfectionists*, 45.



230 METHOD OF KEEPING A JOURNAL AT SEA.

EXAMPLE IV.

Yesterday at noon we were in the lat. of 40° 19′ N. and in the long. of 67° 58′ W. and have sailed till this noon as per log-book; required the bearing and distance of Cape Cod?

LOG-BOARD.

H	K	F.	Courses.	Winds.	LW	Remarks.
1	1		W.N.W.	North.	1	First part of these 24 hours light breezes and fine weather; latter part pleasant gales and cloudy.
2	1					
3	1					
4	1					
5	2	5				
6	3					
7	1	5				
8	1	5				
9	1	5				
10	1					
11	1		N. W.	N. N. E.	1	Saw great quantities of gulf weed, and rock-weed.
12	1					
1	2	5	N.W.½N.	N.E.½E.	1	
2	2	5				
3	2	5				
4	2	5				
5	3		N. N. W.	N E by E	0	At 7 A. M. water discoloured, sounded no bottom.
6	3					
7	3					
8	3					
9	4					
10	4					
11	4	5		E. N. E.		Latitude by observation 40° 52′ N.
12	4	5				Variation ¾ point W.

Figure 5: An example of a logbook entry from the 1826 edition of the most popular American nautical guide.

Nathaniel Bowditch, The American Practical Navigator *(New York, 1826), 230.*

The system these nautical experts preferred was based on the ship's logbook and systematically combined multiple methods for calculating time at sea. The ship's logbook was a paper technology that operated in ways interestingly analogous to the hot-bed in a kitchen garden. It was an organic timekeeper developed to enable mariners to systematically calibrate different methods of keeping time against each other. Though the ship's logbook would not spit out one single time, in its format and contents, the tool enabled mariners to circle in on the most reliable time while at sea. In this sense, it was a probability-generator. It could not tell sailors the precise time, but it considerably narrowed the margin of error. In 1760, neither technology was fully practicable, though both were promising. In nautical manuals of the 1730s, both methods live under the heading "theoretical" rather than "practical" navigation.

As the career of the ship's logbook demonstrates, the utility of different timekeeping practices arises and disperses not only in relation to ideas of nature itself, but also in relation to dominant perceptions of *human nature*. In this case, from 1750 to 1850, changing perceptions of who a “sailor” was and what he was capable of doing transformed the ship’s logbook from a cutting-edge technology expected to reveal universal truths and resolve the toughest puzzles of contemporary sciences, into a practice of so much paper-work, a copybook exercise done to oblige lawyers and lawmakers. Timekeepers are technologies, and it matters how we use them. In the case of the logbook, once Americans stopped using them as timekeepers, they slipped out of the history of time, even as logbooks continued to be employed by and taught to American mariners across the nineteenth century.

Navigation: A Science of Approximations

Until a person spends time on the water far from land, it may not seem to be very important to observe that land does not move. However, from the deck of a rolling ship, perhaps wracked by seasickness or struggling to keep one’s balance, it becomes clear fairly quickly that there are myriad consequences that flow from the fact that ships are never truly at rest. One is that the observer is also always at least slightly moving. This constant movement is the core of the problem of navigation at sea, and is particularly acute where there are no landmarks on the horizon and where currents and winds combine to contradict observable or felt experience.

To judge movement one has to—literally or metaphorically—reach outside of the ship and fix a position relative to something external to the whole system. This is precisely the move that eighteenth century garden calendar authors made when they attempted to anchor temporal orders in observable local environmental processes—thinking those processes represented the face of a fixed, stable, and rationally ordered universal time. Though a garden floats on the tides of seasons and swells of plant growth, a ship is actually carried along in the water, to new places, through new environments, under changing stars. This makes recovering the “stationary precision of the calendar" a far harder task, because the nautical calendar or any other form of timekeeper the mariner needs to be able to consult, has to be truly globe-spanning.[5]

Though the mariner can track changes in observable environmental and celestial patterns as his ship moves across the water, subtle changes are often beyond his perception. From the hold of a ship, for instance, it is nearly impossible to identify if a ship is in a current, and if so, how swiftly the current runs. Newton, explaining the distinction of absolute and relative movement, expands on this point to make a larger argument about spatial perception. "But because the parts of Space cannot be seen, or distinguished from one another by our senses," he argued, "there fore [sic] in their stead we use sensible measures of them. For from the positions and distances of things from any body considered as immoveable, we define all places."[6] Newton expressed what was a commonplace for sailors: to know where one was, a sailor needed external reference points—the stars, soundings, and sightings being preferred methods in the seventeenth century nautical world Newton knew. Whether for Newton or an unknown mariner, the problem of navigation lay not in accepting this concept, but in agreeing upon what point or points were universal enough and accessible enough to anchor a sense of space or time anywhere at sea all over the globe.

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5 The term "stationary precision" comes from John Abercrombie, the horticultural expert mentioned in the previous chapter. John Ambercrombie, *The Practical Gardener, or Improved System of Modern Horticulture.* 2nd edition. (1817) DO Rare Books I-2-4 ABER, viii.

6 Isaac Newton, *Sir Isaac Newton's Mathematical Principles of Natural Philosophy and His System of the World; Translated into English by Andrew Mottee in 1729.* Trans. Florian Cajori (Berkeley: University of California Press, 1934), 10.

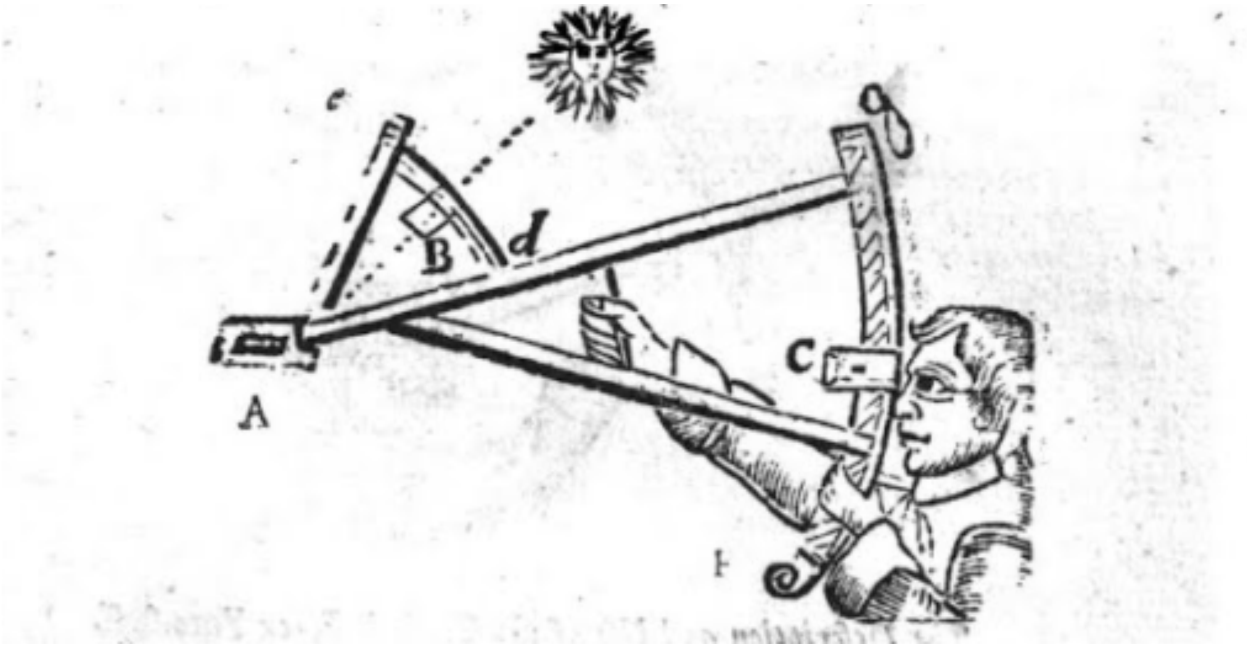

Figure 6: An illustration showing the use of the quadrant. Nicholas Colson, The Mariner's New Kalendar *(London, 1745), 63.*

One of the consequences of moving along with the ship was that not only was an eighteenth-century mariner's sensory perception of movement affected, but the instruments he might employ to determine his location were likewise influenced. For instance, the quadrant, held at arm's length to calculate the distance between stars, rose and fell—along with the mariner's arm—with the rocking of the ship. Landmarks sighted on the horizon with a telescope at the crest of a wave disappeared in a trough. A clock carried aboard and set to track the time from a known point of departure rapidly went wrong as the rocking of the ship, changing temperature, humidity, and pressure would either entirely disable the instrument, or cause it to run too fast or too slow. If the ship fired a cannon, the resulting jolt would throw all of the subtle mechanisms out of connection. Even the needle of a compass, held steady in front of the mariner and checked frequently, varied, its needle tracking not only the earth's magnetic pole but the landscape of its changing magnetic and gravitational fields. As one nautical author summarized, navigation at sea was still generally “at best only an approximation.”[7] Determining the ship’s position in space and time, therefore, was itself a science of weighing approximations, minimizing margins of error, while accepting that certainty was a rare and fleeting occurrence.

When so many of the phenomena that assemble the perceptible world are rendered uncertain—as they are at sea—timekeeping becomes a method for fixing one’s position in space. Mariners worked this problem from both ends. Through sea-sense, bodily experience, weather lore and word of mouth, mariners trained each other how to navigate through dead reckoning, developing methods for recognizing the seemingly imperceptible. Building from practice and observation, dead reckoning reached towards the abstractions of knowing where the ship was on a map. At the same time, mariners worked the other end of the process, contemplating abstract space and time, they tried to bring the abstract rendering of their courses sailed, how long and in what direction, into agreement with their dead reckoning.

Balancing Trust and Risk: Lunars, Chronometers, Logbooks

To know where they were on a map, mariners needed to know where they were in relation to a theoretical grid constituted of lines of latitude and longitude. But because of currents that could not be felt, and leeway that could not be easily estimated, even if a navigator could know without doubt how far he travelled along a given course and at what pace, tracing a simple zigzag line of courses and distances would still not locate him accurately on the map. In short, the solution to the constant motion of space was to establish a fixed point, arbitrarily, external to motion, against which all motion could be judged. This was the purpose of the prime meridian.

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[7] Andrew Mackey, *The Theory and Practice of Finding the Longitude at Sea or Land: TO which Are Added Various Methods of Determining the Latitude of a Place and Variations of the Compass with New Tables* Vol. 1, 3rd edition (London, 1810), 91.

By establishing a moment when time and space could be fixed jointly—noon at Greenwich for instance— sailors around the world would be able to determine their locations relative to that one point. Wherever the ship bobbed in the ocean, the sun—an external reference point—sought them out each day. In theory, if the navigator could calculate the difference between noon wherever in the world he was located and noon at Greenwich, he could work backwards to determine the number of degrees away from Greenwich he had sailed, and locate himself on the gridded map. This method only worked, however, if the navigator had a clear view of the sun, moon and stars, and a good sense of his latitude. What was he to do on a cloudy day when even shadows were obscured?

Though we associate clocks closely with the solution to this problem, in the seventeenth and early eighteenth centuries mechanical clocks could not yet keep reliable time at sea.[8] The constant rocking of the ship disrupted the even swing of the pendulum, causing the clock to gain or lose time, or simply stop functioning. Moreover, experiments in the tropics had proved that even if the problem of the rocking ship could be avoided, changes in heat and humidity affected the metal of pendulums, leading to minute variations in the length of each second.[9] Overtime these slight variations could lead the clocks to run substantially ahead or behind the standards they are supposed to represent. Against this proposal, astronomers and nautical almanac authors supported a system based on lunar observations. This method was time-intensive and relied on

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[8] For additional context on the challenge of chronometers as a universal standard: Jim Bennett, "The Travels and Trials of Mr. Harrison's Timekeeper," in *Instruments, Travel and Science: Itineraries of Precision from the Seventeenth to the Twentieth Century*, eds. Marie Noelle Bourguet, Christian Licoppe, and H. Otto Sibum (New York: Routledge, 2002); Nicholas Dew, "The Hive and the Pendulum: Universal Metrology and Baroque Science," in *Science in the Age of Baroque.* Eds. Ofer Gal and Raz Chen-Morris (New York: Springer, 2012): 239-255.

[9] Nicholas Dew, "*Vers la ligne:* Circulating Measurements Around the French Atlantic*,"* in *Science and Empire in the Atlantic World*. Eds. James Delbourgo and Nicholas Dew (Routledge: New York, 2008), 53-72.

the mathematical competency of mariners and of human computers tasked with compiling enormous nautical calendars to support the method. In the eighteenth century the English Board of Longitude, tasked with solving the problem of longitude and making its use available and accessible to mariners after the disaster of 1707, was not fully convinced that either a method based on a clock or one based on lunars was capable to resolving the problem.[10] The debates about both methods, lunars and chronometers, help illustrate how a very old practice of keeping a logbook might develop in the context of the Enlightenment into a modern organic timekeeper expected to reveal keys to universal time.

Lunars

Faced with the repeated failures of marine chronometers and the improved methods of astronomical observation, British astronomer Nevil Maskelyne (who would become Astronomer Royal after 1765) turned the Board's attention to the sky. Meskelyne proposed that the best and most universal method for keeping time at sea would be based on observable phenomena in the local environment: the moon. The moon orbits the earth at a constant rate, faster than any other object in the sky and, on clear days and nights, is visible around the world, north and south of the equator.[11] If he could track the constant movement of the moon, and compare it to a table of predicted movements for an agreed-upon reference point, a mariner could use the moon to "serve as the hand of an astronomical clock whose dial is the celestial dome and whose points are the stars."[12] The key to this measurement, however, required the mariner to accurately read the angular distance between the moon and a fixed star and then "compare this [angle] with the

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10 see Dava Sobel, *Longitude;* David Landes, *Revolution in Time*; Charles W. J. Withers, "'Absurd Vanity' The World's Prime Meridians before c. 1790," in *Zero Degrees*, 25-72*;* Marche, "Restoring a 'Public Trust'," 695-697.

11 David Landes, *Revolution in Time,* 161.

12 *Ibid., 161.*

predicted time of the same observation for some place of known longitude."[13] This method was called "taking lunar distances" or for short, "lunars."

Meskelyne was not alone in proposing this method, nor was he alone conceiving of it as more reliable and universal than the clock. The proposal had remained theoretical for many decades before Meskelyne brought it to the Board of Longitude. First, the technical ability to make such careful observations accurate enough was not possible until the 1730s with the invention of Hadley's quadrant.[14] Second, Meskelyne's work in the 1760s built on previous efforts by Isaac Newton to interpret celestial mechanics, the extensive effort to observe the moon by Edmund Halley, and the subsequent project of predicting its movements compiled in tables by Swiss mathematician Leonard Euler and German astronomer Tobias Meyer in the 1750s.[15] Although the momentum behind lunar observations as a universal tool for finding accurate time at sea was building, it was not until Meskelyne used Meyer's tables of lunar distances to measure the transit of Venus in St. Helena in 1761 within 1.5° that astronomical navigation began to seem like the best solution to the longitude problem.[16] Of course, even if they held promise, the method of lunar distances required not only Hadley's quadrant, but also compendious calendars of angular distances for each year.

Unfortunately, even if these issues could be overcome, navigating by *lunar distances* was still time-intensive and difficult. The multi-step process for calculating lunars took even Meskelyne roughly four hours to complete.[17] And the necessary nautical almanacs, computing

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[13] *Ibid.*.

[14] *Ibid.*.

[15] Jordan D. Marche, II, "Restoring a 'Public Standard,'" 702; David Landes, *Revolution in Time,* 161.

[16] Landes, *Revolution in Time,* 163.

[17] Landes, *Revolution in Time*, 164.

tables of declination for every three hours of each year through the end of the century, occupied the labor of dozens of human computers working in a put-out system across the English countryside.[18] Astronomical navigation demanded a great deal of mental effort and mathematical competency from a captain or navigator, not to mention a great deal of faith in the accuracy of the computers charged with creating the tables.[19] Following lunars meant investing your life and cargo in the competency of a nameless and faceless computer, likely living somewhere in rural England and doing figures by candlelight to earn extra income.[20] Computers made mistakes, and people died from following their tables.

Sir Hamilton Moore was the author of the most popular nautical guide in the Atlantic World at the end of the eighteenth century. His popularity rested, in large part, on the fact that he inherited Meskelyne's network of computers to calculate the nautical calendars necessary for sailing by lunars. However, Moore missed a serious oversight in the nautical tables of the sun's declination for the year 1800. His mistake was understandable given the thousands of calculations contained in each nautical calendar— easily imagined as the result of a moment's inattention. However, the consequence of this oversight in the nautical tables meant that ships using those tables would be sailing nearly thirty miles out of their reckoning.[21] Several fatal

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[18] Tamara Plakins Thornton, *Nathaniel Bowditch and the Power of Numbers: How a Nineteenth-Century Man of Business, Science and the Sea Changed American Life* (Chapel Hill: The University of North Carolina Press, 2016), 70-77; Simon Schaffer, "Babbage's Intelligence: Calculating Engines and the Factory System," *Critical Inquiry* 21, no. 1 (1994): 203-227; David Alan Grier, *When Computers were Human* (Princeton: Princeton University Press, 2005).

[19] Patricia Cline Cohen, *A Calculating People: The Spread of Numeracy in Early America* (New York: Routledge, 1999).

[20] Thornton, *The Power of Numbers,* 75.

[21] The issue with the leap year occurred because in the Julian calendar centuries are only leap years if they are divisible by 400, but in 1752, Great Britain reformed its calendar to align with the Gregorian calendar in use on the Continent ("removing" eleven days from the calendar to do so). In the new Gregorian system, 1800 was a leap year. As a result, any table published under the Julian system, would be 1 day of after 1800. Compounding the potential for errors, because many people maintained both calendrical systems and because the British Navy maintained some elements of the previous system (for instance, for paying pensions), there were also many reasons beyond errors in the computer's calculation that could cause errors in mariner's use of the nautical tables. See Robert Poole, " 'Give us Our Eleven Days!': Calendar Reform in Eighteenth-Century England," *Past & Present,* no. 149 (1995): 95-139.

accidents were attributed to this error, and nautical guides continued to publish cautionary tales based on this error for decades.[22] The most popular American nautical guide— made popular in large part because of the error in Moore's tables— referred to the mistake as "a very criminal inattention."[23] Navigators and captains placed their lives, and the lives of everyone on board, in the hands of nautical authors they trusted. Following a nautical guidebook implicitly rested on the reputation of the compiler and nameless computers behind the charts in the text.

While basic numeracy was widespread among most middling and upper classes of English and American society in the late eighteenth century, sailing by lunars demanded a much more developed range of skills, skills not typically taught in the grammar schools where navigation and celestial mechanics were still taught through the "use of the globes."[24] Indeed, it was a matter of significance when the first instruction manuals in algebra reached the seaport of Salem, MA. Nathaniel Bowditch, who would grow up to author the most influential nautical almanac in America, frequently told friends about his first encounter with algebra as a young clerk at the chandlery of Ropes & Hodges.[25] Lunar distances might transform the night's sky into the face of a universal clock, but it was not clear that all mariners would be capable of reliably reading that timekeeper. Captain Henry Prince, who captained the first ship Bowditch sailed upon, estimated that at the turn of the 19th century, sailing by lunars was "no small

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22 Accounts range, but as one example (of a near-miss), Thomas Arnold reported in 1822, "In the year 1800, about the middle of March, being bound to the Havanna, I made use of one of Hamilton Moore's epitomes, printed before 1800. Knowing this error, I took the declination for one day earlier. Had I not been aware of it, I should have used the declination for the day as given in the epitome, and should have been about twenty-three miles out in the latitude." Thomas Arnold, *The American Practical Lunarian and Seaman's Guide* (Philadelphia, 1822), 36.

23John Pickering, *Eulogy on Nathaniel Bowditch, LL.D.* (1838), 10.

24 Tamara Plakins Thornton, "the 'Use of the Globes': Mathematical Geography, the Mercantile Imagination, and Global Commerce in Postrevolutionary America." Paper prepared for the 16th Annual Conference of the Program in Early American Economy and Society, Library Company of Philadelphia, Oct. 2016.

25 Daniel Appleton White, *Judge White's Eulogy on the life and Character of Nathaniel Bowditch: Delivered at the Request of the Corporation of the City of Salem, May 24, 1838* (Salem, 1838), 15-16.

accomplishment even for the first and second officers of a ship, and one, to which a common mariner could hardly aspire."[26] By 1800, lunars promised a universal timekeeping method, but one that was limited by the time commitment involved in each calculations and by the difficulty of the calculations.

To make these calculations easier, faster, and more reliable, nautical manuals began to include tables of logarithmic functions, showing the distances between lines of longitude at different latitudes, or the tangents required to get an equation of time using the moon and a star, or the refraction necessary to be considered in calculating time against an object low on the horizon. These instruction manuals included instructions on using common tools, like the mariner's quadrant and sextant, to measure the degrees between two objects in the sky, too. To further assist in the calculation process, some of the more compendious books would also instruct readers in mathematical tools, like Gunter's Scales, that would help with logarithms. As historian Tamara Plakins Thornton argues, "the lunar method took the mariner out of this focus on the particular and the material into the universal and abstract, the sublime work of pure numbers. […] Numbers meant not just abstraction but certainty…."[27] Certainty— as long as a navigator felt he could trust the computers producing the tables and his own skill in observation and calculation.

Chronometers

The history of timekeeping often celebrates John Harrison, English clockmaker, for demonstrating that a clock, as opposed to Meskelyne's celestial observation, could be reliably

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[26] John Pickering, *Eulogy on Nathaniel Bowditch, LL.D.* (1838): 8.

[27] Thornton, *The Power of Numbers,* 77.

used for navigation at sea. Over several modifications and many decades, Harrison received credit for confirming the possibility of the marine chronometer, a clock the English navy assured would be reliable for use at sea. French watchmakers would eventually create the devices today used as marine chronometers, but Harrison demonstrated that a clock of such precision and reliability could be built.[28] With the chronometer in hand, a ship's captain could track courses and distances-run, and use the sun, moon, or stars to calculate local (mean) time. By comparing local time to the time kept by the chronometer, and by a calculation of the miles in each degree of longitude at his ship's latitude, the captain could generate a much more certain estimate of his position on the grid. He could use this position to work backward, correcting his reckoning of courses and distances, and fixing more certain numbers on his estimates of leeway.

In the words of one instruction manual on nautical routine, chronometers were "liable to jump one or two seconds in the daily rate without any apparent cause, and then reassume their former rate in a few days."[29] Since four seconds variation in the chronometer was equivalent to one mile in longitude, even for those who owned this expensive instrument, relying solely on the time kept by the marine chronometer could be risky. In fact, across the nineteenth century, the definition of a good and reliable chronometer never included the expectation that the marine chronometer would keep time in regular units.[30] A clock at sea that *seemed* to keep true time at the end of each day was dangerous since there was no telling how much it fluctuated ahead and behind the true time across a day. Better to have a chronometer that either reliably and

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[28] Landes, *Revolution in Time,* 167-179.

[29] James McLeod Murphy, *Theory and Practice of Nautical Routine and Stowage* (1849), 4.

[30] In 1910 a pamphlet published by the *American Jeweler* explained that "Another difference between chronometer practice and that of ordinary watchmaking is that a chronometer is never regulated to keep exact time. The makers recognize the fallibility of all human effort in this direction and instead of adjusting the chronometer to where it will alternatively gain and lose (as is a common practice in watch-making) the chronometer is regulated so as to have a small but steady rate— preferably a gain." Smithsonian Institution Pamphlet Collection. "A New Chronometer," *American Jeweler,* (ca. 1910.) 4.

consistently gained time or lost time over the course of a journey. The eighteenth- and nineteenth-century chronometer has been, somewhat inappropriately, included in the history of precision timekeeping, when in fact it was a very refined and specific kind of clock *designed* to be inexact in predictable ways.[31] Thus, histories of precision timekeeping that try to trace the establishment of temporal certainty at sea back to the chronometer have been applying ideas out of context. Until the invention of the marine gyroscope in 1893, and for a long time beyond, navigation remained a science of approximations, not certainties.[32]

A famous (though perhaps apocryphal) anecdote from 1794 suggests the skepticism Americans held for chronometers and those who would use them. In the anecdote, one of the most accomplished and learned captains in Salem, Captain Gibout, lost his post (or left it, depending on the version) over a falling out with the owner of the vessel he was set to captain. The owner, Elias Haskett Derby, had learned that Gibout purchased a chronometer during a recent voyage to France and might have been considering bringing the chronometer along during the next voyage. In the anecdote, the very idea that Gibout might put his trust in chronometers signaled an error in judgement for Derby so great that Derby preferred to offer the captain's post to a young man who had never held it before rather than risk letting an experienced captain who might use a chronometer sail his ship.[33]

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[31] "A chronometer which is on time and remains on time is regarded with suspicion, as it is known to be alternately losing and gaining and the result might be such that the captain would be thrown off in his reckoning, with serious damage to life and property." *American Jeweler,* 4. As another example, Henry Marshall wrote in 1877, "But these delicate Instruments with all modern inventions, and all the improvements the ingenuity can suggest, cannot be made to keep perfect time, they are therefore constructed so as to keep uniform time, and if the Error of the Chronometer […] is known on a certain day, and what its daily gain or loss is, it is easy to reduce the time shown by it, to the mean time at Greenwich." Henry Marshall, *Navigation Made Easy, or the Mariner's Daily Assistant and Self-instructor* (1877), 39.

[32] And I believe that difference matters. As Lorraine Daston and Peter Galison argued: "science dedicated above all to certainty is done differently—not worse, but differently—from science that takes truth-to-nature as its highest desideratum." Lorraine Daston and Peter Galison, *Objectivity* (Cambridge: Zone Books, 2010), 34.

[33] Stanford, *The Navigator,* 104; despite having seen the research notes for this book at the Philips' Library, I can't confirm where this story originated, so I've chosen to call it an anecdote, though it certainly seems feasible it may have been true. Either way, the story itself suggests a mindset towards chronometers as untrustworthy.

Though the marine chronometer plays an important role in the history of timekeeping, the obvious limitations to marine chronometers inspired other additional proposals for improved and systematized timekeeping at sea. Behind the chronometer lurked a proposal about human capacity and uncertainty. Calculating the longitude would be much simpler, and the hours of calculation required of captains avoided, if the captain did not need to rely on the moon as a timekeeper, but could instead use a clock to read the time. Doing so would shift the uncertainty of timekeeping from the individual mariner to the machine. If a clock would be created that was capable of going to sea and keeping time at sea reliably, then the question become: in whom did the captains' confidence rely?

According to the British Board of Longitude, there were two methods for finding time at sea at the turn of the nineteenth century.[34] One method, using lunars, was demonstrably more universal and accurate as long as the sea was calm and the sky was relatively clear; however, it could only be called a universal timekeeping method if all men were capable of learning to use and apply it. And only if the minds who calculated the nautical tables could be relied upon.[35] To call it a universal system required a certain understanding of human capacity and a faith that all sailors were rational beings, that the universe was rationally constituted, and that all rational men were capable of interpreting it accurately. The other method, mechanical clocks, removed the question of timekeeping's relationship to human capacity by offering in its place a slightly less universal, accurate, or reliable method of timekeeping, a mechanical clock—if only these delicate timekeeping machines could be trusted to tick-off regular units at sea.

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34 Though they had given the prize to Harrison belatedly on the behest of King George.

35 Charles Babbage concluded that they were not, and threw his energy into mechanical computers.

By 1800, both lunars and chronometers were understood to have limitation and hazards. Neither fully solved the problem posed by telling time from the deck of a moving ship out of sight of land. Instead, each method solved the problem by displacing risk in different ways which help explain the initial reception of each method. In the simplest terms, the lunar method required mariners to trust people while the chronometers required mariners to trust machines. The debate between lunars and chronometers illustrates historian Arwen Mohun's contention that "technological change did not, by itself, determine how Americans understood and managed risk" or which method of navigation American nautical authors supported.[36]At the turn of the century, American risk culture tended to prefer the lunar method, but the cultural reasons behind that preference were changing.

American vernacular risk culture in the early republic was accustomed to relying on trust in humans and individual reputations to help navigate risk. In the first edition of the *Navigator* to be published under his own name, Nathaniel Bowditch drew on his already extensive regional reputation as a mathematical savant to recover the failing reputation of Moore's text, promising readers that he had "*actually gone through all the calculations* necessary" to complete the text.[37] No longer backed by nameless computers or a "criminally inattentive" Moore, Bowditch promised that only one person stood behind the charts and figures in his book.[38]

The choice between each method of timekeeping—the nautical calendar or the marine chronometer—involved a choice about uncertainty. Although the history of time tends to

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[36] Arwen Mohun, *Risk, Negotiating Safety in American Society* (Baltimore: The John's Hopkins Press, 2013), 6.

[37] Pickering, *Eulogy on Nathaniel Bowditch,* 11;

[38] Bowditch's contemporaries noted the change not only in assurances of accuracy, but also in the tone of Bowditch's assurances. Explaining to his reader that he hoped to be "absolutely correct," Bowditch acknowledged that some of the tables still contained minute errors. Identifying those tables, Bowditch then shaded the degree of confidence his readers might place in those calculations relative to other parts of the book, "he [referring to himself], therefore, does not absolutely assert, that these Tables are entirely correct, but feels conscious, that no pains have been spared to make them so." Bowditch in Pickering, 11.

foreground the utility of the chronometer from the mid-eighteenth century forward, it was not until 1826 that the leading American nautical manual, Nathaniel Bowditch's *American Practical Navigator,* included instructions on navigating by the clock. Previous to this, Bowditch strongly warned, "implicit confidence cannot be placed in an instrument of such delicate construction, and liable to so many accidents."[39] Bowditch's competitor for the American market, Andrew Mackey, agreed: "A time-keeper is certainly a most valuable appendage to a set of nautical instruments; if for no other purpose than that of connecting observations taken at different times; but like every other movement, is liable to be put out of order; and therefore astronomical observations are evidently to be preferred." [40]

Logbooks

At the end of the eighteenth century, the ship's logbook evolved into a tool for timekeeping at sea because for more than two centuries it had been a tool for registering and calibrating multiple temporal schedules taking place on the ship. In the simplest terms, a logbook was a book with space for the captain to write notes to himself about the voyage. Over time however, its contents and format grew more standardized, and at the end of the eighteenth century American authors began to imagine that this otherwise humble paper technology might be capable of revealing universal patterns in nature. The logbook developed as a technology intended to mediate between multiple ways of measuring time, calibrating methods against each other, weighing uncertainty. The logbook, not the chronometer or the nautical calendar, was

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[39] Thornton, *Power of Numbers,* 73; Nathaniel Bowditch, *The New American Practical Navigator,* 1821.

[40] Andrew Mackey, T*he Theory and Practice of Finding the Longitude at Sea or Land: TO which Are Added Various Methods of Determining the Latitude of a Place and Variations of the Compass with New Tables.* Vol. 1, 3rd edition (London, 1810), 278.

where time was found and followed on board the late eighteenth- and early nineteenth-century sailing ship.

Logbooks began as remembrancers made necessary because there were many temporal patterns that unfolded aboard a ship, and these patterns overlapped in confusing ways. For example, the three watches of a the sailor's day were organized from noon to noon, as was the reckoning of a "day's work" of a ship at sea. But the captain calculated time at sea according to the civil calendar, running midnight to midnight, based out of the port of departure. Sailors labored all day and all night, so schedules for rest, sleep, or meals varied according to labor rather than sunlight, but the round of watches commenced with the change of the watch at 7 bells (roughly 8:30).[41] And the watches rotated. Throughout the journey, sailors slept in snatches, ate at irregular intervals, and worked at all hours.[42]

Within this constant round of activity, other periodic cycles emerged. Work slowed on Sundays and holidays, calculated by the religious and civil calendar, which depending on the port of departure and religion of the captain might vary considerably.[43] The social and cultural temporal orders of shipboard life were not incidental to timekeeping at sea. They constituted timekeeping—since those schedules determined who raised the quadrant to their eye, who assisted, who wrote what and when. For instance, the captain took observations and checked the

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[41] Richard Henry Dana Jr. introduces nautical routine in detail in his memoir, Richard Henry Dana Jr., *Two Years Before the Mast: A Personal Narrative of Life at Sea* (New York: Barnes and Nobles Classics, 1840, 2007), 18.

[42] Sailors' 24/7 work schedule and isolated social sphere on board ships led Marcus Redicker to argue that "Jack Tar, one of the first collective laborers, was also one of the first alienated laborers." Marcus Rediker, *Between the Devil and the Deep Blue Sea: Merchant Seamen, Pirates, and the Anglo-American Maritime World, 1700-1750* (Cambridge: Cambridge University Press, 1987), 200; Jeffrey D. Glasco, "The Seaman Feels Himself a Man," *International Labor and Working-Class History,* no. 66, New Approaches to Global Labor History (2004): 40-56.

[43] For instance, Quaker captains sailing from Nantucket held their crew to different holiday schedules than Anglican captains sailing from Liverpool, or Catholic captains sailing from le Havre.

chronometer each day at noon, often assisted by the mate.[44] But on Sundays, they were joined by the second mate. Because of the round of labor at sea, and the way nautical routine and social structure shaped who was observing or recording, on some days the possibility of accurate observations increased; on some days concerns about human error increased.

Moreover, accuracy mattered more at some times of year than others. Because of the angle of the sun, minor errors in calculations or observations in March and September translated into larger errors in navigation than they did closer to mid-summer.[45] And on long voyages, even the most concrete ideas about how to calculate the date slipped and swam before the captain's pen. Perhaps the most famous example of this reversal, is that when the Spanish first sailed to the Philippines, the sailors lost one day in their reckoning of the civil day. As a consequence of being "out" of their reckoning one day, for many years the Philippines celebrated Sunday one day "off" the rest of the world.[46]

The tool the captain, navigator, or sailor employed to track the multiple temporal regimes operating on the ship was the ship's logbook. Logbooks integrated in one place multiple temporal orders, tracking the civil calendar and religious calendar, labor on board, and against this they also tracked environmental conditions, general observations, courses run, soundings, the knots per hour, personal impression and feelings, as well as the rate of the chronometer (if

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[44] Arnold, *The American Lunarian,* 36; Joseph Blunt, *The Shipmaster's Assistant and Commercial Digest* (New York, 1853), 12-13; John Hamilton Moore, *The New Practical Navigator* (1799), 75; John McLeod Murphy and W. N. Jeffers, Jr., *Nautical Routine and Stowage, With Short Rules in Navigation* (New York, 1849), 11.

[45] Thomas Arnold, *The American Lunarian,* 36.

[46] Mackey's version of the events: "The Spaniards, in sailing westwardly by Cape Horn, when they discovered the Philippine Islands, lost the greater part of twenty-four hours. In consequence of this, some of the inhabitants of Manilla, in the island of Laconia, keep Monday, believing it to be Sunday, to this day." Andrew Mackey, *The Theory and Practice of Finding Longitude,* 5. Also see Adam Barrow's interpretation of this problem: Adam Barrow, *Time, Literature, and Cartography after the Spatial Turn: The Chronometric Imaginary (*New York: Palgrave MacMillan, 2016).

they had one), celestial observations, and their dead reckoning. The list is extensive, and that is the point. The logbook grew into a tool where all of these different methods of tracking the ship could be compiled and systematically compared.

The logbook first emerged as a tool for Iberian navigators in the sixteenth century and slowly spread northward.[47] English nautical literature first encountered the idea of a ship's logbook in John Davis's *Seaman's Secrets* (1594). As Susan Rose observed in her survey of fifteenth and sixteenth century nautical texts, "sailors had often made such notes [...] but setting it out in a tabular format made for more systematic and uniform recording and a formula which could be taught."[48]

For most of the eighteenth century, manuals on navigation were prescriptive about the format and contents of the logbook but not consistent. As a consequence, it was not entirely clear what kinds of information, organized in what way, should (or must) be in a logbook entry. Mid-eighteenth century logbooks were often very detailed, tracking the hours of each day and aligning with each hour the courses and distances run, the weather, the wind direction, currents, and any observations that were made. The information contained in the logbooks, however, varied so widely, and was organized in such a way, that there was no particular pattern to their contents. This captain tracked each hour of the day, while this one divided the day simply into three sections corresponding to the three watches of the day while another simply noted the events that occurred "this 24 hours."[49]

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[47] Margaret Schotte, "Expert Records: Nautical Logbooks from Columbus to Cook," *Information & Culture* 48, no. 3 (2013): 281-322, 287; also see John F. Campbell, *History and Bibliography of* The New American Practical Navigator *and* The American Coast Pilot (Salem: Peabody Museum, 1964) 13.

[48] On the history of logbooks see: Susan Rose, "Mathematics and the Art of Navigation: the Advance of Scientific Seamanship in Elizabethan England," *Transactions of the Royal Historical Society* 14 (2004): 175-184, 177; 183; Margaret Schotte, "Nautical Logbooks from Columbus to Cook," 281-322. Schotte argues that logbooks are an example of Lorraine Daston's concept of an "epistemic genre," Schotte, 286.

[49] For example, both of these entries were created by captains sailing out of Salem, MA:

To illustrate the ways that navigators used logbook entries, we should consider how the information contained in an entry recorded in 1789 by Elias Haskett Derby on board the ship *The Grand Turk* related to larger ideas about place and time. Three years before this entry was recorded, *The Grand Turk,* under Captain West, became the first American vessel to travel to India and China by way of the Cape of Good Hope. By the Revolution, New England Yankees had become "one of the great sea faring peoples," spending the bulk of their efforts in the

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Friday March 30th, 1764: This 24 hours very good wind in our favor but at 4 am had a squall in which our toping lift unhooked & main Pasel rope broke the boom hung in the water & in this confusions we lost our book tack. Since our Departure from Cape Henry we are 23 miles more N'erly by account than by observation which I am apt to think is owning to Carying[sic] the MS always on the Larboard side with the wind so on the quarter that she has griped too & the error is in the Course which makes nothing in Longitude. Our Course & Distance since left Cape Henry is NWBE 212 miles with Latitude Meridional Distance & Longitude as in the margin.

Philip's Library, Log 4, *Schooner Dolphin, Schooner Swan, and Two Unidentified Vessels,* 1757.

Tuesday to Wednesday, Feb. 11, 1784:

2 "This 24 hours begins with a fresh breeze and fair Weather.
4 T.G. Sail handed and MT mast
St. Sail handed. At 2 PM last
6 Sight of the Caueases & at 4 PM saw
Mauguana about NW 1/2 [?] W at mast
8 Head fresh breeze large Sea
At 6 O Managuan Bore
10 W by N 5 leagues from wich[sic]
I take my Departure it
2 Being in Latt 22=35 N
4 Long = 72 =46 West —
6 At 6 AM set TG Sail
8 The Latter Part moderate
10 The People Employed in Drawing
12 Yarns for Spunyarn
Latt^d by Sun 23=15N

Philip's Library, Log 3001 (OS) *Brig Ocean*, 1783-4. The style of logbook entries even varied within logbooks. For instance, the *Ocean's* entry for February 9th, 1784:

Friday to Saturday March 20th, 1784: "These 24 hours begins with light breezes & cloudy, at 2 morning wind got at SSW Light winds & very thick all round tack ship it being the 1st time since we lost our mast & she worked Very Well — & leak^d Very Well too & knows how to Rowl in a Calm, Very well. Caught 2 Dolphins eat them. Ends light airs & fair weather — Latt^d by Obs. Sun 25.51 N

Atlantic trade routes or in fishing for cod on the Grand Banks.[50] However, after the Revolution, the British asserted control over north Atlantic fishing grounds, forcing American maritime communities, like Salem, to find new sources of income.[51] Convinced by Captain West's success, Derby decided that the future of New England maritime commerce lay in opening that route and establishing permanent trade routes to Canton for the new United States.[52]But nautical charts, meteorological records, and coast surveys were often proprietary secrets guarded by British, French, and Dutch companies and navies.[53] To open routes to China, Derby and other American captains needed – rather literally—to feel their way, nearly blind, across two oceans and around three continents.

The logbooks from these journeys, like the one from *The Grand Turk* below, record that questioning, calibrating approach to navigation. They illustrate how captains used logbooks to seek new information, try to find patterns in observed phenomena, and then use all possible sources of information to approximate their position in place and time.

> "Sunday February 1, 1789: Calm Caught a Dolphin & Shark saw several Sharks & other Fish, middle & Latter part light breeze from NE Whilest Calm tryed the Current & found it set NW 4 1/4 fast my Watch, the Variation of which by several Observations of equal Altitude I have found but small & that very regular until these 24 hours it has gained 4 1/2 Minutes. This with the decrease of the Variation of the Compass, convinces me of having been in a strong Western Currant. Lat Observed 1.48 S Long by Acct 26.57 W Long by Variat^n 28.08 W Long^d by Sun & Moon dis. Observ^d 29.24 W."[54]

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[50] David Walker Howe, *What Hath God Wrought: The Transformation of America, 1815-1848* (Oxford: Oxford University Press, 2009), 47; Daniel Vickers, *Farmers & Fishermen: Two Centuries of Work in Essex County, Massachusetts, 1630-1850* (Chapel Hill: The University of North Carolina Press, 1994).

[51] Daniel Walker Howe, *What Hath God Wrought*, 47.

[52] Stanford, *The Navigator,* 86.

[53] Chaplin, "Knowing the Ocean," 75-77; Allison Sandman, "Controlling Knowledge," *Science and Empire in the Atlantic World,* eds. James Delbourgo and Nicholas Dew (New York, 2008): 31-52.

[54] Elias Haskett Derby, "Log for the Ship, *Grand Turk,*" Philip's Library, log 23.

At first glance this entry might seem like a confusing and unsystematic jumble of observations and commentary. However, on closer inspection, we can begin to see the ways that this logbook entry balances methods of knowing time and space against each other. It begins with the date according to the civil calendar (Feb. 1, 1789), which runs from midnight to midnight, but the entry itself is structured according to the three watches of a days work, which runs from noon to noon. This author has previously wondered if the geographical distribution of fish might be signals of currents or larger patterns, so his early entry on the presence of sharks and fish is another installment his earlier pattern-seeking efforts. He finds a current, discovers that his watch, which he confirmed has been accurate based on astronomical sightings, had now begun to run too fast. The relative slowness or fastness of chronometers and the variations of compasses could be used as geographical cues, since the relative humidity, temperature, and variations in the earth's magnetic field could affect each instrument. Like a dowsing rod, this author uses the presence of variation in his watch and compass to determine whether there are other phenomena affecting his ship that he cannot feel himself. Based on the compass variation, he concludes he must be in a current. Derby's entry concludes with two observations giving his position in latitude and longitude. In this entry, one of hundred in the logbook, Derby has provided a systematic tally of all the available ways of knowing time and location that occurred during that day, carefully balancing qualitative and quantitative ways of reckoning temporal and spatial locations. In 1789, the contents and formats of logbook entries were largely unsystematized, but in the coming decades Derby and other members of Salem's maritime community would lead the country in the effort to systematize the contents and format of logbook entries as a method for revealing a universal timekeeping system based on observable features of the natural environment.

Margaret Schotte, in her study of European logbooks from Columbus to Cook, argued that logbooks developed through three phases. In the first, European ship masters began to keep logbooks to aid their memories as journies grew longer and the minutia of navigation expanded. According to Schotte, in the first phase of their adoption, logbooks were eclectic in format and contents and produced primarily for the individual's use at sea. Next, in the mid-seventeenth century, the logbook developed into a tool of empire, where authors submitted their logs to authorities and also submitted to ever-greater demanded on the contents and formats of the logbook.[55] This fits Mohan's interpretation of vernacular risk culture in America, as well as Vladimir Jankovik, and Lloyd Pratt's arguments about diurnal forms as a practice of self-evidencing.[56] In the final phase, freighted with legal and professional demands for details and precision, Schotte argues that by 1800 European mariners "ceased verifying each element [of the logbook] through daily use."[57]

The three-phase process Schotte identified broadly fits the history of logbooks in the United States if we think of logbooks as primarily spatial tools, though the final phase arrived much later in American logbooks than in European ones. However, by the end of the eighteenth century the logbook had become a far more complicated paper technology than Schotte and Rose account for in their studies focused on navigating space and producing scientific knowledge. Logbooks were technologies operating at the interface between abstractions of space and time and the material world at sea, a juncture where place and time were linked. Logbooks were more than technologies used to navigate space. As an organic timekeeping technology, American

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55 Margaret Schotte, "Nautical Logbooks from Columbus to Cook," 281-322.

56 Lloyd Pratt, *Archives of American Time: Literature and Modernity in the Nineteenth Century* (Philadelphia: University of Pennsylvania Press, 2009); Vladimir Jankovik, *Reading the Skies: A Cultural History of English Weather, 1650-1820* (Manchester: Manchester University Press, 2000), 113-124; Arwen Mohun, *Risk,* 6.

57 Schotte, "Nautical Logbooks," 284

logbooks developed into tools to negotiate uncertainty—in time and space, as well as the competence of the navigator. Because historians of time typically only consider the contest between lunars and chronometers—between the clock and the calendar—we have overlooked a timekeeping technology that mediated between the two methods, and the placebound phenomena in which they existed.

Because of this, I would argue for a slightly modified narrative of the rise and diffusion of logbooks. At its most basic, a logbook was a journal recording watches, courses, and observations, and as such it was an "index of change" aboard ship. As the need for precision timekeeping grew, as European and American ships sailed farther afield and the acceptable margins of error for navigation grew smaller, the logbook developed into a technology that helped a captain calibrate different timekeeping methods against each other. By the beginning of the nineteenth century it became a controlled, systematized space with increasingly standardized contents and format, within which a navigator could weigh several competing methods of reckoning time and space. The logbook could not tell what time it was precisely, but like the hot-bed, it would narrow the margins of error within which choices could be made. Importantly, in the era when neither celestial navigation nor the chronometer were fully practicable or universal method of navigation, the logbook was consciously developed as a solution to the problem of accurate timekeeping at sea. The logbook was a modern organic timekeeper.

Salem's Logbooks

Seafaring had always been dangerous, but as American shipping expanded in the second half of the eighteenth century, so too did the exposure of small ports and coastal communities to the risk of dying at sea. This exposure to risk, in turn, contributed to a growing awareness within seafaring communities about what dangers were more avoidable than others and a sense of what improved navigation might look like. After the American Revolution, American seaports like Salem operated on thin margins both in terms of the capital investment and the proportion of the local population at sea at any point in time. Threatened by the French and British at sea, seeking new trading routes to Southeast Asian ports like Canton, Malacca and Manilla, and with only the scantest protection from the American navy, American shipping sought every advantage it could.

There was also a personal advantage to improving individual skills at navigation by learning to use the logbook to mediate between chronometers and lunars. Nearly half of the men shipping out of the port of Salem in the middle of the eighteenth century could anticipate a promotion to mate, and 27% to ship's master.[58] Mates and ships' masters both were required to have mastered astronomical navigation and demonstrated that skill by keeping an accurate logbook. Thus, roughly half of all mariners in Salem would be required at some point in their careers to learn to keep a logbook and learn the basics of celestial navigation.[59] Excelling at navigation could help keep you safe, and it could also open a path to promotion.

While the international political situation was not something the captains of Salem could change, they could push for improved navigation, which would help their bottom line and help prevent death at sea. In a town like Salem, literally everyone knew someone who had died at sea, and often from preventable errors in navigation. Daniel Vickers and Vince Walsh have done a careful study of mortality in Salem, Massachusetts between 1750 and 1850. They estimate the for those who shipped before the mast during that period, the likelihood of death at sea was

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58 Daniel Vickers and Vince Walsh, "Young men and the sea: the sociology of seafaring in eighteenth-century Salem, Massachusetts," *Social History* 24, no. 1 (1999): 17-38, 30.

59 Vickers and Walsh, "Young men and the sea," 29; Daniel Vickers and Vince Walsh, *Young Men and the Sea: Yankee Seafarers in the Age of Sail* (New Haven: Yale University Press, 2007); Daniel Vickers, *Farmers & Fishermen.*

roughly 30%.[60] While exposure to malaria or bad weather were impossible to avoid, death from faulty navigation was one danger that could be addressed.

It is in this context that American authors began to discuss logbooks as tools with a new purpose. Treatise on navigation introducing the logbook specify that though the technology was quite old by 1800, logbooks were only becoming more necessary rather than less.[61] "This method [of keeping a reckoning], with some alterations and improvements, has been in constant use among mariners, ever since the first attempt towards long voyages," one American nautical author observed, "and is what must ever be retained, even if celestial observations can be made with the greatest certainty and precision."[62] The nautical press championed the idea that with the help of this old tool, the logbook, of the "scientific sailor" would become capable of generating universal truths simply by attending to his bodily experience.[63] Between the chronometer and the calendar was the logbook wielded by a scientific sailor.

The Scientific Sailor

"A SEAMAN, in the language of the profession, is not merely a mariner or laborer on board a ship, but a man who understands the structure of this wonderful machine, and every subordinate part of its mechanism," Philadelphia publisher Thomas Dobson's *A System of Seamanship and Naval Tactics* (1799), the first American edition of this portion of the

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[60] For a more extended discussion, see Jason W. Smith, *To Master the Boundless Sea: The U.S. Navy, the Marine Environment, and the Cartography of Empire* (Chapel Hill, The University of North Caroline Press, 2018), 15.

[61] Again, pushing back against Schotte's periodization.

[62] *Essays, Mathematical and Physical: Containing New Theories and Illustrations of Some Very Important and Difficult Subjects of the Sciences.* (New Haven, 1800), 36.

[63] This sentiment was also in the English guidebooks. To be clear: this is not only an American story, but we can see it in its more extreme version in American contexts because the records (as will be explained) were so well preserved.

Encyclopedia Britannica, explained.[64] The art of sailing, according to Dobson, had not received appropriate recognition or support. Its practitioners suffered from the disrespect of portside spectators, who looked down on "persons without what we call *education*, and in the humbler walks of life."[65] Instruction manuals written for their benefit either shared in this disdain or were more often mathematical treatise too much removed from the actual operation of the ship or the true uncertainties of hydrodynamics and weather to be useful. But the seaman was not ignorant or un-teachable, Dobson declared. Quite the opposite. Defending his subjects, Dobson defined the plight and potential of that the sailor this way: "he possesses a prodigious deal of knowledge; but the honest tar cannot tell what he knows, or rather what he feels, for his science is really at his finger ends."[66] Through years of constant practice at sea, by acquiring vast stores of sea-lore shared between shipmates, and by requiring this sea sense to occupy his whole mind and discourse, Dobson argued that the "rough sailor" was truly the highest expert at his own art, and collectively seamen were capable of generating even more useful "mathematical dissertations" than men like Euler and Bernoulli.[67] Dobson's purpose was to "enable the uninstructed but thinking seaman to generalize that knowledge which he possesses; to class his ideas, and give them a sort of rational system; and even to improve his practice, by making sensible the immediate operation of every thing he does."[68] Individually, sailors knew much more about the

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[64] Thomas Dobson, *A System of Seamenship and Navel Tactics, Extracted from the Encyclopedia* (Philadelphia, 1799) 3; This book is compiled and condensed from abstracts within the first American edition of the *Encyclopedia Britannica* (1799).

[65] Dobson, *A System of Seamenship,* 4.

[66] *Ibid.*.

[67] Dobson, *A System of Seamenship,* 9.

[68] Dobson, *A System of Seamenship,* 11; Historian Marcus Rediker agreed with this assessment: "Seamen created a rich store of knowledge, much of it genuinely scientific and reliably predictive, from the heavens and the earth. The studied and interpreted the movements and characteristics of the sun, moon, and stars, the clouds, winds, and waters, even the wildlife at sea." Marcus Rediker, *Between the Devil and the Deep Blue Sea*, 179. Margaret Schotte's forthcoming book will investigate the knowledge generated by sailors and the literary world of nautical education. Margaret Schotte, *Sailing School: Navigating Science and Skill, 1550-1800,* (Baltimore: Johns Hopkins University Press, 2019).

rules of wind and weather, waves and stars than mathematicians, and they carefully attended to those environmental changes in the practice of their art—if they did not, how else could ships get safely across the face of the water? By the Early Republic, the fundamentals of navigation had become general knowledge for ordinary seamen.[69] This argument mobilized commonsense applications of classical probability and Enlightenment notions of self: given the number of sailors traversing the oceans, in the long term, through daily practice, the sailors' work would reveal generalizable truths.

The idea behind Dobson's scientific sailor was that mariners collectively and intuitively possessed the key to most of the major questions that troubled mathematicians about navigation at sea. Individual sailors might err somewhat, but over time, if they could be trained to communicate and systematize their observations, seamen could collectively arrive at better methods for navigation and sailing than mathematicians. Sailors had not been taught to communicate their knowledge in ways that allowed them to build from individual observation to universal truth. The tool that would effect this revolution was the ships' logbook. As Andrew Mackey explained, "the common method of deducing the ship's longitude, from the course and distance made good, is at best only an approximation to the truth."[70]

Dobson's move to seek generalizable truth in the work and wisdom of ordinary sailors follows a slightly earlier movement within British meteorological tradition of seeking weather knowledge from shepherds or other representatives of local knowledge.[71] The genre of "shepherds' calendars" emerged from the idea that, as the historian Vladimir Jankovik explained

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[69] Rediker, *Between the Devil and the Deep Blue Sea*, 87.

[70] Mackey, *The Theory and Practice of Finding the Longitude,* 91.

[71] Vladimir Jenkovik, *Reading the Skies: A Cultural History of English Weather, 1650-1850* (Chicago: The University of Chicago Press, 2000), 130-137.

in his history of British meteorology, "the Virgilian farmer predicts weather because Jove [God] himself had revealed to him the true correspondence between signs and signified events."[72] Within this framework, Jenkovik argues that British savants began to believe that people in occupations that required their practitioners to pay close attention to embodied experiences of place, had become the best predictors of environmental processes and change. The assumption was that farmers, sailors, and shepherds had absorbed, in some preconscious way, the true patterns of nature that pertained to their particular occupations. This ideas was very durable, and appears in the seventeenth century shepherds' calendars Jenkovik examines, the 1762 edition of *The British Encyclopedia* Dobson copied, as well as meteorological texts throughout the nineteenth century. Charles Bell, for instance, argued in his contribution to the Bridgewater Treatises, that nature "has endowed the most illiterate of the species [sailors] with a certain degree of prescience of some of its most capricious alternations."[73] Though they pursued their tasks intuitively and imperfectly, by simply successfully accomplishing their work as farmers or sailors, practitioners "seize as it were the precursors of the coming phenomena, and for the most part, they merely obey an instinct which compels them to prognosticate."[74]

Because he is compelled, as if by instinct, to recognize and participate in the environmental patterns unfolding around him, the scientific sailor and the weather-wise shepherd also reflect an Enlightenment understanding of the subject. This individual, in Galison and Daston's words, was "fragmented: atomistic sensibilities were combined by the mental faculties of reason, memory, and imagination to force associations."[75] Patterns, associations, surface through the compulsion

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72 Jenkovik, *Reading the Skies,* 137.

73 Bell in Jenkovik, *Reading the Skies,* 137

74 Andrew Steinmetz (1864), in Jenkovik, *Reading the Skies,* notes page 224.

75 Daston and Galison, *Objectivity,* 201.

within all men towards reason, memory, and imagination without the mariner or farmer consciously exerting an effort to restrain himself. Dobson's text suggested that should be possible to teach these intuitive deducers of rational order to communicate that order, after which points someone could collect it, compare it, and from the generalizable truths contained in the sailor's communicated experience produce better general guidebooks.

Nathaniel Bowditch

No American embodied the idea of the scientific sailor more than Nathaniel Bowditch. Bowditch was born in 1773 in the small port town of Salem, Massachusetts. The son of a hard-drinking barrel-maker and former mariner, Bowditch was born into a tight-knit network of Salem seafaring families.[76] He attended grammar school for three years, but after his father's death apprenticed to the ship's chandlery of Ropes & Hodges. At the shop Bowditch spent his days, ostensibly learning the methods of account keeping and stocking ships. Bowditch, however, from an early age caught the attention of his relations, coming to be known locally as a youth with a mind keen for numbers and eager to learn any new material related to them. He was meticulous, as testified by his notes on bookkeeping manuals and methods, and swallowed up any mathematical texts or tools that crossed his path.[77] He taught himself Latin in order to read Newton, and filled his commonplace books with copies of algebraic manuals and logarithms.[78] Working as a surveyor and a ship's clerk, Bowditch's remarkable mathematical ability caught the attention of many of the captains and shipowners in Salem. During a lull between voyages,

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76 See Thornton and Vickers and Walsh on tight-knit Salem community. Thornton, *Power of Numbers,* 7-32; Vickers and Walsh, "Young men and the sea," 17-38.

77 Some examples: Philip Library: B1 F6, Exercise Book, 1784; Bi F7, Field book for land survey of Salem (portions believed to be Bowditch's); B1 F8 MSS 3: Field book for land survey of Salem.

78 Philip's Library: B3 F3: Mathematical tables; on learning Latin and other personal accounts, Philip's Library: MH 42.

Bowditch was approached by Edmund M. Blunt, the New York-based publisher of *The American Coast Pilot*.[79] Blunt wanted to republish an American edition of Moore's *Practical Navigator,* and he wanted Bowditch to help with the revisions and corrections to Moore's instructions for working lunars as well as the tables needed to navigate by lunars.[80]

In 1798 Bowditch was invited to take the position of agent aboard the ship *Astrea* under Captain Henry Prince—the young captain who reputedly replaced Captain John Gibout after he bought the chronometer.[81] The *Astrea* was bound for Manilla, and Bowditch has been invited precisely because his skill with numbers meant that he had learned how to reliably and swiftly work lunars. Among Bowditch's duties aboard ship was keeping the ship's logbook.[82] Chasing the monsoons across the Indian ocean, Bowditch reportedly spent his days closeted with Moore's nautical almanac, working the figures for both practical reasons and personal enjoyment. Bowditch seemed to take a great deal of personal satisfaction in working the repetitive and lengthy calculations required to generate nautical almanac tables, and in the process of working these questions, he discovered nearly three thousand errors in Moore's tables.[83] The most important error was that Moore had not calculated 1800 as a leap year, rendering every calculation after that date inaccurate.

In the ship's logbook that he kept during the journey, we can see Bowditch weighing Moore's directions in much the same way that Derby previously used the logbook to calibrate his

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[79] Thornton, *Power of Numbers,* 60-61.

[80] Bowditch was not the only person Blunt approached for the revisions, but ultimately he is given credit in the new edition for the majority of the revisions, and in subsequent editions, he is the listed as the author. For extended discussion, see Thornton, *Power of Numbers,* 63.

[81] Bowditch first went to sea in 1795 as a clerk aboard the ship *Henry.* For additional context on his early life and voyages see Thornton, *Power of Numbers,* 7-32, 33-43.

[82] Philips Library: Log 1302 *Astrea* (ship).

[83] Thornton includes a more extended account, Thornton, *Power of Numbers,* 43-52; 58-65.

reckoning. In one entry, despite seeming uncertainty, he uses the position of a cape to determine Moore's accuracy, and work backwards towards an accurate position in space.

> "At noon April 25, […] [sun's] Dec. 13.31°N ships latitude 38.39° N at which time the fort of Coscage wore N.W. By W. By compass distant 1 mile : & a church to the eastward, about N. 1/2 mile distant. Nearby the church, & find that the ship in that situation must have been 4'4 miles S. Of cape Roque. Which would make the latitude of Cape Roque 38. 34. 1/4 which agrees within 1 3/4 miles, of that place, as given by Moore."[84]

Like Derby, the owner of the *Astrea*, Bowditch also used the logbook to track new information that might, in time, prove useful. For instance, on the way from the Cape of Good Hope to the Island of St. Paul, he announced in the logbook, "Near this place when the wind howls to the Northward of E. It remains some time. When it lightens to the westward it is almost a sure sign that the wind will shift from the north to W & S. In the latter point it becomes moderate."[85] In August, on the return trip and passing St. Paul, stormy weather prevented Bowditch from taking either a lunar observation or a steady reading from the sun at noon. He only determined that he had passed the island by noting the floating sea kelp, and three days later, judging that they had passed the island because the kelp had disappeared. Hired for his aptitude in taking lunars, Bowditch relied on the logbook as a timekeeper in ways not dissimilar to his predecessors. Even Bowditch, much as he appreciated the abstractions of celestial navigation, relied on the practicalities of the logbook as a timekeeper as a method for reducing the uncertainties of celestial navigation. Looking for a solid fix on his sense of time and space, Bowditch anchored his navigation not only in lunars but also in the mud on the bottom of the ocean, the floating kelp, and weather patterns.

But he could not ignore what appeared to be the continued errors of Moore's guidebook. "At

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[84] Philips Library: Log 1302, 169.

[85] Philips Library: Log 1302, 185.

day break we discovered the Island of Trinidad, where by the mean of several good lunar observations we make in the longitude of 28.39W which is nearly 2[degrees] less than Moore's Epitome," Bowditch announced in July 1796 aboard the *Astrea* in what had become frequent commentaries on Moore, "this great difference induced us to take other observations while in sight of the land, all of which agreeing very well with each other, left no doubt of their accuracy."[86] For a mind so trained to appreciate precise numerical calculations, the cumulative errors in Moore seemed to rankle. And the errors in Moore's tables of declination were not inconsiderable. Most of the year, one second in time was equal to four nautical miles. When Bowditch complained that Moore's coordinates for the Island of Trinidad were two degrees off, he was also complaining that the island was eight miles away from where they expected it to be. Arriving at night or in a storm, thinking the ship was keeping a safe distance from the island, such an error could wreck a ship.

Worse yet, Moore's errors were actually more serious depending on the time of the year. Near the equinoxes, in March and September, Moore's erroneous tables of declination would place an uncareful sailor nearly twenty-four miles off his actual location for each second of error calculated. In the years following Bowditch's revisions to Moore, American nautical manuals featured numerous testimonials from mariners who had accidentally followed Moore and foundered, or known his errors and narrowly escaped a bad end. "In the year 1800, about the middle of March, being bound to the Havanna [sic]," Thomas Arnold, author of the *American Lunarian* explained in 1822 as one example among many, "I made use of one of Hamilton Moore's epitomes, printed before 1800. Knowing this error, I took the declination for one day earlier. Had I not been aware of it, I should have used the declination for the day as given in the

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86 Philips Library: Log 1302, 232.

epitome, and should have been about twenty-three miles out in the latitude."[87]

During the voyage on the *Astrea,* Bowditch corrected Moore and Blunt published the revised 1799 edition under Moore's name. The next year, Blunt published another edition with Bowditch's heavy revisions under Moore's name. However, after that Bowditch considered Moore "nothing but a tissue of errors," Blunt and Bowditch agreed to publish a new work substantially rewritten by Bowditch and published in 1802 under his name: *The American Practical Navigator*. In the preface, Bowditch explained that in honor of the thousands of corrections he had made to the book and the new methods he had inserted for more speedily calculating lunars, he felt he deserved to call the work his own. Much like M'Mahon (who made his name on a copied version of Abercrombie), Bowditch gained a wide readership among American sailors, eager to acquire, for relatively small sums, a guidebook tailored to American practices, with more detailed coasting instructions and piloting information for American contexts. The *Practical Navigator* went through ten editions during Bowditch's lifetime, and after his death continued to be the standard handbook of the American nautical world. Updated, it remains the handbook for the American merchant marine and naval academy even today, now published under the direction of the National Geospatial-Intelligence Agency.[88] When he died, Bowditch's eulogizers celebrated him as the epitome of a "thinking machine," and a "scientific sailor." Bowditch seemed to be the fulfillment of Dobson's prophecy about the kinds of knowledge mariners would learn to produce through his intuitive encounters with nature.

In his early and meteoric rise to celebrity, Bowditch embodied the twin hope of the logbook

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[87] Thomas Arnold*, American Lunarian,* 36.

[88] As an interesting point of fact, the 2002 edition reduced the role of celestial navigation in the text for brevity, but the 2017 edition brought back the excised material because of a recent return of interest in classical celestial navigation. The 2017 edition is only available electronically now. https://msi.nga.mil/MSISiteContent/StaticFiles/NAV_PUBS/APN/Bowditch_Vol_1_LoRes.pdf.

and the scientific sailor. And, just as Dobson hoped they would do, Bowditch used his experience at sea—his encounters with Moore's errors both mathematical and empirical— to generate new and generalizable information by employing the logbook as a way to calibrate and correlate his observations. He tracked these observations in the logbook, too, and upon his return, he compiled this information and published it, for the general benefit of seamen everywhere.[89]

Lunars themselves, all three men asserted, were ideal in theory, but also not fully practicable. The same rocking of the ship that set the clock out of its rate could cause a navigator to misjudge angles of declination. On rough nights or when it was cloudy, no observations could be made at all, and so sailors would of necessity fall back upon the logbook to find their way through space and time. As a consequence, it was not enough that mariners grew more comfortable with celestial navigation; logbooks needed to develop alongside the clock and the nautical almanacs.

If Bowditch was an example to Americans in general about what kind of information sailors might produce at sea, he was also an example to himself. For the most part, Bowditch measured those he met in the world against his own rather rigid internal standards.[90] As a consequence of his high expectations for the capacity and abilities of everyone around him, Bowditch insisted on teaching every member of his crew, from the first officer to the cook, how to work a lunar,

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[89] Bowditch was not without competition. Andrew Mackey's nautical epitome tended to be preferred in the American south, while J.W. Norie's was the handbook of choice in the British Empire. However, it is significant that Bowditch, Norie, and Mackey all shared a skepticism about the role of the chronometer aboard ship. In their opinions, the chronometer was too finicky to be reliable. It did not do what a clock was supposed to do: the chronometer did not count regular units. It gained and lost seconds across each hour. With seconds expanding and contracting in length across an entire journey, a clock could not work in the long run, and so should be set aside in favor of something more perfect. One second of time correlated very directly to a certain quantity of distance, and if using a chronometer meant that one second in time might vary in duration, than it seemed to upset the entire system.

[90] After his death, Bowditch's fourth son, William Ingersoll Bowditch, wrote, "there can be no doubt that father got angry easily. One would think that he would remember that what plainly appeared to Laplace sometimes required two or three days of hard work by him before he could discover how it plainly appeared. This lesson taught to him so many times over and over again ought to have taught him to have been more patient with people who did not view things at once from his standpoint." Philips Library: MH 42, 351.

providing the mental as well as material tools necessary to perform the calculations.[91] One of Bowditch's former cooks, an African American man named Jack, caused a sensation in Genoa in 1817 when the Austrian mathematician and astronomer Aton Frieherr von Zach discovered that he had learned to work lunars and kept his own logbook of the ship's course.[92] "I asked him, 'What method do you use to calculate the longitude by lunar distances?'" the Baron related in the fourth volume of his *Correspondence Astronomique*, "His answer was, 'It's all one to me: I use the methods of Maselyne, Lyons, Witchel, and Bowditch; but, upon the whole, I prefer Dunthorzne's; I am more used to it, and can work with it quicker.'"[93] When Zach questioned him further, Jack produced a copy of Bowditch's *Practical Navigator* and the nautical almanac as well as his calculations on the previous voyage, all more accurately kept than the captain's sons' logbook.

Bowditch made a point of teaching his crews to navigate, because he assumed and demanded that they were capable of the task. He expected all mariners to be capable of mastering the skills of astronomical navigation taught in his manuals. At a time when nearly 25% of all adult males in Boston, New York, and Philadelphia worked in the maritime sector, Bowditch implicitly expressed a deep confidence in human capability, investing more confidence

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[91] Philips Library, MH 42.

[92] Anecdote translated from Zach's *Correspondence Astronomique* (vol. 4, pg. 62) in A Young, *Varieties of Human Greatness* (1838), 29-30. Philips Library: EB 7854. For additional context on navigation and the experiences of nineteenth century African American sailors: in a study of black seamen in the port cities of Philadelphia, New York, and Rhode Island, W. Jeffrey Bolster found that there was considerable "lateral" movement for African American sailors between shipping as seamen, steward, or cook, and increasingly little advancement to mate or ship's master. In addition to being tutored by Bowditch, African American marinors like Jack may have learned navigation in a number of possible contexts, from daily experience on the foredeck, a book, or at one of the newly established navigation classes taught at schools for African American mariners in New York and Philadelphia. See: W. Jeffrey Bolster, "'To Feel Like a Man': Black Seamen in the Northern States, 1800-1860," *The Journal of American History* 76, no. 4 (1990): 1173-1199, 1174, 1184.

[93] Philips Library: EB 7854.

in any ordinary seamen strolling dockside than a shop full of carefully crafted chronometers.[94]

At the same time, he also worked to minimize the potential for human error. To limit this possibility, Bowditch introduced quicker methods for working calculations and he guided his readers away from making use of observations where the margin of error might be too much to avoid. Defending his choices in the *Practical Navigator,* in 1818 Bowditch explained that he had gone out of his way to make sure that "the method of correcting the apparent distance of the Moon from the Sun, or a Star for the effect of parallax and refraction" were entirely done through addition, a method Bowditch argued was "peculiarly well adapted for the use of mariners."[95] Likewise, Bowditch explained that observations near the horizon vary depending on the refraction, and since refraction is influenced by the surrounding temperature and humidity of the air, "for a variation of ten degrees in Fahrenheit's thermometer would produce and alteration of 45" in the refraction of a body, situated 5' above the horizon."[96] Since sailors did not usually refer to thermometers or barometers, Bowditch argued that low altitude calculations like this should be avoided entirely.[97]

The Logbook Systematized

Navigation was a science of approximations and there was no way to eliminate human error in navigating by lunars. The logbook as a tool for calibrating different methods of finding time therefore still had a central role in Bowditch's system of navigation. Didactic instructions for mariners in how to keep a logbook was only half of the project. The other half of the effort

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[94] Marcus Rediker, *Between the Devil and the Deep Blue Sea,* 62.

[95] Nathaniel Bowditch, *Mathematical Papers from the Fourth Volume of the Memoirs of the American Academy of Arts and Sciences.* (Cambridge, 1818), 24. Philips Library: QB 15 B68.

[96] Nathaniel Bowditch, *Mathematical Papers*, 30.

[97] Nathaniel Bowditch, *Mathematical Papers*, 30.

was iterative. Bowditch, the sea captains in Salem, his publisher in New York, and eventually the US Navy, developed both informal and formal processes for reviewing logbooks, standardizing their contents and formats, commenting on well-kept logbooks, and then republishing portions of logbooks as commentaries on nautical charts. Within two decades most coastal states required captains to submit their logbooks for review when entering their ports, and the US Navy required all midshipmen to keep logbooks and all captains to review those logbooks daily. In some cases, the law was even more expansive, and required not only all captains to make the information contained in their logbooks publicly available, but also any passenger who kept a logbook.[98]

Having returned to port and awaiting the publication of the *Practical Navigator*, in 1799 Bowditch assisted with a project organized by Salem's East India Marine Society (EIMS) to begin systematically keeping, collecting, and amending the logbooks of its captains. Members of the East India Marine Society voted that all captains returning to port "shall in all cases present the journals of their voyage to the committee no excuses being admitted that nothing worthy of notice had occurred."[99] With these logbooks in hand, the committee proposed to glean useful information from the texts and accession the logs for future reference. Rather than accepting any content in the logbooks, the committee was specific about *which* kinds of observations a logbook *must* at a minimum include, in addition to any other information which a captain might find useful. Prescriptive notes like this had the effect of standardizing logbook contents and, in turn, approaches to timekeeping at sea. EIMS captains agreed that at a minimum all logbook entries must contain: "the bearings & distance of Capes & Headlands, the latitude & longitude of the Islands, rocks, & Shoals, the Sounds, tides & currents along the coast of any Country he may

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[98] American, British and various Dutch and German regulations on the use of logbooks were summarized and compared in Charles Larimer, *Letters to a Young Master Mariner, on some Subjects Connected with his Calling*, 3rd ed. (London, 1843).

[99] "Articles of Association, Bylaws, Minutes, 1799-1803," Philips Library: B1 F1 EIMS.

visit during his voyage, in any observations to the public."[100] Bowditch was one member of the committee, and took up the task of compiling and annotating the first volumes of logbooks. Perhaps to induce captains to keep the logbooks in closer compliance with their wishes, or perhaps to encourage system and uniformity, following the vote in 1801, the East India Marine Society (EIMS) designed and printed logbooks for their captains to use while at sea.[101] The minutes of the EIMS list which logbooks were submitted as well as those that were lent to captains to review.[102]

This push for system in logbook keeping did not originate in Salem, nor was it pushed exclusively by Bowditch. British nautical manuals also advocated for more regular schedules for observations, and urged that the same seamen would take the observations with the captain and mate each day—so that they would grow accustomed to each other and minimize error. But after Bowditch published his *American Practical Navigator* and the EIMS began collecting logbooks, logbooks developed into new systems for organizing and rationalizing their contents. In turn, Bowditch and other nautical authors developed new tables and charts in their guidebooks based on the more open circulation of logbooks.[103]

At the same time, through compilations, reprinting, and circulation, captains learned to read and reflect upon each other's logbooks. EIMS and nautical manuals established basic expectations about what information must be recorded and what reliability looked like in the text of a logbook, nautical authors cited captains' logbooks in their manuals as both authories and cautionary tales, while publishers like Edmund Blunt (who published the *Practical Navigator*)

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[100] "Articles of Association."

[101] *Ibid.*.

[102] *Ibid.*.

[103] Pickering, 13.

also produced commentaries on charts based on logbook entries.[104] In the first two decades of the nineteenth century, this reading and circulation of logbooks had the effect of "modernizing" this very long established timekeeping technology, rationalizing its content and format so that entries would conform to widely-held expectations of reliability. Employed as an increasingly rationalized tool for mediating and calibrating the multiple temporal regimes that circulated around a ship, this is the era when the logbook—already an organic timekeeper—gained prominence.

The captains of Salem's East India Marine Society were not the only people submitting their logbooks for the further edification of their peers. When Blunt printed a pamphlet correcting some of the common errors in nautical charts in 1819, his amendments drew upon the printed and privately circulated logbooks of captains from up and down the American coast and several from within the British and French navies. Meanwhile, in Salem, Bowditch and later commentators compiled editions of EIMS logbooks along with notes on the condition and quality of the logs, and annotated notes on important observations or concerns in the logbooks.[105] Compilations of the EIMS logbooks preserved in the Phillips Library Some captains include hand-written notes by Bowditch as well as indices: "the preceding table of contents was drawn up by Nathaniel Bowditch, inspector of the journals for the year 1804."[106]

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104 For more on Blunt see, Marche, "Restoring a 'Public Standard' to Accuracy," 705; John F. Campbell, *History and Bibliography of the New American Practical Navigator*, 47-48. As an example of the way captains cited and corrected each other, consider this excerpt from Thomas Arnold's *The American Practical Lunarian*: "The sailing directions I have copied principally from Captain Horsburg's directions; (edition 1818, which is the latest and best extent), to which I have added some of my own remarks. I am indebted to captain John R. Butler, of the ship *Thalia*, of Philadelphia, for correcting a mistake in captain Haywood's directions of St. Mary's, at the entrance of the River Plate, for which see note…" Arnold, *The American Practical Lunarian,* v.

105 Examples of notes and compilations include, Bowditch's comments on the first ten logbooks submitted to the EIMS. "The preceding table of contents was drawn up by Nathaniel Bowditch, [inspector?] of the journals for the year 1804." Philips Library: MH 88, Journals of the East India Marine Society, No. 1-10.

106 Philips Library: MH-88.

Considering the afterlives of their logbooks, some captains made a point of re-copying their books if they were damaged, or, conceivably, if their contents reflected badly upon the authors. A. Northey Jr. for instance, the master of John Collin's Ship *Good-Hope,* copied into the second half of his father's logbook a version of his journey, noting that "the original journal from which this was Copie'd got so defaced, that I destroyed it."[107] Northey, Jr. was clearly thinking about the afterlife of his journal because, in addition to using it to weigh observations and uncertainties, he also included authorial comments on the utility of different practices. "By a Lunor observation taken this day, we made our Longitude 15'.40 East, our Latti. 33.53 South. Thus we passed the Cape without seeing the Sand," Northey Jr. noted on October 31, 1801, followed closely by his didactic comment: "The above shews[sic] the great advantage of Lunar Observations: for no Man in his Senses would ever have stood to the Northward as we did if he put his whole dependence on his Dead reckoning, but would have continued to the Southward until [sic] he had made 3 degrees more westing, and in all probability experience the comforts of another Gale of Wind."[108]

Some of the logbooks entered into the EIMS collections were so self-conscious about how they self-presented that the captains who kept them included colored illustrations. The accuracy of illustrations of ports or headlands testified to the observational care of the logbook keeper. While Derby and his compatriots clearly understood that logbooks would be submitted to the owners upon return, and therefore would eventually have an audience, after the EIMS announced that it would collect and share all of its members' logs, Salem's logbooks became much more carefully kept, and as a result more consistent. Likewise, nautical authors like

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107 Philips Library: LOG 1067.

108 Philips Library: Log 1067.

Bowditch and Mackey, (Moore had died in 1807) emphasized the need for more consistent logbook entry contents, more systematic and generalizable descriptions of sightings and soundings, and plainer language in describing observations at sea.

A good example of this new type of logbook entry can be seen in the logbook kept by the captain of the ship *Aeolus* in 1805. In this entry the captain does not yet employ the standard EIMS logbook, but he is keeping his log in format identical to that specified in Bowditch and Moore. The Captain identifies the civil day, and then notes, for his own reckoning, that it is the 27th day out of port. On the left side of the entry, he lists the hours of the day, divided conceptually at midnight not only by re-starting the count but also by leaving a space in the table. Next to these hours, he lists the knots and headway/leeway, courses and winds. On this particular day the wind was mostly blowing from the west, and the ship seems to be tacking into the wind, moving slowly and near midnight making more leeway than headway. To the right of this table, the captain had kept a running record of all the other encounters which contribute to the motion of the ship, currents, including notes on the weather, the work of the crew and disposition of the sails, soundings, environmental observations, and sighting another ship.[109] Below this, in a section marked-off by double lines, the captain includes his notes for the lunar observations he took at 8:12:4 pm that evening, leading to a calculation for longitude at 170°0” (the last digit is obscured in my image).

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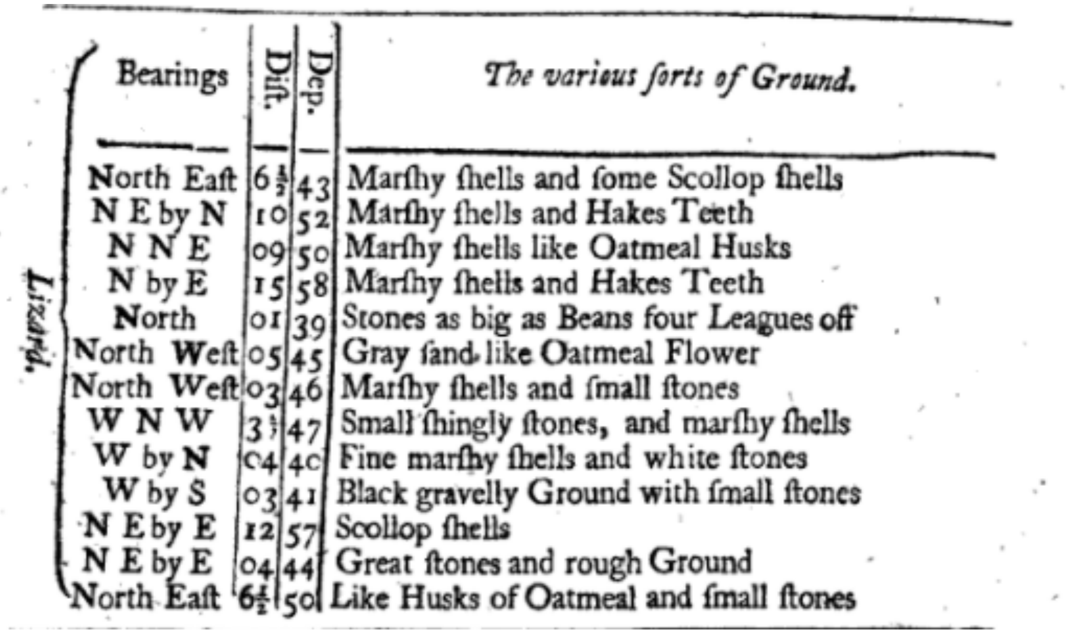
[109] The text of the entry reads:

All This 24 hours light breezes and hazy weather all Sails Out at 2 PM sounded in 26 fat’d water over a Botom [sic] of Corse sand & shells the Anna in [sight] on our lee quarter, saw many Boobeys, swallows, [unclear] shells sum squalls and [unclear].

All night light breezes and clear weather sounded several times through the night had from 24 to 22 fathoms corse sand. The Anna on our lee beam with rather the Advantage in sailing. She spreading more canvas than us & having smooth water

Latter part pleasant People Employ’d at sail making found the current to run to the NE 2 miles p’hour.



	Bearings	Diſt.	Dep.	*The various ſorts of Ground.*
Lizard.	North Eaſt	6½	43	Marſhy ſhells and ſome Scollop ſhells
	N E by N	10	52	Marſhy ſhells and Hakes Teeth
	N N E	09	50	Marſhy ſhells like Oatmeal Husks
	N by E	15	58	Marſhy ſhells and Hakes Teeth
	North	01	39	Stones as big as Beans four Leagues off
	North Weſt	05	45	Gray ſand like Oatmeal Flower
	North Weſt	03	46	Marſhy ſhells and ſmall ſtones
	W N W	3½	47	Small ſhingly ſtones, and marſhy ſhells
	W by N	04	40	Fine marſhy ſhells and white ſtones
	W by S	03	41	Black gravelly Ground with ſmall ſtones
	N E by E	12	57	Scollop ſhells
	N E by E	04	44	Great ſtones and rough Ground
	North Eaſt	6½	50	Like Husks of Oatmeal and ſmall ſtones

Figure 7: Descriptions of soundings off Lizard listed by Nathaniel Colson in The Mariner's New Kalendar. *Colson,* The Mariner's New Kalendar, *126.*

By separating his processes, the captain makes it clear how he is separately working each method for determining location. His reckoning of the ship's location would be based on the table on the left, using the less complicated trigonometry of plain sailing. In the narrative section, he is clearly trying to use soundings to feel his way into a known pattern on the sea floor, a project that might have been assisted by printed tables in books like Bowditch's or pamphlets printed by Blunt, that made the case that the pattern of silt and sand on the ocean's floor can become as reliable a chart as the map of the sky. Indeed, by the time that Richard Henry Dana shipped out for the journey that he would immortalized as *Two Years Before the Mast,* he claimed that American mariners held that the soundings of well known locations were signatures of place.[110] If a captain knew his latitude and was in soundings, he could know precisely where he was—or at least this was the idea. Still, he is intuitively balancing ways of knowing time and place—weighing them against each other, all measures of uncertainty. Thus, though more

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[110] Dana, *Two Years Before the Mast*, 349.

systematic, this method still relies on the idea of the scientific sailor as an intuitive predictor of natural order.

The captain of the *Aeolas* in 1805 was not certain about his location based on the soundings, but he made sure to describe the material he pulled from the bottom of the sea in terms that were becoming much more standardized thanks to the commentaries and examples in the *Practical Navigator* and other publications from Edmund Blunt. As a point of comparison, in 1745 *The Mariner's New Kalendar* offered tables of soundings off the coast of Cornwall. Though comprehensive, the descriptors were anything but consistent and they were far from generalizable. The author described the approach to Lizard Point by telling his readers to that the sea floor 9 miles to the North-North-East of the point had a depth of fifty fathoms, consisting of "Marshy shells like Oatmeal Husks."[111] Other locations around the point sounded in "39 fathoms and Stones as big as Beans four Leagues off" or "47 fathoms, Small shingly stones, and marshy shells."[112] Though they continued to consult *The Mariner's New Kalendar* on the use of quadrants and sextants for navigation (and copied images from the text into their logbooks), by the early nineteenth century Salem's logbook keepers had turned to a more systematic jargon where terms like "silt" "ooze" and "sand" had specific and consistent definitions.

Because the variety of phenomena and detail logbook entries could contain was extensive, publishers and compilers like Bowditch continued to push for a smaller set of necessary types of entries. Blunt, the publisher of Bowditch's *Navigator,* was also a nautical author in his own right, and produced the first national guidebook and charts for piloting the American coastline. Blunt's several editions of the *Coast Pilot* help illustrate how publishers and

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[111] Nathaniel Colson, *The Mariner's New Kalendar* (London, 1745), 126.

[112] Colson, *The Mariner's New Kalendar, 126.*

guidebook authors helped identify and systematize the core impressions of nature American logbook entries must record.

The first edition of Blunt's *Coast Pilot* appeared in 1796 and included the personal and often secretive knowledge acquired by the guides who sold their knowledge of local weather, water, and soundings to arriving merchant ships. Blunt promised to guide large boats safely into any American port. Due to shifting sand bars and secret shoals, the last approach to harbor could be the most hazardous of any journey. Compiling this private local expertise into a commonly available book offered a direct challenge to coast pilots in every harbor, and Blunt acknowledged that his *Coast Pilot* was not welcomed everywhere, especially in the harbors of the American South. Blunt issued new editions frequently based on the experiences of captains and navigators he trusted, corrections forwarded to him by surveyors, and on logbook entries forwarded to him.

In addition to the difficulty of compiling local knowledge into one compendious volume, Blunt faced the challenge of coordinating local jargon and descriptions of water features and soundings into a more universally understandable—standardized—set of definitions. By 1806, Blunt's *Coast Pilot* extended to instructions for entering all major ports and anchorages along the East coast north to the Canadian Maritimes and Newfoundland and south, around the coast of Florida to the coast of the newly acquired Louisiana Purchase. In this edition, Blunt limits his descriptors of soundings to standardized terms: mud, ooze, rocky, sand, shells—all modified by concrete descriptions of color, size, or unusual contents.

Publishers like Blunt policed those definitions in their commentaries on logbook entries. They did this though reprinted examples of useful and reliable logbook entries in their navigation guidebooks.[113] Much the way that Blunt or other captains would comment on the accuracy of a

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113 For instance, in the 1806 edition of the *Coast Pilot,* Blunt includes a lengthy extract from the logbook of "an experienced Navigator" describing the channel between Puerto Rico and St. Domingo. Over the course of several days, the author of this

given position for major landmarks, they also corrected each other based on what seemed to be incorrect or inconsistently described soundings. By the time that Richard Henry Dana Jr., author of *Two Years Before the Mast,* went to sea in 1834, he claimed that the descriptions of the seafloor leading up to the East Coast of the United States had been rendered so consistent that, sailors could confidently anchor themselves in time just by knowing their latitude and feeling their way along the floor of the ocean.[114]

Although determining their place on a map by considering the ocean floor may seem to speak more to geographical knowledge than temporal knowledge, when the color of the mud was correlated with the captain's lunars, dead reckoning, and the chronometer within a logbook entry, soundings were recruited as part of an organic timekeeping practice. To feel confident in his position within space and time, a captain wanted the soundings that located him in space to comport with his sense of time as determined by lunars. If the two disagreed, spatial information like soundings could then help generate temporal information—or at least suggest that an error had been made. Organic timekeeping occurs where human conceptions of time touch the world, and sounding were one of the most concrete ways that a captain, floating on the uncertainties of space and time at sea, could concretely connect to the world unfolding around them.

In addition to standardizing the description and charts of soundings in circulating literature and in logbooks, Blunt's revisions to the *Coast Pilot* exemplify another method through which logbook entries became more standardized. Blunt not only read, collected, and reprinted

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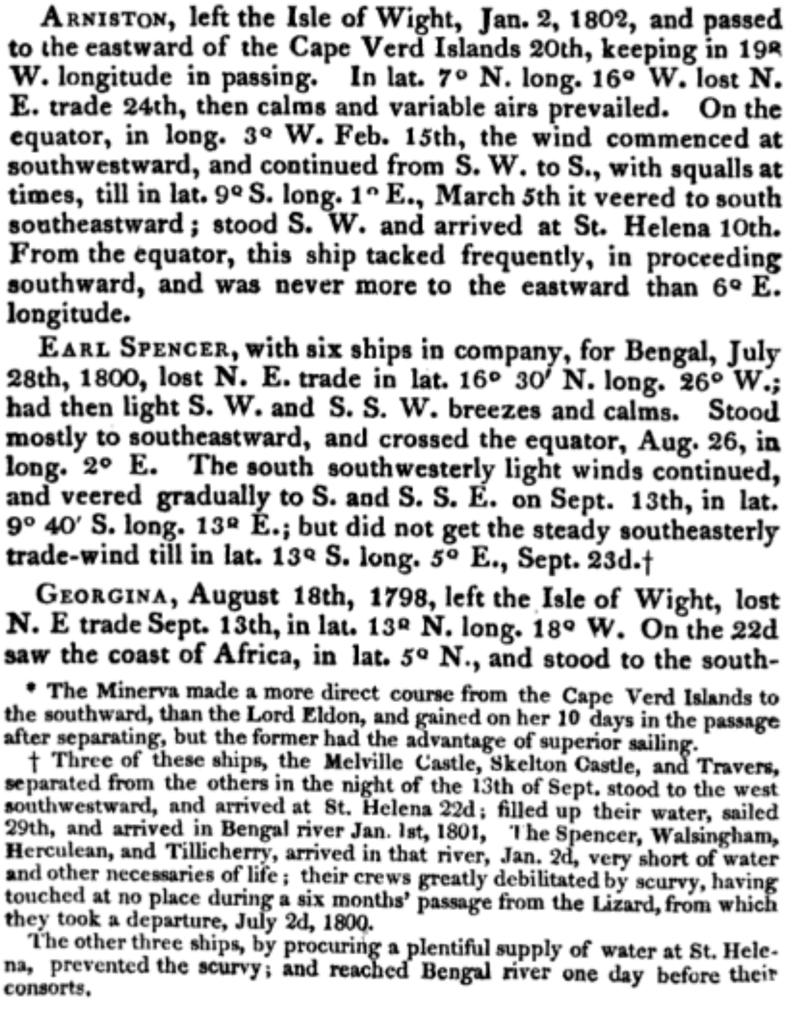
logbook includes entries such as, "About 10, A.M. we saw the water discoloured: were upon a shoal, call the *White grounds*, […] You have there 10, 12, and 15 fathoms. The sand at the bottom is of such a shining white, that it pierces thro' the water. Edmund M. Blunt, *The American Coast Pilot* (Newburyport, 1806), 244.

[114] "The sounding on the American coast are so regular," Dana explained, "that a navigator knows as well where has made land, but the soundings, as he would by seeing the land. Black mud is the soundings of Block Island. As you go toward Nantucket, it changes to a dark sand; then, sand and white shells; and on George's Banks, white sand; and so on." Dana, *Two Years Before the Mast,* 349.

portions of American and British logbooks, but he also used them (and referred to them) when correcting errors in his previous editions. This iterative process both called out specific logbook keepers for being particularly keen observers and navigators, and also cast doubt on different (non-standard) logbook keeping methods. To receive public credit from Blunt in the *Coast Pilot* was a considerable boon for captains' careers. However, in order to gain Blunt's approval, captains needed to conform to his format and standardized vocabulary—to conform to his way of describing the world.[115]



Arniston, left the Isle of Wight, Jan. 2, 1802, and passed to the eastward of the Cape Verd Islands 20th, keeping in 19° W. longitude in passing. In lat. 7° N. long. 16° W. lost N. E. trade 24th, then calms and variable airs prevailed. On the equator, in long. 3° W. Feb. 15th, the wind commenced at southwestward, and continued from S. W. to S., with squalls at times, till in lat. 9° S. long. 1° E., March 5th it veered to south southeastward; stood S. W. and arrived at St. Helena 10th. From the equator, this ship tacked frequently, in proceeding southward, and was never more to the eastward than 6° E. longitude.

Earl Spencer, with six ships in company, for Bengal, July 28th, 1800, lost N. E. trade in lat. 16° 30′ N. long. 26° W.; had then light S. W. and S. S. W. breezes and calms. Stood mostly to southeastward, and crossed the equator, Aug. 26, in long. 2° E. The south southwesterly light winds continued, and veered gradually to S. and S. S. E. on Sept. 13th, in lat. 9° 40′ S. long. 13° E.; but did not get the steady southeasterly trade-wind till in lat. 13° S. long. 5° E., Sept. 23d.†

Georgina, August 18th, 1798, left the Isle of Wight, lost N. E trade Sept. 13th, in lat. 13° N. long. 18° W. On the 22d saw the coast of Africa, in lat. 5° N., and stood to the south-

* The Minerva made a more direct course from the Cape Verd Islands to the southward, than the Lord Eldon, and gained on her 10 days in the passage after separating, but the former had the advantage of superior sailing.

† Three of these ships, the Melville Castle, Skelton Castle, and Travers, separated from the others in the night of the 13th of Sept. stood to the west southwestward, and arrived at St. Helena 22d; filled up their water, sailed 29th, and arrived in Bengal river Jan. 1st, 1801, The Spencer, Walsingham, Herculean, and Tillicherry, arrived in that river, Jan. 2d, very short of water and other necessaries of life; their crews greatly debilitated by scurvy, having touched at no place during a six months' passage from the Lizard, from which they took a departure, July 2d, 1800.

The other three ships, by procuring a plentiful supply of water at St. Helena, prevented the scurvy; and reached Bengal river one day before their consorts.

Figure 8: Many nautical authors created a model journey from by excerpting ship's logbooks and included commentary on routes, observations, and judgement in the footnotes. This example is from Thomas Arnold's The American Practical Lunarian (1822).

Arnold, *The American Practical Lunarian*,222.

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[115] The logbooks and coast pilots operated somewhat like the atlases Daston and Galison discuss. Atlases "simultaneously assume the existence of and call into being communities of observers who see the same things in the same ways." Daston and Galison, *Objectivity, 19*-27, 27.

A 1819 pamphlet on the "dangers" included in Blunt's charts of the Atlantic offers a typical example of the circulation and referencing of logbooks within the nautical press. Blunt employed logbooks as reference material for the charts included in his pamphlet, and he also discussed why he weighted the word of different captains differently depending on the quality of their logbooks. For instance, he explained to readers that he could only cautiously endorse the inclusion of "*A Shoal 70 leagues W. By N. From the Island of St. Jago.*"[116] "This shoal is laid down in the English chart of 1777, and is said to be mentioned in the journals of several English East India ships," Blunt began, but then cautioned: "of what ships or at what time we are uninformed."[117] And so, though the danger remained marked in the map, Blunt clearly suggested that without having actually seen the logbooks of captains who had encountered the danger, he was unprepared to discuss it with any certainty.[118]

Other authors joined Blunt in commenting publicly on the content and format of logbooks, further standardizing expectations about what a logbook entry should include. Thomas Arnold, the author of the *American Lunarian* (1822) included extensive comments on other logbooks in his sample journey from the Cape Verde Islands across the Equator. For example, on

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116 Edmund M. Blunt, "Analysis of the authorities upon which the dangers have been inserted in Blunt's new chart of the Atlantic, or Western Ocean. To which is added, an accurate table of the variations of the magnetic needle" (New York, 1819), 4. Hagley Library, pamphlet collection.

117 Blunt, "Analysis of the authorities," 4.

118 Logbook keepers also cited other logbooks in their entries. Since logbooks were often kept to demonstrate ability and turned over to superiors or future employers, the practice of citing other authors lent legitimacy to their work and also demonstrated their assiduous study of the art of navigation. For instance, in an entry from 1821, midshipman Samuel Du Pont recorded this entry, anticipating his Commander, Jacob Jones, would read his logbook at the close of the day.

"I *find by our observation today that we have made southing these last twenty four hours, from which I conclude there is a South & Easterly Current. The following remark is taken from the memoirs of Captain John Purdy on different currents [quoting the memoir] 'In the early part of the of the year when the Snows and Ice are melting the [outset ?] must be considerably increased it may therefore be presumed that there is in this Season a considerable efflux of water from the Gulf setting to the S&E over the [laid?] of the Newfoundland banks and which probably has been Mistaken for the Florida Stream. With the latter it may perhaps blend to the SouthEastward so as to add to the General tendency of the markers in this part of the ocean to that Direction —' [Du Pont adds] I have therefore allowed 20 miles ESE current."*

Hagley Museum and Library, Soda House, Log Books, Samuel Francis Du Pont, #1633, # 3, May 18, 1821.

one page alone, Arnold references several logbooks as authorities on whether a shoal had or had not been sighted off the coast of Fernando Noronha. He notes the conflicts between the accounts, too, “The Northhampton’s journal describes it as a dangerous shoal, very little above water, with breakers all around […] The Glory’s journal describes it as 2 low sand banks.”[119] Arnold, resolves the issue by declaring, “by mean of the observations and chronometers of 10 different ships, the Roccas shoals is in lat. 3°52’ ½” S. Long. 33°31’ W.”[120] The sample journey continued for several pages, composed of summaries of the logbooks of ships that made successful made the trip and recorded it in ways that Arnold thought admirable and useful. His summaries give a sense of what kinds of details were expect in logbooks, but also of the ways that logbooks were weighed and assessed after the journey. Since the logbook was a timekeeping tool, the process of standardizing the contents of logbook entries must be understood as a process also of standardizing timekeeping practices.

Blunt’s and Bowditch’s endorsements also signaled when phenomena had become so accepted as a reliable method for fixing space and time that they really should be included in logbook entries. One example of this is the increasing use of thermometers to identify and navigate in currents. Thermometer readings had become expected content in logbook entries by the second decade of the nineteenth century. Benjamin Franklin famously mapped the Gulf Stream in the mid-eighteenth century, but it was not until the beginning of the following century that mariners began to attempt to navigate by the thermometer.[121] The temperature of the water, Blunt explained, “declares by a sudden fall of the mercury, the time when the ship comes into the

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[119] Arnold, *American Practical Lunarian,* 27.

[120] Arnold, *American Practical Lunarian,* 27.

[121] Chaplin, “Knowing the Ocean,” 73-96.

water between the Gulph Stream and the coast, and by a further fall, it declares the time when she comes within soundings."[122]

If soundings could substitute for latitude and longitude, than an instrument capable of not only identifying when a ship entered or left a current but also signaling the soonest moment when soundings could be taken, had the effect of establishing a wide parameter for the margin of error. Like so many elements of the logbook, thermometrical navigation could not tell a captain where they were in a current, but if they knew the very basics—their direction and the principle of navigating by soundings—then a captain who reliably recorded the temperature of the ocean could still remain on the safe side of uncertainty. Along the American coast, Blunt promised that after leaving the Gulf Stream, mariners could rely up on "generally, twelve hours safe run," before arriving in dangerous waters.[123] This method was particularly necessary because currents confounded dead reckoning, and on a stormy day, out of sight of land and unable to take an observation, a captain's dead reckoning could easily be hundreds of miles off if the ship was in a current.

Soundings and water temperature were only two of the many other phenomena that Blunt, Bowditch, Arnold, Mackey, and many others encouraged their readers to consider systematically, and publicly evaluated in captains' publicly circulated logbooks. Arnold's manual included a lengthy section on natural history, suggesting to sailors that once it was properly mapped, mariners would be able to navigate by the magnetism of the earth and the variation of the compass.[124] He also instructed them on the use of the barometer for navigation.

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122 Blunt, "Analysis of the Authoriries," 21.

123 Blunt, "Analysis of the Authorities," 21

124 Arnold, *The American Lunarian,* 139-155 ; also, John Churchman, *An Explanation of the Magnetic Atlas or Variation Chart, Hereunto Annexed, Projected on a Plan entirely new* (Philadelphia, 1790)

One contributor to the Franklin Institute's Journal went so far as to suggest that marine chronometers might be even come to be regulated *by* the changing atmosphere as a ship sailed through new latitudes.[125] The new typical logbook entry tended to look like this one from the Clipper, *Challenge,*

> Friday February 18, 1853: "34 days out. Commences with light airs and variable winds from the eastwards took in all standing [?}] sails and braced up in the wind. 8 PM and hauled more to the northward, set all port studding sails. At 10 PM winds not SW squared the yard and set all Starboard stuffing sails remainder of the night bright breezes and pleasant weather. Morning on this was the same. People variously employed about the ship. Ends with light breezes and fine weather.
>
> Latitude by Obs. 28.04 South
> Longitude per Chronic 19.23 West
> Barometer 29.85 Thermometer 80
> Wind North — NNWest — Distance 90 miles
> Course South. 47' East.[126]

Individually, most of the phenomena that came to be expected in a logbook entry were not reliable indicators of location or time. But, this was the utility of the logbook: it offered a way to systematically compare those phenomena in order to arrive at a more reliable approximation of the ship's position. As Blunt explained, "when the spirit of adventure had extended the American commerce beyond the capes of either continent, what was before useful, became then indispensably necessary."[127] By the 1820s not only Salem's East India Marine Company, but also Blunt's publishing house, the US Navy, and many others printed standardized logbooks for purchase by navigators and sailors alike. The 1813 copy of *Seamanship in Theory and Practice,* published by Blunt for the Navy, included instructions for the systematic keeping

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125 Benjamin Baker, "March 28," *Franklin Journal* (Philadelphia, 1826), 189.

126 Philips Library: Log 1852.

127 Blunt, *The American Coast Pilot*, preface.

and sharing of logbooks as well as sample logbook entries.[128] On naval vessels, all logbooks kept aboard ship would be inspected and compared on the first and fifteenth of each month. At the end of the journey, all logbooks were to be submitted to the navy department, and anything of possible scientific significance was to be copied and forwarded along with the personal assessment of the record provided by a superior officer or examiner.

In his forward to *Theory and Practice,* Blunt echoed Dobson in arguing that a sailor must command both the theory and practice of sailing to be truly called a seaman. To that end, his book included sections on hydrodynamics and physics, in addition to instructions on rigging and handing sails. However, even as his naval manual helps illustrate the increasing standardization and systematization of the organic timekeeper that was a ship's logbook, Blunt's very title helps explain why what had seemed like a cutting-edge tool in the hands of scientific sailors in 1800 could, could come by 1830 to seem like so much paperwork. In 1796 Dobson claimed that sailors did not need to know the theory behind their sensations they only needed to learn to systematically record their experiences crossing the ocean and learn, slowly, to apply numbers to those encounters. In 1813, Blunt claimed this was not enough, sailors needed to know theory as much as practice.

By the 1840s, the leading nautical authors could reverse the balance and insist that sailors needed lesson in principles before attempting to practice their art. This shift accounts in large part for the changing ways logbooks were employed. As perceptions of human nature and capacity shifted, the log book transformed from a standardizable and universalizable timekeeper into a measure of human reliability, a test of its keeper's character.

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128 Edmund M. Blunt, *Seamanship in Theory and Practice* (New York, 1813).

Good Sea-Sense Reduced to a Calculus

By the end of the 1820s the ship's logbook had become what I would call a modern organic timekeeper. With its increasingly standardized format and contents, the logbook established a systematized forum within which different methods for tracking local time and place could be measured and compared against each other in order to find a position within more abstract system of Cartesian space and regularized time. The logbook mediated between those abstractions and its keeper's empirical or embodied experiences in the world. With all the possible inputs collected in one place, the format of the logbook and the captain's good sense, in theory, then worked through the overlapping approximations of place and time within each entry, generating the best approximation of the ship's location. Since all of methods of timekeeping at sea were approximations, the logbook could not generally produce a precise location in space or time. Instead, it was a science of systematically balancing uncertainty, backed by the idea of a scientific sailor traveling through a clockwork universe.

This also was not unlike the melon in the framing-ground. The melon could not tell a gardener precisely when to plant, but over a very long period it could help attune his judgement to the conditions required for a successful planting of his corn and squash. This idea worked because gardenbook authors believed in the stability of nature, and in the Enlightenment ideal that in the long term, a man's good sense would lead him to find and follow its patterns. The same thinking applied to the logbook in the hands of the scientific sailor. As Dobson claimed, enough mariners successfully traversed the oceans, that*, in the long term* and collectively, they must have intuited some fundamental and generalizable truths about timekeeping and navigation at sea. The logbook and the melon were each tools that offered a way to systematically investigate temporal (as well as spatial) uncertainty. They did not stack-up regular units to arrive as a specific quantity of time, in the hopes of being precise. Rather, they circled-in on an ever-narrower range of feasible times, never arriving at a precise moment, just a diminishing margin of error. The French mathematician Pierre-Simon Laplace, one of the founders of classical probability and the author of *Mechanique Celeste*, famously quipped that probability was "only good sense reduced to a calculus."[129] Bowditch spent his life translating Laplace into English, and might reasonably have claimed that his goal in training mariners to keep a logbook and take lunars was to assist them in "good *sea-sense* reduced to a calculus."

Intellectually, these two tools were practical outgrowths of Enlightenment understandings of human nature and probability. As Gigerenzer et al. argue in their history of probability, *Empire of Chance*, the idea that the universe was ultimately regular, stable, and predictable inspired men like Laplace to conceive of probabilities as "the makeshift tools of intellects too feeble to penetrate immediately to the real nature of things."[130] Bernoulli's theorem supported this outlook, since it posited that in the long run, "observed frequencies would stabilize around the 'true' underlying value, that regularity would ultimately triumph over variability."[131] In the realm of navigation, theory and mathematics assisted men to see the patterns that eluded them, to train themselves in 'good sense' so that their intuition could be trusted to reveal generalizable truths about nature. Consequently, the authors argue that "the calculus of probabilities sought to codify these intuitions (which the probabalists believed to be actually subconscious calculations) for use by *hoi polloi* not so well endowed by nature."[132] In the world of *The Practical Navigator,* this process of honing one's intuition was considerably assisted by the collective accumulation of

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129 Laplace in Gerd Gigerenzer, Zeno Swijtink, Theodore Porter, Lorraine Daston, John Beatty, and Lorenz Krüger, *Empire of Chance: How Probability Changed Science and Everyday Life* (Cambridge: Cambridge University Press, 1989), 13.

130 Gigerenzer et al., *Empire of Chance*, 11.

131 *Ibid.,* 29.

132 *Ibid.*, 16.

geographical knowledge supported by the nautical press and the American Coast Survey (established in 1807).

These were the ideas and the minds—Laplace, Bernoulli, and Newton—that set fire to a young Bowditch and inspired his life's work.[133] Bowditch believed, as Thornton put it, in "the power of numbers" to render the world intelligible and regular. He also believed that all men through their intuition could perceive the ultimate order of the world, and he worked hard to teach sailors how to translate their intuition into numbers.[134]

Though he would go out of his way to teach his readers and sailors the simplest methods for calculating observations, Bowditch also held everyone to a very high standard. So great was his faith in the intelligence of others, that he could not tolerate faults in those around him. "One would think that he would remember that what plainly appeared to Laplace sometimes required two or three days of hard work by him before he could discover how it plainly appeared," Henry observed, "This lesson taught to him so many times over and over again ought to have taught him to have been more patient with people who did not view things at once from his standpoint."[135] Instead, Bowditch was known throughout his life for his short temper and intellectual impatience. In his frustration with the divide between what he wanted to be and what was, Bowditch demonstrated a remarkable (though often vituperous) faith in human capacity.

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[133] Even on his deathbed, Bowditch apparently was still thinking of Newton and Laplace. He reportedly told his third son: "Archimedes was of the same order of talent as Newton [….] And Leibnitz was equal to either of them. Euclid was a second-rate mathematician, but I should like to see some of his handwriting. My order of talent is very different from that of Laplace. Laplace originated things which could have been impossible for me to have originated. Laplace was of the Newton class, and there is the same difference between Laplace and myself as between Archimedes and Euclid." Philips Library: MH 42.

[134] Bowditch's biographer describes his worldview in this way: "Here is the essential key to Bowditch. His love for mathematical order and certainty colored his perspective on all human affairs. It also defined his temperament. Moral grey areas did not exist for him; right and wrong could no more be confused with each other than plus and minus. Stoke by moral self-assurance, he vented his temper in calling out what he perceived as incompetence, venality, or injustice. His tactlessness sometimes alienated his associates, but in many ways his mathematical temperament was congruent with his age. … Above all, his enthrallment with the precision and certainty of numbers shaped his impulse to systematize the institutions under his control." Thornton, *The Power of Numbers*, 5.

[135] Philips Library: MH 42.

Principles before Practice

Though Bowditch continued to swim in the mathematical seas of Enlightenment ideals, many of his contemporaries moved on. Just as Romanticism, in the view of Gigerenzer et al., "shook the confidence of the probabalists in the existence of a single, shared standard of reasonableness," Romantic literature and popular culture began to reshape widely held ideas about the abilities of the common sailor and—by extension— the purpose and potential of the logbook as a timekeeper. As reason came to be defined against intuition or sensibility, the notion that the sailor's intuitive encounters with the ocean would produce through the logbook generalizable mathematical truth waned. Responding to this expanding cloud of doubt, logbooks began to incorporate new kinds of empirical evidence to help the navigator weigh different methods of reckoning space and time. In this new era, references to nautical theory, evidence of good judgement, and even hand writing joined lunars, water temperature, and soundings as criteria that must be weighed within each logbook entry.

By the 1830s authors of nautical guides began to worry that mariners of all stations (from ordinary seamen to captains) could not adequately practice their craft without first being well-educated in the principles behind the practice. Without being thoroughly grounded in the theory behind calculations of celestial navigation, for example, mariners would not necessarily know how to identify and correct errors in calculations made in haste or inaccurate observations. Proper knowledge of theory might help logbook keepers better recognize and correct human error. Blunt argued as much in his previously mentioned *Theory and Practice*, and he was not alone. "They are very strict with respect to the midshipmen," Samuel Francis DuPont wrote in 1819 aboard the US Sloop *Erie*, "Before they can be promoted, it is necessary for them to be perfectly acquainted with geometry trigonometry navigation and astronomy. I think it is a very necessary rule."[136] DuPont insisted that the ability to understand the principles of navigation directly reflected a sailor's practice at sea, arguing that such tests, "will keep them from promoting some that do not know the stem from the stern, or that do not know how to mark a days work or that cannot take a meridianal observation which his very often the case."[137] DuPont, the son of an aristocratic family who would grow up to become an admiral and diplomat, may not have held much respect for the common sailor and been lead to claim that no one was useful aboard ship who couldn't work a lunar. Like Blunt, Thomas Arnold also instructed his readers that the inability to work lunars or keep a log reflected badly upon the mariner's character. "The keeping of an exact reckoning, and being versed in the lunar observations, is of the first importance," Arnold explained in his preface, "the neglect of which not only affects the reputation of the mariner and the safety of the ship, but has caused the loss of many valuable lives and the ruin of numerous families."[138] Celestial navigation invested confidence in the ability and reliability of human computers, mariners, and navigators. By the 1820s, authors of nautical texts and sailors themselves had begun to worry that the source of uncertainty in navigation was primarily errors in human judgement, the result of a lack of theory or principles required to properly interpret charts, take lunars, or track courses.[139] As a result, the navigator's judgement

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136 Samuel Du Pont, to Charles, March 9, 1819, Hagley Museum and Library, Soda House, Correspondence, Series A, W9-82, 1-193.

137 Samuel Du Pont, to Charles, March 9, 1819, Hagley Museum and Library, Soda House, Correspondence, Series A, W9-82, 1-193; much of Du Pont's correspondence from this period mentions his training in algebra, trigonometry, and astronomy.

138 Arnold, *American Practical Lunarian,* iii.

139 As Schotte explained, citing French and German examples, "while central authorities may have grown to respect the navigator's paper tool, they could not bring themselves to trust the unsystematic intuition of traditional mariners nor yet the young men who had passed through the new training programs." Schotte, "Nautical Logbooks," 299.

became part of what was weighed and calibrated within each logbook entry when estimating location and time.

This transition suggests a shift in the logbooks' contents based on previous success. By the 1820s, two decades-worth of systematically compared logbooks, pilots notes, charts, and coastlines had been assembled through the work of the nautical press, associations like the EIMS, and the Coast Survey. The logbooks had born fruit. Consequently, these collective charts of coastlines and courses entered the realm of possible information that could—and increasingly *should*—be expected to appear within a logbook entry as part of the process of approximating location in place and time. These were layers of abstractions that were put to work on the foundation already existing within the logbook, and mariners needed more specialized training to interpret this additional layer within the logbook entry.

In the 1820s and '30s, the proper keeping of a logbook reflected concerns about reliability in more quotidian ways, as well. Arnold, for instance, warned his readers that one leading source of error was the simple inattention of common sailors asked to assist in record-keeping for navigation. "I have frequently noticed the figures misplaced, as 98 for 89, 45 for 54, &c," Arnold explained, "and it frequently happens, that this person does not rightly hear or understand when the altitudes or distances are called out."[140] In *Letters to a Young Master Mariner*, Charles Larimer explained English and American nautical insurance and law to a supposedly inexperienced captain. "How many masters of vessels have I seen who have just been able to keep a reckoning, and that was all!" Larimer lamented. Since "sailors […] are a thoughtless class of men," Larimer insisted that the captain alone was individually and morally

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[140] Arnold, *American Practical Lunarian,* 48.

responsible for its safe passage.[141] The attentive keeping of a logbook, Larimer explained, would keep the ship and its cargo safe, but it would also testify to the captain's good character, diligence, and earnest efforts to follow the best principles of navigation. By this point, many European vessels and all American vessels were required to keep a log. Some states, like Virginia insisted that upon arrival at port, the log must be handed-over or the captain would face a fine.[142] Congress, meanwhile, passed laws requiring all sailors to sign the logbook upon hire, the captain to keep a record of the ship's sick and injured in the log, and on whaling ships each day's catch by each man was required to be recorded in the day's entry.

Given the history of the logbook, all of these changes make sense. They reflect a long-term effort to systematize and regulate cycles of labor aboard ship—a project that had always been a core, though not the only, purpose of the logbook. By the 1830s, logbooks had become legal documents, and the schedules of labor and credit contained in their pages were regulated by domestic and international law. This changed the context for keeping the logbook, since it became a legal document that could be used to evaluate and prosecute the kinds of "criminal inattention," that led to errors in navigation. When sailors died at sea, the logbook entries would be used by a judge as evidence of the labor contract (sailor's signature) and the captain's judgement and character in upholding the contract.[143] The logbook came to reflect the careful judgement of its keeper, as evidenced by its contents. Nothing demonstrated this more than Larimer's admonition to the young master:

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[141] Charles Larimer, *Letters to a Young Master Mariner, on some Subjects Connected with his Calling.* 3rd edition. (London, 1843), 19-20.

[142] Larimer, *Letters to a Young Master Mariner, 43-44*; Arnold, *American Practical Lunarian,* 625, 627, 628, 663, 826.

[143] For British example see Schotte, "Nautical Logbooks," 301; Larimer, *Letters to a Young Master Mariner,* 19-20, 44.

> “P.S. Your handwriting is very indifferent; now that you have time to yourself, you must really try to improve it. You may, with a very little attention, write a good, plain hand. Nothing prejudices me so much against a captain as to receive from him a badly written, mispelt letter. Most of the losses at sea are announced to the unfortunate owners, or others concerned, in such epistles; and, when the circumstances attending those losses come to be investigated, the ignorance of the writer is too often found to be the cause.”[144]

Although new criteria had come to be emphasized in the 1830s, the logbook continued to function as a timekeeping technology as it had in earlier eras. In the first decade of the new century water temperature became an important element of logbooks, reflecting new ideas about ocean currents, and in the 1830s handwriting became important, reflecting new ideas about human error and perception. The shift in content shouldn’t be mistaken for a change in the logbook’s utility. The increasing emphasis on handwriting, standardized formats, and accurate descriptions as tests of human error changed the typical content of logbook entries. Schotte read this shift as a sign of the “degradation” of the logbook and its descent into formalism. I disagree. To me, this shift in content represents the continuing use of the logbook as an organic timekeeper.

As an organic timekeeper, the logbook offered a space and method for systematically calibrating multiple methods for measuring space and time one against the other. In the first several decades of its widespread use among American mariners, nautical experts focused on systematizing formats, descriptive language, and establishing minimum expectations about the logbooks’ content. As logbooks became a far more common technology and as the geographic information contained within them was collected, compared, and circulated, nautical authors proposed new material that needed to be considered within the space of the logbook entry.

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144 Larimer, *Letters to a Young Master Mariner,* 18.

Handwriting, references to nautical theory, and compliance with the law all also represented empirical evidence the navigator could include in each entry to demonstrate to himself and an outside authority that he had weighed all available information in estimating his location in space and time. The success of early logbook sharing, expanded geographical knowledge, and more widespread expertise in celestial navigation all made it possible to add elements to the navigator's process of weighing information.

By the 1840s, the logbook was more common than ever, and with the assistance of the work of Bowditch, Blunt, Mackey and other nautical authors ever more people aboard each ship knew how to use a logbook to arrive at a good estimation of a ship's location at sea. In the previous century's debates over marine chronometers and celestial navigation, the logbook had emerged as a tool to mediate between two imperfect timekeeping systems. Those who backed the logbook and celestial navigation expressed skepticism in the reliability of the chronometer and machines; those who backed the chronometer expressed skepticism in the reliability of human minds to carry out the complicated observations and calculations required to make the system work. In the intervening years, the calculations to work lunars was simplified and the errors of the nautical calendars was minimized. Meanwhile, marine chronometers were produced in ever larger numbers and at lower costs, and methods for tracking their inconsistencies improved. A decade before he died in 1838, Nathaniel Bowditch relented and included chronometers in the *Practical Navigator*. And yet, at the time of his death, despite changes in both chronometers and celestial navigation, the logbook remained a vital part of navigation at sea, mediating between the cultural abstractions of space and time and the material world through which the ship sailed.

In 1849 James McLeod Murphy wrote *Nautical Routine and Stowage,* in coordination with an instructor at the US Naval Academy, to prepare young men for their midshipman's exam. His instructions for young officers represent the shifts in nautical guidance under way. Murphy begins his instructions by affirming the outlook of previous generations of nautical experts. "The science of seamanship is characterized by one distinguishing feature, peculiar to itself," Murphy elaborated, "its guiding principles, in lieu of being established laws of observance, are rather matters of *opinion*."[145] These opinions, though somewhat systematized through "reason and practice," were nevertheless "as unsettled in their adaptation to case and circumstance, as the elements upon which they were born and cherished."[146] In a sentence that might have been lifted from Bowditch, Murphy admonished his readers to remember that "the whole science may be truthfully defined to be, the application of *common sense* to the equipment and management of ships."[147] Despite changing technology and an accumulation of geographic knowledge, *The Practical Navigator* was published for nearly forty years after Bowditch's death without a major revision. This is largely because the basic problem of calculating the ship's position in space and time did not change until the 1890s with the invention of the gyrostabilizer.

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145 James McLeod Murphy and W.N. Jeffers, *Nautical Routine and Stowage, With Short Rules in Navigation* (New York, 1849), vi.

146 Murphy and Jeffers, *Nautical Routine and Stowage,* vi.

147 *Ibid.*.

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Factory Time and the Flow of the River

Seeking the Wrong Kind of Time

Historians chronicling the transition to capitalism tell a common story about how timekeeping changed in the first half of the nineteenth century.[1] Whether focusing on humans or the natural environment, this narrative insists that the river of natural time was disrupted, cut-up, controlled, and commodified in the transition to capitalism. Examining a modernity seemingly typified by "markets, machinery, and science," environmental historians interested in agricultural landscapes and rural historians interested in capitalism developed a larger literature that pointed

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[1] This chapter draws upon the broader debates of New Rural Historians on "the transition to capitalism" in early America. I should mention that though the historiographical debate hinges of discussions of a "transition" to capitalism (and with it, it is implied, to modernity), I am not convinced that this transition occurred in quite the way that much of this literature suggests. As I will elaborate over the course of this chapter, I align much more with Allan Kulikoff's view that the transitions that took place within American culture at the beginning of the nineteenth century prompted by the first Industrial Revolution and the Market Revolution were more transitions within an already capitalistically-inclined culture. At the same time I also agree with James Henretta's argument that early American communities cannot be understood strictly through the lens of liberal individualists. Allan Kulikoff, "The Transition to Capitalism," *The William and Mary Quarterly,* third series, 46, no. 1 (1989): 120-144, 134; James A. Henretta, "Families and Farms: Mentalite in Pre-Industrial America," *The William and Mary Quarterly* 35, no. 1 (1978): 3-32; For the broader debates about the transition to capitalism see for example: Steven Hahn and Jonathan Prude, eds. *The Countryside in the Age of Capitalist Transformation: Essay in the Social History of Rural America* (Chapel Hill: The University of North Carolina Press, 1988); Christopher Clark, *The Roots of Rural Capitalism: Western Massachusetts, 1780-1860* (Ithaca: Cornell University Press, 1990); Christopher Clark, "Economics and Culture: Opening up the Rural History of the Early American Northeast," *American Quarterly* 43 (June 1991): 279-301; Allan Kulikoff, *The Agrarian Origins of American Capitalism* (University Press of Virginia, 1992); Joyce Oldham Appleby, "The Vexed Story of Capitalism Told by American Historians," *Journal of the Early Republic* 21 (Spring 2001): 1-18; Also useful to interpreting the evolving perspective within this field on the transition to capitalism are: Christopher Clark, Daniel Vickers, Stephen Aron, Nancy Grey Osterud, and Michael Merrill, "The Transition to Capitalism in America: A Panel Discussion," *The History Teacher* 27, no. 3 (May 1994): 263-288; Naomi R. Lamoreau, "Rethinking the Transition to Capitalism in the Early American Northeast," *Journal of American History* 90, no. 2 (September 2003): 437-461; For specific discussion of dams, canals, and new types of property related to industry and agriculture along rivers in the Northeast see: Gary Kulik, "Dams, Fish, and Farms: Defense of Public Rights in Eighteenth-Century Rhode Island," in *The Countryside in the Age of Capitalist Transformation,* 25-50; Ted Steinberg, *Nature Incorporated: Industrialization and the Waters of New England* (Amherst: University of Massachusetts Press, 1991); Brian Donahue, *The Great Meadow: Farmers and the Land in Colonial Concord* (New Haven: Yale University Press, 2007); Robert M. Thorson, *The Boatman: Henry David Thoreau's River Years* (Cambridge: Harvard University Press, 2017); John McPhee, *Founding Fish,* (New York: Farrar, Straus, and Giroux, 2002).

towards a deeply persuasive logic in capitalism and industrialization.[2] Often focusing on the river valleys of New England, these histories suggest that the transition to capitalism (and with it, modernity) can be traced through the spreading influence of industrial production.[3] They have read in this process the special alchemy of capitalism and industry that transformed the natural time of the rivers that powered the mills into the commodified units of the clock. In this literature, it is in the factory building and its associated technologies extending into the countryside—the turbines, canals, millpond, and dams— where the natural time of the river and of human life seemed to be transformed into standardized and regularized units and simultaneously divided from each other.

"If value is measured out in units of money, and land in units of space, what is the currency of labour?" British anthropologist Tim Ingold asks in his study of environmental perception, "the answer, of course, is *time*—but it is time of a peculiar sort, one that must be wholly indifferent to the modulations of human experience. To most of us it appears in the familiar guise of clock-time: thus an hour is an hour, regardless of what one is doing in it, or of how one feels."[4] The time that governed industrial labor was "uniform, homogenous, … purely quantitative, shorn of qualitative variations."[5] Laboring in the factory, this literature concludes, alienated workers from nature and natural time by substituting a time based on "artificial" metrics for one previously based on feelings, perceptions, and social activities.

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[2] Speaking to both agricultural historians and environmental historians, Deborah Fitzgerald offered what might be considered the core of this thread. Describing industrialization—and modernity more generally—as an "overarching logic," Fitzgerald argued that it "functioned as a metric of ideas, practices, and relationships that *persuaded* farmers to change." Deborah Fitzgerald, *Every Farm a Factory: the Industrial Ideal in American Agriculture* (New Haven: Yale University Press, 2003). For the source of the concept of modernity as "markets, machinery, and science" as a shorthand among environmental historians in the late twentieth century see Samuel Hays, *Response to Industrialism (*Chicago: The University of Chicago Press, 1957).

[3] See Tim Ingold, "Time, Work, and Industry," *The Perception of the Environment; Essays on Livelihood, Dwelling, and Skill* (New York: Routledge, 2000), 323-338, especially 328.

[4] Ingold, *The Perception of the Environment*, 195.

[5] Sorokin and Merton (1937) quoted in Ingold, *The Perception of the Environment*, 195.

Factory clocks operating on regular units have seemed to most historians to be fundamental to the pursuit of efficiency in large-scale manufacturing. For example, historian Alexis McCrossen argues in *Making Modern Time*, that clocks were essential to industry because "they provide a consistent means to measure increments of time; ideally the duration of five minutes is exactly the same regardless of place, task, or clock. Increments of time are thus akin to other interchangeable parts at the core of mass manufacturing techniques."[6] This premise leads McCrossen to articulate what has been a core assumption of historians of capitalism and labor: "in the factory system, hourly wages and the imperatives of efficiency—maximum output per hour worked—required fealty to clock time."[7] Although her study offers considerable nuance to the overall argument, McCrossen's explanation could be a late twentieth-century paraphrase of Lewis Mumford's far more emphatic declarations from the 1930s about the relationship between the clock and industrialization. Mumford's claims on behalf of the factory clock consolidated Weber and Marx's assessment of the role of precision timekeeping in industrial capitalism and was elevated through several generations of graduate school classrooms into what has become a bedrock understanding of clock-time's relationship to modernity.

> The clock, not the steam-engine, is the key-machine of the modern industrial age. For every phase of its development the clock is both the outstanding fact and the typical symbol of the machine: even today no other machine is so ubiquitous. […] There had been power-machines, such as the water-mill, before the clock; and there had been various kinds of automata […] But here was a new kind of power-machine, in which the source of power and the transmission were of such a nature as to ensure the even flow of energy throughout the [clock] works and to make possible regular production and a standardized product. In its relationship to determinable quantities of energy, to standardization, to automatic action, and finally to its own special product, accurate timing, the clock has been the foremost machine in modern technics: and at each powered it has remained in the lead: it marks a perfection toward which other machines aspire.[8]

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[6] Alexis McCrossen*, Marking Modern Times: A History of Clocks, Watches, and Other Timekeepers in American Life* (Chicago: The University of Chicago Press, 2013), 19.

[7] McCrossen, *Marking Modern Times,* 19

[8] Lewis Mumford, *Technics and Civilization (*Chicago: The University of Chicago Press, 1934, 2010), 14-15.

Because of this strong association between clock-time and factory production, the factory clock became an iconic representation of the juggernaut created by clocks, capitalism, and visions of modernity.[9] Building on the social histories of E.P. Thompson, historians point to the mid-nineteenth century as a period of transition when self-directed task-oriented labor governed primarily by the rhythms of the natural world and characterized by a lack of interest in precision timekeeping was overtaken by the time-discipline and clock-consciousness of industry, capitalism, and urban life.[10] This transition has been measured through the spread of wage labor, through the burgeoning market for clocks advanced by the Market Revolution, and through the increasing prominence of public time-bells, railroad schedules, clocks, and telegraphed time-signals.[11] Although the process was incomplete in the mid-nineteenth century, histories built on this foundation point to the compounding changes in American culture that would, by the early twentieth century, lead to the supposed alienation of American culture from natural time and the ascension of clock time.[12] It is a bedrock assumption of this historiography that industrial time is necessarily abstracted and alienated from the rhythms of the natural world because industrial labor was governed by the factory clock operating on "mechanical" and "artificial" time and

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9 See for example, T.J. Jackson Lears, *No Place of Grace: Antimodernism and the Transformation of American Culture, 1880-1920* (Chicago: University of Chicago Press, 1981), 10-11.

10 See Thompson on the sharp transition; E.P. Thompson, "Time, Work-Discipline and Industrial Capitalism"; Mark M. Smith, "Old South Time in Comparative Perspective," *The American Historical Review* 101, no. 5 (December 1996): 1432-1469; Michael O'Malley, "Time, Work, and Task Orientation; A Critique of American Historiography," *Time & Society* 1, no.3 (1992): 341-358.

11 Bartky; Carlene Stephens, "'The Most Reliable Time': William Bond, the New England Railroads, and Time Awareness in 19th-Century America," *Technology and Culture* 30, no. 1 (January 1989): 1-24; Martin Bruegel, "'Time that Can be Replied Upon,' The Evolution of Time Consciousness in the Mid-Hudson Valley," *Journal of Social History* 28, no. 3 (1995): 547-564; Thomas Allen, *A Republic in Time: Temporality & Social Imagination in Nineteenth-Century America* (Chapel Hill: University of North Carolina Press, 2008); Ian Bartky, *Selling the Time True: Nineteenth Century Timekeeping in America* (Stanford University Press, 2000).

12 See McCrossen, *Marking Modern Time;* Michael O'Malley, *Keeping Watch: A History of American Time.* New York: Viking Penguin, 1990); Thomas Allen, *A Republic in Time: Temporality & Social Imagination in Nineteenth-Century America* (Chapel Hill: University of North Carolina Press, 2008); Ian Bartky, *Selling the Time True.*

industrial production transformed goods into commodities, interchangeable units lacking a relationship to specific places, peoples, or cotton cloth production processes.[13] However, the confidence with which historians from Mumford to McCrossen have asserted the seeming inevitability—even necessity—of regularized timekeepers in industrial production does not fully reflect the views or experiences of water-powered factory operatives, managers, or owners looking forward from the mid-nineteenth century.[14] The idea that regularized clock time would become an inevitable staple of industrial cotton production represents a misunderstanding about how a water-powered factory operated and the purposes served by the clocks in a cotton mill.[15] The factory clock in a water-powered cotton mill was employed for labor-discipline in much the way that E.P. Thompson described, however, the factory clock did not keep time in regular units nor was it abstracted from the processes of the natural world. In the cotton mills of New England, the factory clock was a modern organic timekeeper. It was specifically designed to tell time with units that expanded and shrank as environmental conditions changed throughout the day.

As I will demonstrate, factory owners, managers, and operatives in a water-powered or hybrid water and steam-powered cotton factory understood their labor as deeply placebound,

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[13] See McCrossen on interchangeable units of time, David Nye on transition from steam to electricity since the electrified factory is still tied to natural processes, embedded in environments; Alexis McCrossen*, Marking Modern Times,* 19; David Nye, *American Technological Sublime* (Cambridge: The MIT Press, 1996).

[14] As an example, in *American Technological Sublime* David Nye makes a direct leap from Lowell in the 1850s to Ford, arguing that the types of rationalization initiated in smaller factories held a direct relationship with those that came to organize later ones. David Nye, *American Technological Sublime,* 123.

[15] Geographers Paul Glennie and Nigel Thrift would also argue that it signals a lack of attention to the theoretical dimensions of time-discipline. "Many arguments […] point to a tendency for the phrase/concept 'time-discipline' to be used somewhat uncritically. In particular, it has usually been used in the singular, whereas we see time-discipline as a multi-faceted concept whose elements ought not to be conflated with one another." Glennie and Thrift see those three related elements as regularity, coordination, and standardization. They insist (and I agree) that "various permutations of these elements are possible, whereas prevailing conceptions of time-discipline, following Thompson's approach, require all three to be a part of a single disciplinary force." Paul Glennie and Nigel Thrift, "Reworking E.P. Thompson's 'Time, Work-discipline and Industrial Capitalism'" *Time & Society* 5, no. 3 (1996): 275-299, 285-286.

inextricably connected to a regional ecosystem. They did this in order to create uniform thread and cloth. Consistent cotton cloth could only be created with close attunement to local environmental conditions. In this context, factory designers improved factory production by using organic timekeeping technologies to bring human and machine labor into closer alignment with the periodic but not fully predictable patterns of the regional environment. The timekeepers they employed registered and communicated change in the natural world to factory managers and operatives in real time within the factory building, and were used to govern labor and discipline it to operate in closer synchrony with local environmental patterns.

The factory clock was part of a larger system, connected to the building, the machines, the dams upstream, and the turbines below, all powered by falling water. As I will show, the factory clock registered variations in this larger ecosystem. The factory clock was therefore one face among many of the modern organic timekeeper that was the water-powered cotton factory building itself. Because the factory building itself was connected to a regional ecosystem through the waters that flowed over its turbines and dams, it is also not accurate to consider the factory building as isolated from its regional ecosystem. Time was registered, communicated, and read by more than the clock in the water-powered factory. Working in the factory taught operators to attend to these changes.

To demonstrate these claims and consider their consequences in context, this chapter and the chapter that follows examines the lives and writing of two mid-nineteenth-century figures: Henry David Thoreau and Lucy Larcom. Each of these figures had much to say about time, natural processes, and the factory, though they approached organic timekeeping from different angles. The writing of Lucy Larcom, a mill operative and poet working in the Boott Cotton Mill in Lowell in the late 1830s and early 1840s, introduces the material world of cotton production and some of the ways early New England factory workers perceived time in the mill. The early publications of transcendentalist apprentice and critic of the expanding market Henry David Thoreau offer a window into changing mid-nineteenth-century ideas about how human society could (or should) relate to time in the natural world in time.

These accounts show how Larcom and Thoreau, and the technological subcultures they represented, sought to find and follow modern organic timekeepers that organized time in universal and standardized ways, but did not measure time in regularized units. Unlike the scientific sailors or mechanical gardeners of the previous chapters who used organic timekeepers for discrete tasks or to answer specific questions, Larcom and Thoreau believed that daily labor could be organized according to organic timekeepers. They both describe timekeepers that disciplined labor on scales substantially larger than a kitchen garden or a single ship, but also in more intimate ways than a melon seedling ever could. Where previous organic timekeepers solved questions of necessity in order to make practical choices visible—when to plant the corn, where on a map you were—they were rarely employed to compel behavior. There was good reason to follow a melon seedling, but gardeners were not coerced or compelled to do so. Larcom and Thoreau sought an encounter with natural time that compelled labor through a logic so commonsensical it was almost like instinct.[16]

In combination, Larcom and Thoreau show that in the cotton factory industrial time discipline governed by the factory clock was intended to bring about a closer relationship between workers, machines, and the rhythms of the natural world. This synchronization was an

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16 The encounter with time that Larcom and Thoreau describe is importantly different from the coercive time-discipline that Thompson describes in English factories, the socially-enforced time-discipline Thomas C. Smith found among Japanese peasant farmers, or the time-obedience that Mark S. Smith explores in antebellum plantation labor; Mark M. Smith, *Mastered by the Clock; Time, Slavery, and Freedom in the American South* (The University of North Carolina Press, 1997); Thomas C. Smith, "Peasant Time and Factory Time in Japan," *Past & Present* 111, no. 1 (1986): 165-197; E.P. Thompson, "Time, Work, and Industrial Time-Discipline," *Past & Present* 38, no. 1 (December 1967): 56-97.

ideal sought not only by industrialists, but also by ecological writers like Thoreau who hoped to see a similar kind of time discipline governing the life and labor of farmers.[17] This is not so surprising, since, as theorist Elizabeth Freeman argues, "in modernity, synchronic time arguably dominates all other forms."[18] By rejecting the regular units of the clock as insufficiently sensitive or dynamic enough to allow full synchronicity, Thoreau and the mill managers and operatives at Lowell were not articulating an anti-modern impulse, but instead extending their commitment to a particular vision of modernity, a sociotechnical imaginary of organic timekeeping.[19]

To understand the changes in organic timekeeping wrought by industrialization in New England, we must stay close to the river. We must first look upstream, to the headwaters of the Merrimack, and the ideals that inspired Henry David Thoreau's ecological visions. Only after traveling upstream with Thoreau and becoming acquainted with mid-nineteenth century ideas about how time in nature should be kept can we venture back down the river to a rendezvous in Lowell with Lucy Larcom and the material world of factory production. In the mills, men and women grappled on a daily basis with the practical challenges of organic timekeeping in a water-powered factory. Ultimately, these threads coalesce in the following chapter as Larcom and other mill operatives carry their ideas about organic timekeeping back to the countryside, and Thoreau applies his ideal of organic time-discipline to the social lives of farmers on their way to market.

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17 I use Elizabeth Freeman's definition of "synchronization,": "To synchronize something means to cause it to operate at the same time, rate, or pace as something else." Elizabeth Freeman, "Synchonic/Anochronic," in *Time, A Vocabulary of the Present,* eds. Amy Elias and Joel Burges (NYU Press, 2016), 130.

18 Freeman, "Synchronic/Anachronic," 131.

19 A sociotechnical imaginary is a concept Sheila Jasanof and Sang-hyun Kim have been developing within the field of science and technology studies in order to address gaps within political theories of modernity. Sociotechnical imaginaries, they explain in their recent edited volume *Dreamscapes of Modernity* (2015), are "collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology." Sheila Jasonoff and Sang-Hyun Kim, *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (Chicago: The University of Chicago Press, 2015).

Natural Time, the River

In many ways, there can be no better guide to the ecological and economic transformations taking place along the rivers of New England then Henry David Thoreau. Robert M. Thorson estimates that Thoreau spent roughly twice as much time sojourning on the rivers near his home than he did exploring the woods and fields around Concord during the years 1851 to 1861.[20] During that period, Thoreau rowed across the surface of placid mill ponds, he navigated down silted channels, and measured the height, depth, and breadth of the Concord river. He created a Kalendar to map the seasons on the water, and drew surveys of its shores and meadows. "Unequivocally, Thoreau's default destination was his system of three-rivers, his go-to place for finding God in nature," Thorson concluded after cataloging every river visit recorded in Thoreau's diaries.[21] The landscapes of the Concord and Merrimack rivers were far from wild. Rather, they were working landscapes, shaped by the multiple uses on and along their shores. Though corporations could own mill seats, build dams, canals, and lease water rights, New England riparian law preserved the river as a commons, however circumscribed. All users had to ensure that the same quantity of water left their mill or dam as entered it. "Thoreau is often said to have turned to 'Nature,'" another of Thoreau's biographers notes, "but what he actually turned to was, more exactly, the 'commons' – spaces that, back then, were still open to everyone."[22] With forests and hay meadows increasingly owned by individuals, rivers were one of the last great commons of New England, and they fascinated Thoreau.[23]

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[20] Robert M. Thorson, *The Boatman: Henry David Thoreau's River Years* (Cambridge: Harvard University Press, 2017), 132.

[21] Thorson, *The Boatman,* 132.

[22] Laura Dassow Walls, *Thoreau: A Life* (Chicago: The University of Chicago Press, 2017), preface, xiii; Thoreau's love for the river as "a wild commons" is also discussed in Thorson, *The Boatman,* 105.

[23] For more on the loss of the commons in and around Concord, see Brian Donahue, *The Great Meadow*.

Apart from the evident enjoyment he found in briskly flowing water and the snap of sails, the rivers of New England posed an endless, engrossing puzzle for Thoreau because they were so thoroughly shaped by human use and at the same time were so clearly agents in their own right.[24] Every dam builder could expect the river to begin piling silt behind the coffer, slowing, slowly challenging such control.[25] The Merrimack, likewise, at once powered the epicenter of New England's industrial growth, but was also an example of the region's last great commons. Ultimately, the rivers were a puzzle, helping to elucidate both ecological and economic relationships. Rivers beckoned because, as literary historian Thomas Allen put it, "Thoreau [sought] to teach his compatriots what to make of the market, […and to] extend the logic of the market into a venue where it might be appropriated and put to the service of another social agenda."[26] Afloat on a working landscape like the Concord or Merrimack rivers, Thoreau could hope that such oscillating between poles would eventually settle into harmony: "Art is not tame and nature is not wild," He declared, "man tames Nature only that he may at last make her more free even than he found her, though he may never yet have succeeded."[27] Though he may never yet have succeeded, the river offered the hope for a more balanced relationship between man and nature.

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[24] This interplay has been a source of fascination for river historians as well. For more on the history of hydraulic power: Richard White, *The Organic Machine: The Making of the Columbia River* (New York: Hill and Wang, 1995)*;* Matthew Evenden, "Beyond the Organic Machine? New Approaches in River Historiography," *Environmental History* 23, no. 4 (2018): 698-720; Christopher Morris, *The Big Muddy: An Environmental History of the Mississippi and Its Peoples from Hernando De Soto to Hurricane Katrina* (New York: Oxford University Press, 2012); Sara B. Pritchard, *Confluence: the Nature of Technology and the Remaking of the Rhône* (Cambridge: Harvard University Press, 2011).

[25] Linda Nash, "The Agency of Nature, or the Nature of Agency," *Environmental History* 10, no, 1 (2005): 67-69.

[26] Thomas M. Allen, *A Republic in Time*, 139-140. Similarly, following Thoreau as he surveyed the Concord River, historian Deagan Miller found that Thoreau "learned to survey in order […] to triangulate between nature and mankind; to pinpoint the connections that employ a person in a deep context at once cultural, economic, and natural." Deagan Miller, "A Map of Radical Bewilderment, On the Liberation Cartography of Henry David Thoreau" (March, 2018) https://placesjournal.org/article/a-map-of-radical-bewilderment.

[27] Henry David Thoreau, *A Week on the Concord and Merrimack Rivers,* ed. Kathy Casey (Mineoloa: Dover Publications, Inc., 2001), 208.

Upstream

Henry David Thoreau explored the idea of natural time as a river most conspicuously in his first published work, *A Week on the Concord and Merrimack Rivers* (1849).[28] This book opens early one Saturday as Thoreau and his brother John load a tent, some cooking implements, a few maps, and several ripe melons into a small sailboat, and begin a journey up the Concord and Merrimack Rivers. The resulting book was based on an actual journey Thoreau took with his brother in September, 1839, though the contents of the book reflect more than ten years of journal entries. During this formative period, Thoreau had also begun his intellectual apprenticeship to Ralph Waldo Emerson who had recently moved his family to Concord. Emerson encouraged his protégé to publish his revised notebooks as a version of his journey with John. The resulting text demonstrates a young man's melding of transcendentalism, ecology, and natural theology/machine metaphors, as well as a bittersweet resurrection of Thoreau's brother, John, who had died of tetanus in 1842.[29] Though Thoreau delved more deeply and extensively into the concept of natural time as a river than many of his contemporaries, the ideas about natural time expressed in *A Week* nevertheless offer a window into the ways that the concept was developing in the mid-nineteenth century. In *A Week,* Thoreau seeks an encounter with time elemental while traveling through the heart of New England's emerging industrial

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[28] For more on Thoreau see, Laura Dassow Walls, *Thoreau, A Life*; Laura Dassow Walls, *Seeing New Worlds: Henry David Thoreau and Nineteenth-Century Natural Science* (Madison: University of Wisconsin Press, 1996); Robert M. Thorson, *Walden's Shore: Henry David Thoreau and Nineteenth-Century Science* (Cambridge: Harvard University Press, 2015)*;* Thorson, *The Boatman;* Christopher Sellers, "Thoreau's Body: Towards an Embodied Environmental History,*" Environmental History* 4, no. 4 (1999): 486-514.

[29] For more perspectives on *A Week,* see the extended discussions in: Walls, *Seeing New Worlds;* Walls, *Thoreau, a Life*; Aaron Sachs, *Arcadian America: The Death and Life of an Environmental Tradition* (New Haven: Yale University Press, 2013); Deagan Miller, *This Radial Land: A Natural History of American Dissent* (Chicago: The University of Chicago Press, 2018); Thorson, *The Boatman.*

countryside. For this reason, *A Week* offers us an opportunity to, metaphorically, explore what lies "upstream" from the factory time of Lowell.

Though based on an actual journey, the narrative of *A Week* is an allegory. It begins early one Saturday morning at the beginning of fall as the two brothers push their boat out into the Concord River and begin to row upstream. Pulling against the current, their voyage takes most of the week. On the way, Thoreau explores the material countryside along the shores of the two rivers, and also draws his readers into allegorical time and space.[30] Rowing across rivers real and imagined, including the Musketaquid, the Merrimack, the Nile, the Euphrates, and the river Stix, Thoreau and his brother reach their destination. On Thursday, they pull their boat onto the shore and travel inland, hiking. This is the turning point of the voyage. In the morning, the brothers feel the weather has changed. They hoist a sheet over their hand-built boat and glide swiftly back down the river, out of archetype and towards Concord and the quotidian present.

The immediate landscapes through which Thoreau and his brother traveled in 1839 were in the midst of rapid change. After the success of the textile mills at Waltham, MA, in 1821 a group of Boston-based investors began looking for a site to build a new manufacturing endeavor.[31] The investors found a promising location at the Pawtucket Falls, near the town of East Chelmsford, where the Merrimack River fell 30 feet over a series of rapids. The Pawtucket Falls lie just above the juncture of the Concord and Merrimack Rivers, and roughly sixteen river miles north of Thoreau's home in Concord. The Boston Associates built a dam at the Pawtucket,

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30 The text of *A Week* is chimeric, seeming to shift between polarities. "Thoreau can be quoted to sound like the perfect transcendentalist," Walls observes, "the mystic of the empyrean, or a rock-bound realist." Walls, *Seeing New Worlds,* 49.

31 For more on the creation of Lowell see Thomas Dublin, *Women at Work: The Transformation of Work and Community in Lowell Massachusetts, 1826-1860* (New York; Columbia University Press, 1981); Robert F. Dalzell, Jr., *Enterprising Elite: The Boston Associates and the World They Made* (New York: W.W. Norton & Co., 1993); Ted Steinberg, *Nature Incorporated;* Lindy Biggs, *The Rational Factory: Architecture, Technology, and Work in America's Age of Mass Production* (Baltimore: The Johns Hopkins University Press, 1996); Patrick Malone, *Waterpower in Lowell: Engineering and Industry in Nineteenth-Century America* (Baltimore: Johns Hopkins University Press, 2009).

and within five years, as historian Ted Steinberg explains, "there were two levels of canals and 2,600 people in the newly incorporated town of Lowell."[32] The millpond created behind the dam reached nineteen miles above the Pawtucket Dam. Those accumulated waters spilled over the Pawtucket Dam or ran along canals and over turbines, tasked with supplying 3,595 cubic feet per second of water to power the mills of Lowell through their fifteen hour workday, six days a week, year round.[33] Eventually twenty-six corporations would draw water power from the dam and canals the Boston Associates built across the Merrimack at this site alone.[34] And this was just Lowell. From its headwaters, the Merrimack River traveled 110 miles to the sea.[35] Over the course of its fall from the surface of Lake Winnipesaukee to sea level, the river dropped through 269 vertical feet and carried an average annual flow of roughly 7,000 cubic-feet per second.[36] Eager to capture the profits and water-power of the entire region, the Boston Associates financed a string of mill seats at each major fall in the Merrimack.

On their way to Concord, NH, the Thoreau brothers passed though the nineteen miles of flooded meadows created behind the Pawtucket Dam, then the textile town at Nashua where six factories relied on the water power created by the falling water of the Merrimack, and portaged around the fifty-four foot Amoskeag Falls that powered the mills at Manchester, NH.[37] To ensure adequate water supplies to power the mills, a subsidiary corporation of the Boston Associates called the Lake Company developed a system of water storage along the Merrimack so that

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32 Patrick M. Malone, "Surplus Water, Hybrid Power Systems, and Industrial Expansion in Lowell," *IA: The Journal of the Society for Industrial Archeology* 31 no. 1 (2005): 23-40, 26.

33 Patrick M. Malone, "Surplus Water, Hybrid Power Systems, and Industrial Expansion in Lowell," 26.

34 Steinberg, *Nature Incorporated,* 67.

35 Malone, "Surplus Water, Hybrid Power Systems, and Industrial Expansion in Lowell," 25.

36 Malone, "Surplus Water, Hybrid Power Systems, and Industrial Expansion in Lowell," 25, 26.

37 Steinberg describes these sites in far greater detail; Steinberg, *Nature Incorporated,* 77.

water could be held upstream during wet seasons, and then released during periods of drought. Although this system had just begun in 1839 when Thoreau began his journey, eventually the Lake Company built three water storage lakes, the closest one located roughly eighty miles upstream from Lowell.[38] "In all," Steinberg summarizes, "the cities of Lowell, Lawrence, and Manchester controlled the flow of the Merrimack River for roughly forty-five river miles, or close to 40 percent of its course."[39] Because it was powered by water, the Lowell system extended nearly a hundred miles upstream from the actual factory buildings noisily churning beside the Pawtucket Dam.

On the sunny journey in 1839, Thoreau went searching for an Arcadian middle landscape by rowing through the heart of New England manufacturing.[40] He was, in effect, travelling a river landscape already deeply modified and to a certain extent controlled by the group of men who founded Lowell and its associated manufactories.[41] Rather than thinking of *A Week* as a journey to the wilderness of New Hampshire and a return to civilization, we should remember that for the bulk of the narrative Thoreau and his brother placed themselves in the heart of the question: rowing across the mill ponds, treading the canal paths, and portaging the mill dams built by the Boston Associates and their competitors.

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[38] Steinberg, *Nature Incorporated,* 112.

[39] *Ibid.,* 79.

[40] "By midcentury, the [Merrimack] valley was the heartland of the large integrated cotton mill." *Ibid.,* 52.

[41] *Ibid.,* 65, 53.

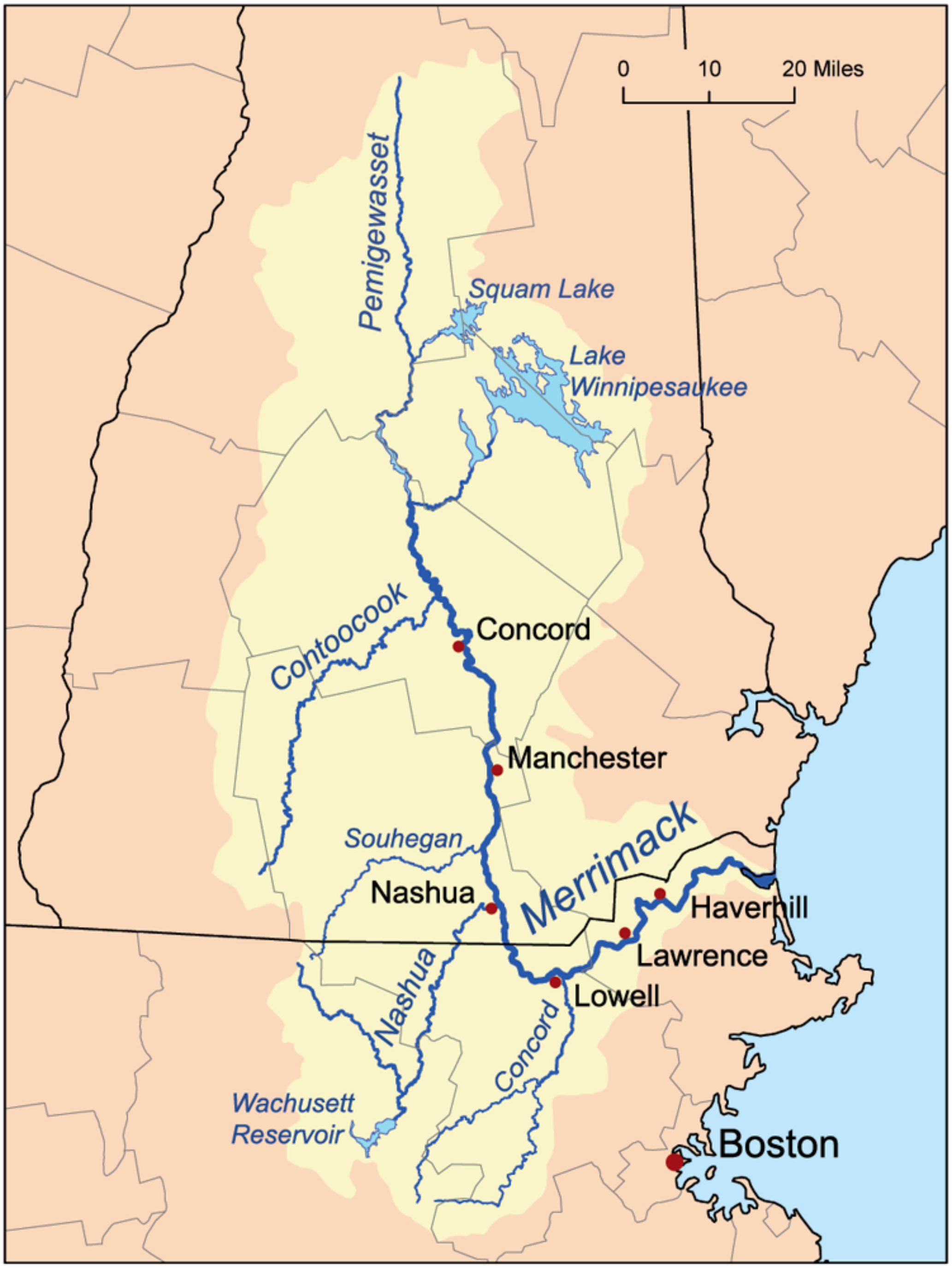

Figure 9: A map of the Merrimack River watershed with major mill seats including Lowell and Lawrence. Image via Wikimedia Commons,

https://de.wikipedia.org/wiki/Merrimack_River

The Synchronous Sublime

Not surprisingly, in *A Week,* Thoreau tested older ideas about time against the industrial landscape he moved within. Almost immediately after launching the narrative, Thoreau reflected on the dissonance between garden books and the natural temporal cycles he hoped to fit his life within. Like horticultural authors of the late-eighteenth century, Thoreau found fault with the format and approach of calendrical genres to convey changes in natural time and guide human activity. "We are apt enough to be pleased with such books as Evelyn's Sylva, Acetarium, and Kalendarium Hortense," he began, "but they imply a relaxed nerve in the reader. Gardening is civil and social, but it wants the vigor and freedom of the forest and the outlaw."[42] The apprentice transcendentalist did not seek the civil partnership with nature afforded by a garden calendar—the mere *aligning* of art and nature. Thoreau expressed a desire for something more intimate and dynamic. "We would not always be soothing and taming Nature, breaking the horse and the ox, but sometimes ride the wild horse and chase the buffalo," he declared in *A Week*.[43] Through his critique of earlier garden literature, Thoreau began to define an experience of nature and time in which participants maintained "the greatest independence of each other," and yet moved along in synchrony.[44]

In *A Week,* Thoreau envisioned natural time as the rationalizing principle that manifested a cosmic order. Doing so, he was adapting some of his new mentor's, Ralph Waldo Emerson, claims in *Nature* (1836). Literary Historian Laura Dassow Walls argues that *Nature* "presented

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[42] Thoreau, *A Week,* 32.

[43] Thoreau, *A Week,* 33.

[44] See Alexis McCrosson on the wider social meeting of synchronicity in the mid-century. Alexis McCrossen, *Marking Modern Time: A History of Clock, Watches, and Other Timekeepers in American Life* (University of Chicago Press, 2013), 42-43; for political meaning of synchrony see: Alexis McCrossen, "The Sound and Look of Time," *Common-Place.org* 13, no. 1 (October, 2012) http://www.common-place-archives.org/vol-13/no-01/mccrossen/.

to its readers a way to reunite that sundering trinity, Nature, God, and Man, through a recovery of the spirit that flowed through all and bound all lawfully into one."[45] This philosophical reunification is called rational holism, one later modification of the idea of the clockwork universe described in the first chapter.[46] Rational holism propounded that there was ultimate order in the universe, that it was commensurate with human understanding, and that by learning to connect spiritually and physically with the periodic but not fully predictable patterns of the natural world, the book of Nature would become legible (and in turn come to compel human action.)[47] When Thoreau dreamed of "ceasing to row against the current" in *A Week* or asked what it would be like to march in unison with the drumbeat of nature, he was playing with practical applications of Emersonian rational holism. Rational holism suggested that through synchronization with natural processes, human beings could draw into a closer relationship with Nature, coming to follow an essential natural time that existed behind and beyond all surface patterns. Emerson taught his apprentice—as well as countless audiences across early America—that synchronization with natural rhythms signaled the path towards a life in harmony with nature.

In the first chapter of the dissertation, it was a seed technology, the early melon, that ultimately offered colonial gardeners the opportunity to standardize and calibrate universal timekeepers in local place and time. Being well versed in the garden literature out of which the practice of growing early melons developed, it may not be fully coincidental that melons figured

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45 Laura Dassow Walls, *Seeing New Worlds,* 60.

46 She adds: "the whole can be known only through reason's unmediated and intuitive connection with spirit, a vision frequently named 'transcendental.'" Walls, *Seeing New Worlds,* 60- *62.*

47 Because of his emphasis on the idea that nature existed within concatenating polarities, Emerson tended to draw forward patterns of periodic but not fully predictable phenomena—and the fact that these phenomena were not *fully* predictable but could nevertheless be commensurate with human understanding, was necessary to his vision of nature and spirit. "A life in harmony with nature," Emerson explained in *Nature*, "… will purge the eyes to understand her text [….] so that the world shall be to us an open book." Ralph Waldo Emerson, *Nature and Other Essays*, ed. Lisa Perniciaro (Mineola: Dover Publications, Inc., 2009), 14.

frequently in Thoreau's writing about natural time. In narratives like *A Week,* the occasion of eating a melon often precipitated extended reflections on the idea of a more perfect time in nature.[48] In one passage, for example, Thoreau played with melon-shaped metaphors for the universe and wondered what it might look like to participate in the "river" of time that flows through and beyond himself.[49] There, beside the river, Thoreau and John "drew forth a melon for our repast, contemplating at our leisure the lapse of that river and of human life."[50] In this passage, which opens and closes with the brothers ruminating on melons and time, Thoreau describes natural time as a river that flows through material and metaphysical life. Thoughts, stars, stones, and markets were all ordered through the flow of time, a river. They also all followed an ultimate order, "the hardest material obeys the same law with the most fluid," and those were the laws of Nature.

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[48] Knowing this may seem like a fantastic claim, here is the extended quote from *A Week* where the very act of eating a melon becomes the impetus for the experience of time: "In the middle of the day we rested under a willow or maple, which hung over the water ; and drew forth a melon for our repast, contemplating at our leisure the lapse of that river and of human life. As this current, with its floating twigs and leaves, so did all things pass in review before us; while far away, in cities and marts on this very stream, the old routine was proceeding still. There is a tide in the affairs of men, as the poet says; and yet the ebb always balanced the flow, and the shores were unchanged, but in longer periods than we can measure./ The hardest material obeys the same law with the most fluid. Trees are but rivers of sap and woody fibre, flowing from the atmosphere and emptying into the earth by their trunks; as their roots, on the other hand, flow upward to the surface. And in the heavens there are rivers of stars and Milky Ways. There are rivers of rock on the surface, and rivers of ore in the bowels of the earth. And our thoughts flow and circulate, and lapse into the current year. As things flow they circulate, and all streams are tributary to the ocean, which itself does not stream./ There are moments when all anxiety and stinted toil and desires must cease, in the infinite leisure and repose of Nature. Laborers must have their nooning undisturbed. The sailor, in a sultry day, stretched on the deck of his craft, and drifting with the sluggish water, is even more of a philosopher than a reformer. Sometimes we cease to row against the stream, and float or sail upon the tide of life, — rock, tree, kine, knoll, and all the panorama of the shore assuming new and varying positions as wind and water shift the scene, favoring the liquid lapse of thought./ When I go into the Museum and see the mummies, wrapped in their linen bandages, I see that the times began to need reform as long ago as when these walked the earth. I go out into the streets, and meet men who declare that other times and other dynasties are now at hand. But still I know that as man stood in Thebes so does he stand in Dunstable to-day./ The sap of all noble schemes drieth up, and the schemers return again and again, in despair, to "common sense and labor;" but to return is not the right way, nor will it be the last. Such is the testimony of the poet, and Time seems longer than Eternity; but there are secret articles which the historian can never know, as often in the treaties of states there are secret articles inserted which are of more importance than all the rest. […] slicing the melons which are a fruit of the East, our thoughts reverted to Arabia, Persia, and Hindustan, the lands of contemplation, the dwelling-places of the ruminant nations […] At length we threw our rinds into the water for the fishes to nibble, and added a breath to the life of living men…." Henry David Thoreau, *First and Last Journeys of Thoreau; Lately Discovered Among His Unpublished Journals and Manuscripts, vol. 1.,* ed. Franklin Benjamin Sanborn (Boston, 1901), 11-16.

[49] "Let us wander where we will, the universe is built round about us, and we are central still. If we look into the heavens they are concave, and if we were to look into a gulf as bottomless, it would be concave also. The sky is curved downward to the earth in the horizon, because we stand on the plain." Thoreau, *A Week,* 414.

[50] Thoreau, *A Week,* 77.

In Thoreau's writing, natural time—another resource held in common—figured as a river. Like the actual rivers of New England, the river of natural time seemed to be a site where the tangled relationship between Art and Nature might be brought into a more perfect alignment. "What is Time?" Thoreau asked himself halfway through *A Week*. And he answered: natural time was like marching to a drummer, "when the pulse of the hero beats in unison with the pulse of Nature, and he steps to the measure of the universe."[51] Thoreau pushed his boat into the heart of the Merrimack because that was where he hoped to catch a different, deeper rhythm: the current of natural time.

Farmers, Fishermen, and Factory Workers

Even as Thoreau was revising his ideas about time and nature on the upper portions of the Merrimack, downstream a young woman named Lucy Larcom had begun her fourth year working in the Boott Cotton Mill at Lowell, MA. Many years later, Larcom would become a poet and social critic, but in 1840, she was a young and literary mill girl. Larcom was born in 1824 in Beverly, Massachusetts, a town walking distance from Nathaniel Bowditch's home in Salem. As a shipmaster interested in problems of navigation and astronomical calculation sailing out of Salem, Larcom's father Benjamin would likely have known Bowditch, and the *Practical Navigator* would almost certainly have been part of the Larcom family's library.[52] Growing up, it is also very likely that Larcom and her nine siblings encountered some version of those ideas about organic timekeeping contained in the previous chapter. The knowledge of distant places

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[51] Thoreau, *A Week,* 110.

[52] "It was a small world. As Salemites walked the fifty streets and alleys of their town, they must have recognized almost every face. Marriage ties going back decades linked individuals in tight webs of kinship, but even those who somehow escaped the family tree were familiar, encountered in multiple contexts." Tamera Plakins Thornton, *Nathaniel Bowditch and the Power of Numbers: How a Nineteenth-Century Man of Business, Science and the Sea Changed American Life* (Chapel Hill: The University of North Carolina Press, 2016), 8.

and the sense of connectivity encouraged by astronomical navigation permeated far beyond the wharves of Salem and Beverly.[53] While the previous chapter discussed the spread of organic timekeeping at sea, in the coastal culture of farmers and fishermen, it would be foolish to assume that those ideas about time and nature were not also carried ashore. "Men talked about a voyage to Calcutta, or Hong-Kong or 'up the Straits,' – meaning Gibraltar and the Mediterranean, — as if it were not much more than going to the next village," Larcom recalled. "It seemed as if our nearest neighbors lived over there across the water."[54]

Yet, Larcom was born in an era during which Essex County rapidly changed, and with the early death of her father, her immediate family was quickly drawn away from the sea and into the manufacturing industry just beginning to flower in the region.[55] Describing this transition, historian Daniel Vickers explained that after 1807, "first the embargo, then the War of 1812, and finally the revival of European shipping cut into the profitability of the carrying trades and slowly persuaded merchants to redirect the considerable capital they had been accumulating since the 1790s into other channels."[56] The special circumstances that had enabled Salem to

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[53] In later memories of her childhood, Larcom remembered that "the sea was [Beverly's] nearest neighbor, and penetrated to every fireside, […] The farmers up and down the shore were as much fishermen as farmers; they were as familiar with the Grand Banks of Newfoundland as they were with their own potato-fields" Among the children of Essex County, one of the consequences of this intimacy with the sea was a sense of connection to distant regions—a sense further supported by discussions of navigation and timekeeping in the home and formal education in it for young men who went to sea. Lucy Larcom, *A New England Girlhood, outlined from memory* (Boston: Houghton, Mifflin, and Co., 1892), 93; Larcom's autobiography echoes what historian Daniel Vickers demonstrated in his now-classic history of labor practices in the county surrounding Salem and Beverly, *Farmers and Fishermen* (1994). In his study of labor practices in Essex County, Vickers found that in Salem (and likely nearby Beverly as well), nearly all young white men were expected to spend some portion of their youth at sea. Daniel Vickers, *Farmers and Fishermen: Two Centuries of Work in Essex County, Massachusetts, 1630-1850* (Chapel Hill: The University of North Carolina Press, 1994); Daniel Vickers and Vince Walsh, "Young Men and the Sea: the Sociology of Seafaring in Eighteenth-Century Salem," *Social History* 24, no. 1 (1999), 17-38, 21.

[54] Larcom, *A New England Girlhood,* 94.

[55] Literary critic James E. Dobson observed that Larcom was notably unsentimental about her memories of childhood given the conventions of autobiography prevalent in the 1870s and 80s. "*A New England Girlhood* fails to conform to the conventions of the linear and temporally progressive autobiography in part because of [Larcom's] inability to return to scenes of childhood experience rife with nostalgic sentiment. […] The future instantiated by Larcom's present social time precludes such imaginative, self-indulgent representations of her past." James E. Dobson, "Lucy Larcom and the Time of the Temporal Collapse," *Legacy* 33, no. 1 (2016), 82-102, 84.

[56] Vickers, *Farmers and Fishermen,* 313.

briefly become the home of the richest men in America during the 1790s, shifted so that wealthy businessmen like Elias Hasket Derby began to invest instead in manufacturing rather than sailing. In the previous chapter I argued that this shift, accompanied by changing perceptions of human capacity, led to the marginalization of the scientific sailor and ever-more-limited opportunities for non-white sailors after the 1830s all along the East Coast. Competition for berths grew while wharfside work dwindled. Vickers reported that by 1832 nearly 13,000 Essex County residents were employed by manufacturing, and by 1850, "there was hardly a spot in the region where the majority of men were not artisans or industrial laborers."[57]

This transition occurred within less than a generation. Children like Lucy or her neighbors, raised near the sea and often with the expectation of working on sailing ships for a portion of their lives, more often found themselves making a living within a factory than from the sea. However, we should not assume those mill operatives left their ideas about organic timekeeping on the farm when they entered the factory. The idea of organic timekeeping was pervasive in American culture.

The factories at Lawrence and Lowell were established as large-scale experiments not only in the conversion of commodities to capital, but also in what was hoped to be a better form of industrialization. During the first quarter of the nineteenth century, many Americans cultivated a strong skepticism towards manufacturing and urbanization, fueled not only by republican ideals but also by negative impressions of British manufacturing towns. However, the assumed opposition between manufacturing and pastoralism had yet to be fully established in

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[57] Vickers, *Farmers and Fishermen,* 313.

American culture in the 1850s.[58] Rather, the fact that in 1850 most American factories were in rural regions encouraged many Americans to believe that it was the defects of urbanization rather than industry to which the ills of European factory towns should be attributed. The notion of "the factory under the elms," historian Jonathan Prude explained, "encouraged the premise that in the United States industry would not yield the evils commonly ascribed to the manufacturing cities of Europe (and especially of Britain)—and thus that industrialization would not threaten America's self-images as a pastoral republic."[59] And during the first half of the nineteenth century, Americans tended to agree with Philadelphian lawyer Horace Binney Wallace when he explained that though technology at first seemed to divide human society from nature, ultimately "the perfections of Art always throw us back upon Nature."[60] Extending Wallace's claim: instead of alienating the worker from nature, the perfected manufactory might, in was hoped, draw workers closer to Nature. Many early nineteenth-century industrialists also refused to choose between art and nature, but instead insisted that the perfection of their art would only be found through a closer connection to nature. The factories powered by the rivers of New England also seemed to operate at the junction of Art and Nature; suggesting a hoped-for reconciliation between the two.

In 1840s and 1850s, the industrial landscape of Lowell came to be viewed through what David Nye called the "technological sublime." "In an age when one seldom saw more than one or two machines together at one time," Nye explained, "the view of a large factory room

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[58] In fact, Jonathan Prude used Herman Melville's short story "The Tarterus of Maids" to illustrate how fairly uncommon this assumed opposition was. Jonathan Prude, "Town-Factory Conflicts in Antebellum Rural Massachusetts," in *The Countryside in the Age of Capitalist Transformation*, 71.

[59] It should be noted that Prude takes issue with this perspective because it "gives the impression that rural industrialization was essentially placid." Prude, "Town Factory Conflicts," 72.

[60] Wallace quoted in Thomas Bender, *Toward an Urban Vision: Ideas and Institutions in Nineteenth-Century America* (Baltimore: Johns Hopkins University Press, 1982), 16.

humming with incessant activity created astonishment at the ingenuity and apparent perfection of the arrangements."[61] Nye observes that "even the Amoskeag and Lowell factories, which reached impressive proportions, were at first perceived to be in harmony with the natural order."[62] Powered by the river, filled with synchronized labor, and in an era when nature was understood within machine metaphors, there was ample reason for Americans in the mid-nineteenth century to see the factory as a transcendent landscape. Part of the symbolic power of the factory clock, therefore, came from its role in organizing this orderly landscape while visually representing that order.

For nineteenth-century New Englanders, Lowell was understood as an experiment in pastoral industrialization. Closer to rural communities, operated by young white Yankee women working seasonally and living in family groups, the thought was that the virtues attributed to pastoralism, domesticity, and industrious labor could vindicate manufacturing. When the Larcoms faced poverty after the death of Benjamin Larcom, Lucy's mother began to consider manufacturing jobs. "Some of the family objected, for the Old World traditions about factory life were anything but attractive," Larcom recalled, "but they were current in New England until the experiment at Lowell had shown that independent and intelligent workers invariably give their own character to their occupation."[63]

The idea that a pastoral setting would ameliorate the experience of working in a mill, raising manufacturing to an art through connection with nature, was never fully realized— just as the ideals of the early melon or the scientific sailor were primarily aspirations. However, they

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[61] This "combination of complexity and order on a massive scale," hinged on the orderly integration of human and machine labor and was "a visual metaphor for the promised cornucopia of industrial production." Nye, *American Technological Sublime,* 113, 115.

[62] *Ibid.,* 133.

[63] Larcom, *A New England Girlhood*, 146.

were ideas openly discussed and commonly referenced in the 1830s and 1840s. An important cultural touchstone, they shaped visions of modernity even as they failed to uphold all of the demands placed upon them. At the age of eleven, Larcom's family moved to Lowell and shortly after she began working in the Boott Cotton Mill, already exposed to the question—or perhaps the challenge—that if any manufacturing operation could lead a mill worker back to nature, it would be one of those built and run at Lowell. The ideal of the perfectible factory was so widespread that "occasionally a young girl was attracted to the Lowell mills through her own idealization of the life there," Larcom explained. "Instead of an Arcadia, they found a place of matter-of-fact toil with a company of industrious, wide-awake girls."[64]

As an author and poet, it was the mental lives of these "wide-awake girls" who worked at the factory in the 1840s that Larcom described in her poetry and autobiography. And it was these female mill operatives' journeys back to a sentimental nature or communion with the technological sublime that her most famous works explore.[65] In these works, written for the mill girls' publication *The Lowell Offering,* or published through *The Atlantic* or in monographs, Larcom reveals a sense of organic time that shares important similarities with Thoreau's vision of time, as well as offering significant updates to Bowditch's ideas of a mathematically-derived universe. If Thoreau helps us see the mid-nineteenth century manifestation of the Arcadian ideas explored in the first chapter, Larcom is the era's update to Bowditch's interest in the idea of a mathematically derivable universe that was legible to ordinary workers. Despite these differences, ideas about synchronicity are central in both of their writing.

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[64] Larcom, *A New England Girlhood,* 255.

[65] For more on the sentimental and romantic depictions of nature in mill girl writing see, Chad Montrie, "I think Less of the Factory Than of my Native Dell," Labor, Nature, and the Lowell 'Mill Girls,'" *Environmental History* 9, no. 2 (2004), 275-295.

In *A Week* Thoreau described an experience of organic time where each participant maintained "the greatest independence," but acted in close relation to each other. Describing life in the factory, Larcom begins with the moral lesson, "we discovered that human beings are not a mere 'mess' but an orderly Whole, of which we are a part," and then ties that lesson to the practical and deeply material circumstances that inspired the discovery.[66] "This we working-girls might have learned from the webs of cloth we saw woven around us. Every little thread must take its place as warp or woof, and keep in it steadily. Left to itself, it would be only a loose, useless filament."[67] Though symbolic, this observation was no more than the truth for a mill operative whose daily labor was chiefly composed of transforming disordered filaments into cops of thread and bolts of cloth.

However differently they arrived at it, in the early 1840s Larcom and Thoreau ultimately described remarkably similar understandings of organic time. From the process of spinning and weaving cotton thread, Larcom learned "that we are entirely separate, while yet we entirely belong to the Whole."[68] Larcom's views—and the other mill girls' publishing during the 1840s and 1850s—reflect the practical lessons of mill labor as much as they echo the intellectual currents of their time. Before we can explore the larger context, we need to understand where her ideas about time and technology came from. To do this, we should begin where she did: with the practical and material experiences of working in a cotton mill.

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[66] Larcom, *New England Girlhood*, 184-5.

[67] *Ibid.*.

[68] *Ibid.*.

An Idyl of Work

Lucy Larcom's most famous piece of writing, *An Idyl of Work,* follows three "wide-awake" girls around Lowell and then tags along on their holiday in the country when the mill wheel slowed during a spring flood.[69] The story opens simply, with "three girls in their work-aprons" looking out the window of their Lowell factory building, watching the waters of the Merrimack run brown and thick below them. They could feel the change in the river in every corner of the factory, and Larcom's poem builds the sense of anticipation: "the stream/ Had risen to a flood, and made the factory-wheels/ Drag slow, and slower, til they almost stopped."[70] As the flood rose, even the girls on the floor not looking out the windows began to feel its effects: "the spindle scarcely turned, the thread ran slack,/ And lazily the shuttle crossed the web."[71] Powered by the river, the factory building and all its component parts, human or otherwise, registered the changing environmental conditions surrounding the mill. As the water rose, the ever-present noise of "the groaning shaft and ceaseless clattering loom" was replaced by a pregnant repose—a quiet that in Larcom's prose telegraphed a great deal of information about the environmental conditions outside the mill and upstream on the Merrimack. The girls read this information in the lines of thread before them, in the uneven and sluggish sliver of cotton. The movement of the machines told them to anticipate a long holiday. The girls in Larcom's poem began to make plans for a trip up the Merrimack river to visit the wilds of New Hampshire.

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[69] For more on the literary context for this work see, Mary Loeffelholz, "'A Strange Medley-Book': Lucy Larcom's an Idyl of Work," *The New England Quarterly* 80, no. 1 (March 2007), 5-34; Joe Lockard, "Lucy Larcom and the Poetics of Child Labour," *ESC* 38.3-4 (September/December 2012), 139-160.

[70] Larcom, *Idyll*, 12.

[71] *Ibid.*.

As Larcom's poem suggests, nineteenth-century cotton factories were extremely sensitive to the environmental conditions of their regional as well as local place and time. Even as owners, managers and designers attempted to smooth the effects of seasons and regulate the flow of power through the mill, the interconnected buildings and machines registered a wide variety of natural patterns. Mill operatives were able to read those changes through their interactions with machines, their bodily comfort in the work rooms, and finally, in the actual line of cotton, transformed from bale to sliver to thread. The river spoke through the mill building, its condition and idiosyncrasies articulated in the whizz of spindles, the clatter of machines, and in the very twist of the thread. In the water-powered mill, cotton became a tickertape of environmental conditions within and around the factory. In its final form, it was an index that recorded change in local time and place.

As a continuous real-time register of changing environmental conditions, the mill building itself was a kind of modern organic timekeeper—part of this interconnected factory timekeeping system that included the factory clock, but extended well beyond the clock into all the systems within a mill. Though the mill owners and designers of Lowell pursued "regularity, order, and control," little of this process of registering and reporting time in the mill involved counting time in regularized units.[72] Factory managers sought regular units of production, but the unit they employed to measure labor was a "day's work" not individual hours or minutes calculated by a mantel clock. Machinery designers calculated a "day" as ten-hours of machine operation calibrated to the flow of energy through the factory, and energy did not flow evenly through the factory or across the days of the year.[73] Seeking to increase productivity, American

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[72] "Regularity, order, and control – those were the prime concerns of those who managed Lowell and the other large-scale textile mills in the Merrimack valley." Steinberg, *Nature Incorporated,* 62.

[73] In a technical paper from 1900, engineers for General Electric estimated that despite decades of improvement in steam-powered cotton factories, factory managers still anticipated that the loss of power between the prime mover and the shafting

cotton mill managers and designers in the mid-nineteenth century rejected the regular units of the clock as a method for organizing labor, and instead developed timekeeping technologies that would allow them to align their labor more closely with the rhythms of the natural world.

Dams, Locks, and Regulators

Water-powered mills, like those at Lowell and Lawrence, sought the ideal of perpetual production, which required a steady flow of water over the wheels that powered the machines in each factory. In pursuit of a perpetual and steady flow of energy through their mills, mill owners and designers used several technologies to try to modulate the amount of water that fell over the wheels and turbines that powered mills. Among these, the most important were dams, locks, and regulators. Though they operated on different scales and with different degrees of sensitivity, broadly speaking dams, locks, and regulators all did about the same thing: directing the flow of energy through the system, banking it, diverting it, or dampening it. When historians discuss the ways in which mill owners exerted control over natural systems, these technologies are necessary parts of their argument. However, because of friction and variability within the system, many historians have over-read the degree of control over environmental conditions these technologies enabled. Because these technologies could not control the flow of water as much as would be required to enable regular flow production, American cotton mill owners and designers had to develop systems that could incorporate the periodic but not fully predictable patterns of the

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would vary between 16% and 18%. This estimate only covers the loss of power between the prime mover and the first set of shafts communicating its power vertically through the building, and does not include the loss due to friction or stoppages farther along the system. The authors of the 1900 report explain that though there is a shorthand of roughly 40% loss of power across the whole system, "it is impracticable, however to accurately measure the losses where the system is used, for the reason that you cannot determine the friction of the shafting while carrying its load of machinery under full production. The power lost by slipping of belts and by increased pressure on bearings cannot be ascertained, except approximately." "Development of the Electric Drive" Presented to the Southern Cotton Spinners Association (May 10, 1900) Trade Paper, *General Electric*. Smithsonian Institution Trade Catalogs, 26971.

natural world. Seeking uniform products, they built to accommodate irregularity and variation in most other aspects of mill machinery and labor.

Water to power the factory came from rivers, which, however broad or deep they might run, still experienced seasonal variations. They ran high in spring, froze in winter, and could fall perilously low in late summer. With too little water to fall into their buckets, the massive waterwheels that translated the power of the river into the factory could not turn. Given this, the dangers of drought for industrialists like the Boston Associates might seem obvious. The risk of high water, however, may be less clear.

Water wheels convert falling water into energy to power the mill when the weight of the water, as it fills the buckets of the wheel, overcomes the inertia of the wheel and causes the it to rotate, dumping water into the stream below. Careful proportions of wheel size, drop, and water volume governed the optimal speeds at which the wheel operated. For the mill to harvest the most energy from the falling water with the least loss to friction, wheel size, bucket capacity, wheel rotation, and water volume needed to be proportion.[74] In flood, the glut of water racing through the canals delivered more water than each bucket on the wheel could carry. As a result, excess water flowed over the top of the full buckets, pooled at the foot of the wheel, and clogged the canals that returned the waste water to the river below. This backwash prevented the wheel from rotating as quickly as it was designed to, compounding the problem.

The first layer of regulation on the flow of water through the river system came from dams. At Lowell, it was Pawtucket Dam that stockpiled the water of the Merrimack in a mill

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[74] Many hydraulic manuals explained how to calculate these proportions, though constant improvements were sought and published, including ones from Increase A. Lapham. Lapham estimated that the ideal proportions for an overshot wheel was 3:2 and an undershot was 3:. Increase Lapham, *Notebooks Containing Tables and Rules, Used by Laphem at Milwaukee in 1840*, Box 1, Folder 9, Notebook pages 6 and 7; *Franklin Journal and American Mechanic's Magazine*, vol. 1, ed. Thomas P. Jones (Philadelphia, 1826), 104; Charles Elbredge Leonard, *The Mechanical Principe; Containing all the Various Calculations on Water and Steam Power, and on the different kinds of machinery used in manufacturing; with tables showing the cost of manufacturing different styles of cotton goods* (New York: 1848).

pond above the town. From there, the Boston Associates diverted the waters of the Merrimack through a series of canals that flowed through the foundations of the factories. Locks along the canal could be opened and closed to ensure optimal amounts of water flowed into the textile mills. Any surplus water held in the millpond flowed over the top of the dam and continued downstream.[75]

Although the factories of Lowell and Lawrence were located downstream, their influence could be felt over 100 miles upstream by the 1850s. During dry seasons, like late summer, the Boston Associates released water from upstream holding lakes, flooding the hay meadows that farming communities along the shores of the river relied upon to support their system of mixed-husbandry.[76] Low water was not the only threat to the continued pace of production in mills. High water also slowed the wheels. And so, in spring when farmers relied on high water to flood their meadows and bring new layers of nutrients to hay fields, mill owners again worked against the farmer's needs, and held back water behind locks and dams, trying to ensure a steady flow, rather than a deluge. Connected by the river, farming communities upstream came to know, in a general way, what was happening downstream in the mill towns, and, likewise, mill operatives downstream could watch the river and gain a pretty good sense of how water was moving through the rivers of the region upstream.

Given the relatively delicate ratios at which a waterwheel optimally operated, dams and locks were comparatively blunt instruments to regulate the flow of water through the system. Additionally, dams and locks ensured that an optimal amount of energy passed over the

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75 The total fall from dam to the river below Lowell was 31 feet, but not all of the factories drew power from water that fell the entire distance. Water that found its way from the Swamp Locks above the city to the Merrimack Canal, fell thirty feet and the weight of its passage powered the Merrimack Company's waterwheels. Another quotient of the Merrimack River stored behind the Pawtucket Dam was channeled toward a series of canals on two plateaus, with the general drops being either 13 or 17 feet. Steinberg, *Nature Incorporated,* 67.

76 Steinberg, *Nature Incorporated,* 104, 105, 113; Brian Donehue, *The Great Meadow, 232-33.*

waterwheel assuming the entire mill was in operation. However, even when water conditions were optimal, not all of the machines in the factory would necessarily be "on-line," and so the actual demands for energy from the millwheel might be much lower than the amount of water supplied to the system by dams and locks assumed. In a situation like that, the wheel might spin too quickly. This, too, threatened cloth production, was unsafe for workers, and could also damage the machines in the factory.

To mitigate the effect of the wheel spinning too quickly, the mills at Lowell had installed "governors" or "regulators" on their mill wheels by the 1840s. Invented much earlier by James Watt, governors were "revolving pendulums" attached to the main shaft near the waterwheel. "In proportion as the machinery moves faster or slower," mathematician Robinson Buchanan explained in his essay on mill work and machinery, "the centrifugal force acts upon the governor, and raises or depresses an iron cross, which, acting on a level, reverses the motion of the wheel-work, which operates upon a slide so as to enlarge or lessen the passage of the water to the water-wheel."[77] Ideally, the governor acted to keep the amount of water falling through the mill wheel in proportion to the ideal rate at which the wheel and its attached machinery should spin. In all, the mid-nineteenth century factory building was designed to smooth variation in the flow of power through its walls, whether that variation occurred from a lack of water, an abundance of water, or the hazards of having too-optimal conditions.[78]

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77 Robinson Buchanan, *Practical Essays on Mill Work and Machinery,* vol. 1 3rd ed. (London, 1841), 313.

78 In support of seeing the factory building itself as a unit, Lindy Biggs argued that "as engineers began to consider the factory building as a major component of the production process, the building became part of production technology, considered by some engineers to be the 'master machine.'" Lindy Biggs, "The Engineered Factory," *Technology and Culture* 36, no. 2 Supplement: Snapshots of a Discipline: Selected Proceedings from the Conference on Critical Problems and Research Frontiers in the History of Technology, Madison, Wisconsin, October 30-Nov. 3, 1991 (April 1995), S174-188, 174.

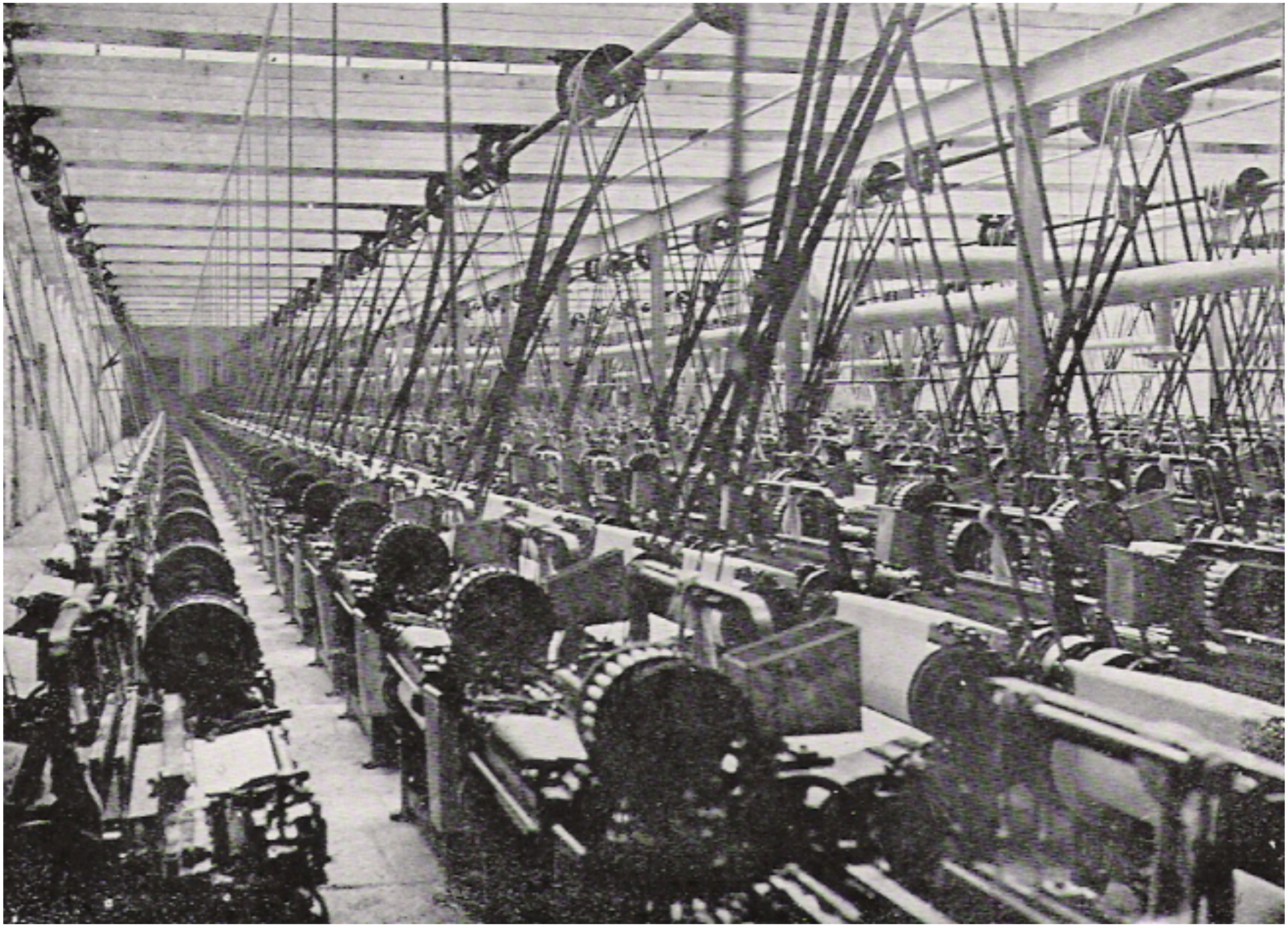

Figure 10: the network of belts and shafts in a textile mill. E. L. Hoskyn, *More Pictures of British History* (London, 1914), 61. Image from Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Cotton_mill.jpg

Dams and canals also helped mitigate the effects of New England's frigid winter. In winter, when the waters of New England began to freeze on the surface, raising the height of the mill pond could ensure that there was still water to fall over the water wheel and power the mill. Running water freezes after still water, and so the steep walls of the canals encouraging water to run swiftly also helped prevent freezing in the winter. Finally, industrialists moved their water wheels into the basements of their buildings, supplied directly through canals. Keeping the wheels under cover and underground also helped prevent freezing. "In a severe winter," Robert Baird, author of *The American Cotton Spinner* (1854) observed, "it may be expedient to run a water wheel all night to prevent its freezing."[79] Though the mill pond and coffer dam were typical of water-powered factory design, and though elsewhere extensive measures were also taken to control the flow of water into a mill, Steinberg argues that "few mill towns, aside from those formed by the Boston Associates, were quite as thorough and matter-of-fact as Lowell in their drive to master water."[80] Nevertheless, even with a network of dams stretching up to Lake Winnipesaukee in New Hampshire, even with many thousands of feet of canals channeling water from the Pawtucket Dam through the basements of twenty-six mills, and even with those waterwheels meticulously maintained to avoid freezing and swamping—the Boston Associates were unable to prevent all fluctuations in the level the water that powered the mills in Lowell and Lawrence.

To produce cotton thread and cloth, mill owners needed to attend to environmental variation in more ways than simply attempting to control the flow of the energy through their factory. The actual process of cotton spinning and weaving was also highly sensitive to local

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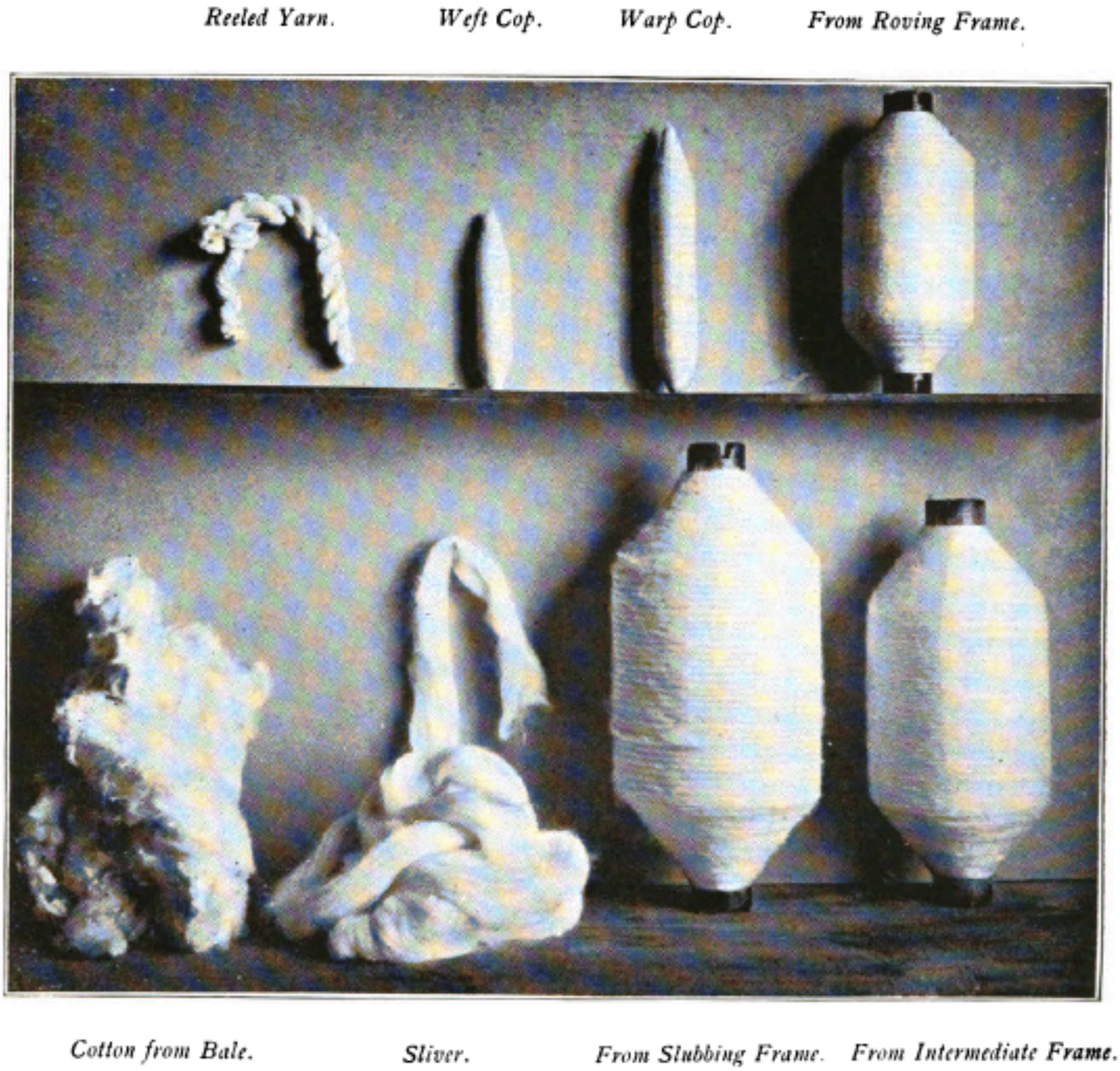
[79] Robert Baird, *The American Cotton Spinner and Managers' and Carders' Guide: A Practical Treatise on Cotton Spinning…* (Boston, 1854), 38.

[80] Steinberg, *Nature Incorporated,* 69.

environmental conditions. When historians argue that the Boston Associates exerted control over nature through their factories, they tend to focus on the external and built environment, without considering the interconnected systems that produced cotton cloth. Within this system, the energy of the river was among the easiest phenomena for mill owners and managers to control. Other factors, like the amount of static electricity in a room or the relative humidity or heat of a region, were harder to control. Because of these interconnected environmental conditions—most of which were only marginally within managers' ability to mitigate— New England's water-powered factories were built in particular environments and *for* particular environments. They were built as much to accommodate nature as control it. It is easy to imagine textile mills as dull brick monstrosities, plopped down beside rivers, filled with machinery so heavy that the floors sagged under their weight. Though constructed with bricks, beams, and iron machines, textile mills were dynamic systems, calibrated to register and respond to local conditions. Only by doing so could the water-powered textile mills of New England produce standardized cloth and thread. Like Thoreau's boat in the heart of the river's current, the factories along its bank were also caught in the stream of natural time. They could only operate if they sought a closer alignment between Art and Nature. This alignment was facilitated by organic timekeeping. Remember, organic timekeepers operate at the juncture between cultural abstractions and the material world, in those instances where place and time were inextricably linked.



SOME STAGES OF COTTON SPINNING.
(From a Photograph by Mr. H. Garside.)

Figure 11: The stages of cotton spinning from bale (bottom left) to thread (top left). Image in John Mortimer, Cotton Spinning: The Story of the Spindle (Manchester, 1895), 123.

The Local Environments of Flow Production

When Larcom began working at Lowell, the mill corporations built mills to be what historian Thomas Dublin called "a complete and standardized unit of production."[81] Each building was between four and six stories tall, built of brick, with a bell tower and clock connected to the roof of the main building. Each part of the production process tended to have its own floor in the factory, and the rooms were connected vertically by an elevator.[82] Some processes, like carding, were isolated from the rest of the production process for safety, while others, like the drawing room, operated on different schedules and under precise environmental conditions, and therefore were more isolated within the factory layout.

The goal of the cotton factory design was to move cotton fibers between rooms and through the factory as continuously as possible. This meant that the internal layout of the factory building was dictated more by the process of production than by the energy needs of different machines. Within each building, the cotton entered the picking room where the bales were unpacked mixed, cleaned, and fluffed. The cotton then passed through the scutching and carding rooms dedicated to the process of fluffing and then aligning loose cotton fibers. From the carding room, the now-aligned fibers were formed into long, yard-wide airy mats called "laps." Leaving the carding room, the mats of cotton were then gently twisted and stretched to form medium-sized tubes of consistent thickness called roving, which were then twisted and rolled into "slivers." To transform slivers into thread, they first needed to pass through a drawing process, where the slivers were spun and stretched into single-ply thread. To make strong and consistent thread, multiple plies need to be spun together, and so the slivers passed to the spinning room to

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[81] Dublin, *Women at Work,* 61.

[82] *Ibid.,* 61.

be twisted together on spindles and wounded onto bobbins as thread. From here, the production process split. Some of the thread was transferred to the warping room where it was meticulously wound onto beams to supply the length-wise threads on the looms called warp. The rest of the bobbins that left the spinning room, would go to the power looms on the top floor to provide the weft, or cross-wise threads, for cloth. "In this fashion, intermittent, and yet continuous, the work goes on with clock-like regularity," summarized James Mortimer when he described the of the process in 1895, "and with a wonderful harmony in the adaption of mean to an end, and that end being the combination of fibre in a given quantity of carded cotton so that it shall produce a certain measured length of yarn."[83]

As the cotton traveled from one room to the next, it responded to the environmental conditions within each room, whether that was the energy of the river passing through the machines or the humidity of the air. These conditions affected the way that fibers aligned, spun, and fit into a weave. Because of flow production, once these conditions were inscribed in the lap, sliver, thread, or weave they could not be erased. For this reason, the rooms in the Lowell cotton mills were designed to respond to and mitigate the effects of their local environments, while never being able to fully overcome those conditions.

At Lowell, for instance, the carding room was specifically adapted in response to New England environments. In the early stages of cotton thread production, cotton fibers must be separated and then aligned using cards and rollers. This took place in parts of the factory known as the scutching, lapping, and carding rooms. The process of combing and fluffing cotton threw bits of fluff into the air. The cotton fluff in the air caught in the spinning shafts, gummed into gears, and inhaled by workers. The motes were also highly flammable. In Britain, the motes

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83 James Mortimer, *Cotton Spinning, The Story of the Spindle,* (Manchester, 1895), 128.

caused serious problems when they clogged machinery and serious illnesses among workers when they clogged their lungs, but the general humidity of the British climate kept the flammability of cotton fluff from being an insurmountable issue for factory owners. However, in the fairly dry New England summers and extremely dry winters, the threat of a fire in the carding room sparked from static electricity led factory designers to separate the carding room from the rest of the mill and to design mill machinery that produced less friction.[84]

Another way that the New England cotton mill adapted to its local setting was in the ways that managers controlled the heat and humidity of the carding room. Cotton fiber is fairly short and so needs to be carded carefully and spread evenly to avoid weaknesses in the thread. If the fibers are not evenly distributed, when the cotton is spun into thread there will be sections that either do not twist sufficiently or where too few fibers hold a stretch of thread together. Where this happens, the thread is more likely to snap. Cotton's short fibers are also—in part due to static electricity—more likely to spring out of a twist. This creates coarse or fuzzy thread and lowers the quality of the cloth.

To combat the threat of weak and fuzzy thread, New England's mill managers kept the carding room warm and somewhat humid using steam. Mill managers' manuals identified 65 degrees Fahrenheit as an ideal temperature for the carding room, but one that was often difficult

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84 A point made almost universally among mill manuals. See for reference: Robert Baird, *The American Cotton Spinner and Managers' and Carders' Guide: A Practical Treatise on Cotton Spinning Giving the Dimensions of Machinery, Drought and Twist Calculations, etc.; With Notices of Recent Improvements Together with Rules and Examples for Making Changes in the Size and Numbers of Roving and Yarn. Compiled from the papers of the Late Robert H. Baird* (Philadelphia, 1851); James Montgomery. *The Cotton Manufacture of the United States Contrasted and Compared with that of Great Britain. (*Glasgow, post 1839); Robinson Buchanan, *Practical Essays on Mill Work and Machinery*, vol. 1. revised 3rd edition with additions by George Rennie, esq. (London, 1841); Daniel W. Snell. *The Manager's Assistant: Being a Condensed Treatise on the Cotton Manufacture, with suitable explanations, &c.: to which is added, various calculations, tables, comparisons, &c. of service to the manufacturer and general reader* (Hartford, 1850); R. Scott, *The Practical Cotton Spinner, and Manufacturer: the Manager's Overlooker's and Mechanics Companion.* Corrected and enlarged by Oliver Byrne (Philadelphia, 1851); *Cotton, from the pod to the factory: a popular view of the Natural and Domestic History of the Plant, the adaptation and improvement of the raw material, with the rise and progress of the Cotton Factory, to its present state of perfection, and a brief history of bleaching and dyeing.* (New York: Homans & Ellis, 1844).

to maintain. Carding rooms were notoriously un-healthy environments among mill operatives. "In those rooms where the cotton wool undergoes the first process of carding and breaking," an operative employed in Pittsburgh explained, "the atmosphere is one floating mass of cotton particles."[85] The mix of damp, humid, and mote-filled air, combined with the oil used to reduce friction in the gearing and prevent fires, "emits a most offensive fetter."[86] In her poetic tour of the cotton mill, Larcom spared little time for the first step of the process. "With its great groaning wheels,/ its earthquake rumblings, and its mingled smells/ of oil suffocation" the carding room communicated its internal environmental conditions—fetid, damp, warm—to the next stage of the process when it produced an even sliver of cotton. When the cotton sliver was uneven or contained lumps, it was a sign that the environment within the carding room was too cold, hot, or dry.

Whether spinning wool, flax, or cotton, the quality and durability of thread is determined not only by the way that the fibers are aligned as they are rolled into slivers, but also in the speed at which those slivers are twisted into thread. In the spinning process, too, the New England water-powered cotton factory registered local environmental conditions. The speed at which slivers are spun into thread must be consistent, but it also must be in proportion to the thickness of the thread being produced. Early spinning machines struggled to spin consistently and to have a consistent up-take of unspun fiber. The result was a weaker thread and much waste. In fact, the

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[85] "Report of the Select Committee appointed to visit the Manufacturing Districts of the Commonwealth for the purpose of investigating the subject of the employment of children in manufactures," (Harrisburg, 1838), 79-80, Pamphlet Collection of the Hagley Museum and Library.

[86] "Report of the Select Committee*,"* 79.

thread produced on early water frames was too weak and inconsistent to be used in the weft of the cloth because it often snapped when a weaver threw the shuttled across the warp-threads.[87]

As new inventions allowed mills to spin at ever-faster speeds, the problem of weaknesses from inconsistencies in the thread did not go away; it compounded.[88] As loom shuttles moved faster and faster, hurtling across the warp threads at speeds reaching a hundred miles an hour, the consistency of thread twist and thickness mattered more as well because the tension the thread was placed under—the snap of the shuttle as it raced across the warp—was also proportionately higher. Higher speeds did not eradicate the relationships between components of the production process. Instead they helped make legible the practical limits of production. Regulators, higher dam coffers, and covered wheels (etc.) could mitigate the variation of energy and help smooth seasonal variations in waterpower, but they could not eradicate all sources of variability from the system. For every gain they made in regulating energy and reducing friction, mill owners could run their mills faster, but the faster they ran the more even small amounts of friction or variations in energy mattered.

Reading the Thread

Mill operatives learned to read local environmental conditions through their labor and through the sliver and threads passing before them. In the weaving room, where "a hundred girls […] hurried to and fro, with hands and eyes following the shuttle flights," Larcom casually

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[87] Richard Guest, *Compendious History of the Cotton Manufacture: with a Disproval of the Claim of Sir Richard Arkwright to the Invention of its Ingenious Machinery (*Manchester, 1823).

[88] For example, sometimes all of the threads in a spinning mule with a thousand spindles could break at once. Comparing the time it would take to repair damage to a single-spindle on a spinning wheel to the time it would take to fix a thousand-spindle "sawney" break in a spinning mule, James Bessen argued that "although multiplying the number of machines per worker increased throughput, it also increased *defects,* often by a more than proportional factor." James E. Bessen, "Technology and Learning by Factory Workers: The Stretch-out at Lowell," *The Journal of Economic History* 63, no. 1 (March 2003), 33-64, 39.

described an unconventional kind of literacy among the weavers. A large portion of a weaver's attention was focused on the ratio between the tensile strength of the thread being spun in other parts of the mill and the optimal speed at which their looms could run. They spent their days bent over two or more looms, "threading it, watching for the scarlet mark/ that came up in the web, to show how fast/ their work was speeding."[89] Weavers could tell when the carding room humidity was off or when the spindles spun inconsistently because the threads in their shuttles broke more often.[90] Female operatives like Larcom cared about waste and breaks because their wages were "directly proportional to the number of yards of cloth or yarn their machines produced during a payroll period."[91] Breaks or waste yarn meant lost wages. Historians often focus on the manual labor of working in a cotton mill, but James Bessen makes a strong case that working in a cotton mill simultaneously required a great deal of mental labor. The majority of an operator's time at a power-loom, for example, was spent "monitoring" the two or three looms under her charge, and anticipating (often intuitively) when breakages would occur.[92]

Mill operatives' writing is filled with descriptions of the information threads and cloth conveyed about production within the textile mill system. For example, an anonymous story in the *Lowell Offering* showed mill girls using hand glasses to inspect the work of an operative suspected of running her loom too fast, producing sub-par cloth. They could read the error in the calibration of the machine in the cross hatchings of threads under the lens.[93] In another example,

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[89] Larcom, *Idyl*, 80.

[90] Thomas Dublin found that "women held all machine-tending jobs in the production process after carding." Dublin, *Women at Work,* 65.

[91] *Ibid.,* 67.

[92] See Bessen, "Technology and Learning," and James E. Bessen, 'More Machines, Better Machines… or Better Workers?" *The Journal of Economic History* 72, no. 1 (March 2012), 44-74. Only male operatives working in the machine shops were paid hourly wages, Dublin, *Women at Work,* 66.

[93] "Editorial," *Lowell Offering* (December 1845), 281.

Larcom's epic poem includes the complaint of a mill girl who worked in the room where threads were wound onto beams to be used in looms. In this passage, the operative reflects on sin within a human life through the metaphor of winding thread onto her beam. She begins:

> … I've seen
> One thread drop down through the long films o warp
> Winding themselves around the dresser's beam,
> And catch, and tangle, and make such a snarl
> As hours could not undo. And after all
> Mending attempted, with the woof filled in,
> 'T was marked "Imperfect"; doomed to some cheap use.[94]

Here, the mill girl acknowledges the way that tangles in one department of the production process carried forward into the weaving room ("the woof filled in"). Though some repairs could be attempted, the imperfection in one stage of the process could not be erased. In this case, the dresser winding the thread onto a beam lost wages for slow work even as the weaver in the next stage lost wages as a consequence of badly woven cloth from that same beam. In Larcom's poem, another mill girls consoles her complaining friend that she has made similar errors, and could, in theory, even be responsible for the problem with the unruly thread that ruined the cloth.

> "And the spinner of that thread, —
> I might have been the one, — careless of oil,
> Or band, or spindle, was responsible;
> Not you who dressed [the winding beam], or she who wove.[95]

With eyes, hands, and ears trained to attend to their machines, operatives learned to read the conditions of other rooms and of the river in the thread passing before them.

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94 Larcom, *Idyl,* 173.
95 Larcom, *Idyl,* 173-4.

Figure 12: An operative monitoring threads being fed onto a warping beam. As noted, this basic technology for cotton mill production did not radically change between 1850 and 1908 when this image was taken. Lincoln Cotton Mills: Evensville, Ind *National Archives and Records Administration ID 523100, image posted on Wikimedia Commons.*

The American System of Manufacturing

Inventors, designers, and mill managers also understood the ways that environmental conditions within and without the mill system affected the production of cotton cloth at each stage of the process. They referred to the effects of these conditions, as well as methods for mitigating their affects, when writing manuals for mill managers and operatives or when advertising their machinery for sale. It was a commonplace within mill management literature that textile mills were designed for specific environments, in part because even on a structural level, American mills differed in significant ways from English and Scottish mills.[96] American mills differed both in structural ways as well as in the ways they were operated. In combination, these differences tended to make American textile mills more sensitive registers of regional environmental change than the steam-powered mills so often studied in Manchester or Birmingham, England. The differences between British and American cotton manufacturing and factory construction was important for two reasons. First, the American system tended to be more sensitive to variations within the regional ecosystem than the British mills. Second, the most influential literature on time-discipline in factory settings was written primarily based on British mills in which the crucial role of organic timekeeping methods was somewhat less visible.

The structural difference between English, Scottish, and American mills originated partly in the relative availability of material, labor, and water or coal to power the mill. Until the anthracite coal fields of Western Pennsylvania began to produce coal, waterpower remained the most feasible method for powering American mills, even if in theory coal power offered greater control over energy flow within the factory.[97] Another major difference between American and English and Scottish mills could be found in the method factories used to connect machines to the rotating main shaft. American mills tended to use long leather belts rather than rotating shafts to power machines in the mill.[98] The belts had a lower initial cost and were easier to repair, but they also caused more friction. Since New England was already less humid than Britain, the

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96 James Montgomery. *The Cotton Manufacture of the United States*; Justitia [pseud.] "Strictures on Montgomery on the Cotton manufactures of Great Britain and America," (1841); Robert Scott, *Scott's Practical Cotton Spinner and Manufacturer: or Manager's Overlookers' & Mechanics' Companion.* (Manchester, 1840); For context on James Montgomery and his mill manuals, David J. Jeremy, *Technology and Power in the Early American Cotton Industry: James Montgomery, the Second Edition of His "Cotton Manufacture" (1840), and the "Justitia" Controversy about Relative Power Costs* (Philadelphia: American Philosophical Society, 1990).

97 James Montgomery, *The Cotton Manufacture of the United States*, 16-19, 173, 175.

98 Montgomery, *The Cotton Manufacture of the United States,* 17-18.

choice of belts rather than shafts meant that American mills tended to be at greater risk for fires, over and above the already increased risk that simply could be attributed to the drier climate.

Operatives and managers were well aware of the danger, and learned to attend closely to the humidity of the surrounding region because it affected their safety and their pay. James Montgomery, a mill manager in Maine and author of one of the most influential mill management handbooks of the era, instructed his readers to anticipate slowdowns and danger when the humidity drops. "One thing is certain," Montgomery announced, "the climate of this country is much drier than that of Britain; and it is always observed that the air here becomes more highly charged with electricity in very dry weather, particularly before rain. On some occasions it is so much so, as to affect the work considerably in the carding rooms, and especially the drawing frames, and not one of them working properly, but all, more or less, lapping up on the upper rollers, and making a great quantity of waste, besides spoiling the work."[99]

American mill operations were large scale and tended to make a limited number of products based on standardized machinery. The production process was designed to optimize "flow" between rooms, and sought the ideal of perpetual production. Within this "*system* of manufacturing that was set up for continuous flow from raw cotton to fabric," industrial archeologist Patrick M. Malone explains, "the system was most economical when it ran at full capacity."[100] Overall, American factories operated according to longer hours than in Britain and ran at higher speeds.[101] Although they sought the ideal of ever-faster perpetual production, the

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[99] *Ibid.,* 54.

[100] Malone, "Surplus Water, Hybrid Power Systems, and Industrial Expansion in Lowell," 32.

[101] Additionally, after the stretch-out of 1842 and continuing until the turn of the century, American weavers always tended more looms than their British counterparts. Bessen, "More Machines," 57.

faster American mill managers operated their factories, the more their machines registered the idiosyncrasies of the river and local environments. High speeds offered the potential for mills to produce more goods per day, but they also increased the risk of fire, of poorly carded cotton, of uneven slivers, of weak or broken threads, and loosely woven cloth. Economic historian John Lyons estimates that well-operated British cotton mills in the 1830s could only assume a 75 to 80 percent utilization rate.[102] Given the copious contemporary commentary on how much more prone to environmental hazards American mills were, it seems reasonable to assume that American mills of the same period operated at an even lower rate.[103]

Mill management handbooks warned that the faster a textile mill ran, the greater the need for operatives to develop a deep and intuitive knowledge of the production process *and* a strong knowledge of local environments. The speeder, for example, a machine used to put the first twist in cotton roving in preparation for spinning, operated in direct relation to local environmental conditions as well as in relation to the production of the carding room—conditions which could only be deduced based on experience in place. "The belt of this speeder must neither be kept too slack nor too tight, for it will produce bad effects on the roving in either case."[104] If the belt was too tight, it would twist the roving too much and prevent the machines at the next stage from drawing out the fibers into fine single threads. If it was too loose, than the roving would have no strength and break easily. Variation in the speed of the belt "aggravated" the issue, but the puzzle was present even under ideal circumstances."

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102 Utilization rate equals actual production divided by machine rate. John Lyons, "Powerloom Profitability and Steam Power Costs: Britain in the 1830s," *Explorations in Economic History* 24, no. 4 (1987), 392-408.

103 Bessen suggests that in Lowell and Lawrence this may also have been related to the high turnover of skilled workers in American mills before the 1842 transition towards hiring more local immigrant laborers. Bessen, "Technology and Learning,"40.

104 Baird, *American Cotton Spinner* (1851), 128.

Thus far, I have said relatively little about formal timekeeping in the water-powered factory building. Instead, I've described a number of systems within the mill that interface with different ways of measuring time. Mill dams and governors directly connected to changing seasons and regional weather patterns. The choice of machine speed, mill layout, and belting was materially connected to patterns of humidity and heat—to seasons—in the mills' local environment. Measures of production across a workday or year were therefore connected to the speed at which the machines in the mill could run. These larger patterns of heat and cold, light and dark, high water and low, were already implicated in the operation and configuration of the mill before the mill managers at Lowell would even produce an annual schedule or enforce time discipline across a workday. The factory building mediated between the operative's daily time schedule and the flow of energy through the watershed.

As should be clear by now, cloth production is necessarily a matter of ratios. When cotton cloth production was consolidated under one roof in the factory system, or when American mills began to run at faster speeds and higher production during the 1840s, those ratios did not disappear. They ramified. For example, Bessen found that when mill operators moved to monitoring three looms rather than two in 1842/3, a transition known as "the stretch-out," actual output per loom hour at Lowell and Lawrence decreased.[105] Machines at Lowell were powered by belts attached to shafts, connected to the main shaft of the factory by cogs. And behind that system was the waterwheel, transforming the movement of the Merrimack into yards of cotton cloth. Whether the mill was powered by steam or water, the power was translated up through the

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[105] For a much more detailed discussion of this transition as it related to technology changes in other rooms in the factory see footnote 44, in Bessen, "Technology and Learning," 47.

mainshaft, through several floors, and through a complicated network of belts, pulleys, worms, and winches. At each of the points where the teeth of cogs met, or belts looped over twisting shafts, or worms worked into systems of cogs, friction reduced the overall power available. It was a rule of thumb that in the standard six-story factory in Lowell, roughly 40% of the power produced by the mainshaft was lost to friction as that energy was distributed unevenly throughout the building.[106]

Like the thin places in the twist of a cotton thread, in an attenuated system such a mill, any variation in power in the mainshaft was communicated in slower speeds to the rest of the building. But not all parts of the mill experienced these variations in the same way. Machines located far from the mainshaft or on the top floor experienced those fluctuations more than those located closer to the shaft because friction had already reduced the overall load. These fluctuations posed specific problems for cotton manufacturing, because they disrupted the delicate ratios upon which the endeavor was based. "There is a medium in the speed of these machines," Robert Baird reported in the 1854 edition of *The American Cotton Spinner,* a popular handbook of cotton manufacturing, "to exceed [that speed] proves to be injurious to both the machine and the work."[107]

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106 See footnote 20 in this chapter for the larger discussion on this figure.

107 For his larger discussion on speed and irregularity see, Robert Baird, *The American Cotton Spinner,* 57-59; These limits were typically accounted for by the inventors of machinery, both in terms of the power required to run their machines and also the gearing required to produce consistent yarn of specific quality. Mill designers crafted machinery intended for specific environments, and intended to react dynamically to variable regional environmental conditions. In his personal copy of *Bridesburg Manufacturing Co. Cotton and Wool Machinery,* inventor Barton H. Jenks made notes on these ratios and optimal speeds. Jenks' notebooks also included more elaborate calculations that related the production of individual spindles to the speed of the run shaft operating a certain quantity of spindles running at 275 revolutions per minute for an assumed ten hour day. He included notes on limits as well. "Multiples should not run in after the reaction gears faster than 4 seconds of time for mules [operating] over 550 spindles." In another notebook, Jenks sketched the order for an entire factory beginning with his assumption about the revolutions of the main line shaft. With a mainshaft rotating at 230 revolutions per minute, in order for the system to produce yarns in the range of #6 to #20 yarn the picker must revolve at 506 rev/min, the spreader at 460 rev/min, the clipper card at 143.75 rev/min, and the railway head at 460 rev/min – among other machines in the process. Calculations such as this one, also included estimations of human labor. For instance, Jenks noted to himself that "Spooler Girls tend 12 spindles & works for 400 excelsior spindles." Barton J. Jenks Papers, "Cost of Spinning" Bridesburg Manufacturing Co. Cotton and Wool Machinery (1867), Series 1, Box 1, Hagley Museum and Library.

Spinning too quickly or two slowly changed the quality of the yarn that was being produced, a change that consumers could also read in the twist of the thread. "In the case of a cotton-mill, for instance, which is calculated to move the spindles at a certain rate," mathematician Robinson Buchanan explained, "if from any cause the velocity is much increased, a loss of work immediately takes place, and an increase of waste from the breaking of threads, etc&; on the other hand, there must be an evident loss from machinery moving too slow."[108] Mill operatives could tell when this was the case, just as they could tell when the flooded river was causing spindles to turn too slowly. "The weaver's ability to anticipate and to detect errors quickly effected her productivity," and productivity mattered a great deal to weavers because they were paid by the piece.[109]

Flow production, and the steady flow of energy through the mill, could also be interrupted by sudden shifts of available energy within a mill as machines came online or went off. When threads broke, for instance, mill operatives needed to stop their machines, fix the problem, and then bring them back online. Before the invention of "stop motions," this practice was very difficult, but even after a method of taking a machine out of the system so it could be repaired was invented, the sudden jerks and swift increases or reductions in speeds within the system that occurred when machines were taken offline changed the speeds at which all machines in the building operated. "When a part of the machinery of a mill is suddenly stopped, or suddenly set a-going, and the moving power remains the same" Buchanan explained in his *Practical Essays on Mill Work and Machinery* (1841), "an alternation in the velocity of the mill

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[108] Buchanan, *Practical Essays on Mill Work and Machinery*, 307.

[109] In fact, one historian has argued that one of the three major explanations for increases in output from cotton mill operatives between 1819 and 1902 must be attributed to mill operatives' improved ability to monitor and "read" their looms. He specifically cites the increased production at Lawrence between 1835 and 1855 as an example where output per loom increased out of proportion to increased loom speed—all during a period when weavers were asked to increase the number of looms them tended from two to three. Bessen, "More Machines, Better Machines," 67-8.

will take place; it will move faster or slower. Every machine having a velocity at which it will work at greater advantage than at any other speed, the change of velocity arising from the above cause, is in all cases a disadvantage, and in delicate operations very hurtful."[110] Because variations in the energy that flowed through the system registered in the cotton flowing between rooms in the factory, the building itself might be considered a giant environmental register and the cotton itself as kind of ticker-tape communicating the conditions within and without the building.

Synchronicity

Work in a cotton mill was monotonous, but it also required a high degree of mental acuity and vigilance from operatives. Operatives spent more than ten hours a day watching thousands of threads feed onto a spindle, monitoring the blur of multiple shuttles traveling a hundred miles an hour crossing thousands of warp threads, anticipating breaks and smashes, intuiting tempo changes and snags. Each day in the mill promised mentally as well as physically taxing labor. Reforming literature of all stripes, including that of Karl Marx, overlooked (or undervalued) the mental labor required to work in the weaving room, the spinning room, or carding room. This led some of reformers to overemphasize the ways in which temporality was imposed upon workers. Seeing mill operatives as merely arms, hands, and backs in motion facilitated this misinterpretation.[111] Had Marx attended more closely to the mental, not just physical, labor of operatives in the Manchester mills, he might have modified his claim that

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110 Robinson Buchanan, *Practical Essays on Mill Work and Machinery*, 307-308.

111 Simon Schaffer on the difficulty posed to Victorians of exploring the consequence of automation without negating the intelligence of workers. Simon Schaffer, "Babbage's Intelligence: Calculating Engines and the Factory System," *Critical Inquiry,* Vol. 21 no. 1 (1994), 203-227, 222.

"Time is everything, man is nothing; he is, at the most, time's carcass."[112] Time *was* everything in the mill, and as a result, the sensing, anticipating, and attentive mind of each operative was necessary for time, energy, and cotton to flow smoothly through the factory system.[113]

Synchronicity, as much as regularity, was the key to this complicated web of belts and bolts and shafts and spindles.[114] The machines needed to be made to work in relation to each other, and operatives needed to work in relation to the machines they tended. In the water-powered cotton mill, timekeeping and time-discipline become methods for bringing about a closer union between human labor, machines, and the river. Larcom explained the relationship this way:

> "And in a misty maze those girlish forms,
> Arms, hands, and heads, moved with the moving looms,
> That closed them in as if all were one shape,
> One motion."[115]

As it moved through the production process from bale to lap to roving to sliver to thread to beam to bolt, the cotton carried forward place-specific information about the environment within and surrounding each room of the mill. In this process, the cotton became a rolling index of change. The height of the river could be measured in the twist of a thread, the humidity of the

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[112] Karl Marx, *The Poverty of Philosophy* (Chicago: Charles H. Kerr & Company, 1920), 57.

[113] One reason the mental labor of working in a mill has been overlooked may be that in the transition to immigrant labor after the stretch-out, formal literacy rates among mill operatives dropped substantially. In the 1830s when the mills were mostly filled with short-term workers from rural New England, literacy rates were near 100%. After the transition to local, long-term, immigrant labor, literacy dropped to nearly 50%. However, as this chapter argues, mills taught operatives through their labor a different kind of literacy. Reading written words was never a requirement of the job, however, the ability to read thread and cloth became ever-more necessary for long-term employment. Bessen argues that in the transition to immigrant labor, the mills moved towards workers with greater skill. In effect, faster speeds and higher production in the mid-nineteenth century had the effect of (at least temporarily) re-skilling industrial labor and increasing the mental demands of factory labor; William Cooke Taylor, an important booster of automation in Britain defended the effects of automation by stressing the continued and necessary role of human intellectual labor in factories: "Such combination requires no small exercise of mind and no conceivable adaptation of wood and iron will produce a machine that can think." William Cooke Taylor, *Notes on a Tour in the Manufacturing Districts of Lancashire,* (1842), quoted in in Simon Schaffer, "Babbage's Intelligence," 222.

[114] E.P. Thompson makes this claim as well, but he attaches it to regularity and the clock in ways that I would disagree with.

[115] Larcom, *Idyll,* 12.

outdoors or heat of the carding room could be communicated in the thickness of a lap or the weakness of the roving. The speed of spindles was communicated to the weaving room in snapped threads or fuzzy cloth. And, because power was lost from one floor to the next in the mill, calculations of speed always had to be place-specific, even by location on a floor or proximity to malfunctioning machines. The revolutions per minute of a spindle on a spinning jenny close to the main shaft were not identical to those farther away from the mainshaft. If measured by a wristwatch, in a ten-hour period, their products would differ. For that reason, in a dynamic system like the cotton mill, synchronicity could not be found through strict and externally-defined regularity. A clock ticking away regular units unconnected to the energy flowing through the system within the factory would be of relatively limited use. Factory designers and managers, instead, sought a form of timekeeper that would be meaningful *in relation* to the work that took place within the textile mill. Because the system itself fluctuated so frequently, the factory clock they employed was also a variable register directly connected to the factory building itself. The pace of the factory clock fluctuated based on its location within the mill and throughout the day, week, and year. To work in a mill required a deep though narrow knowledge of local ecosystems, and operators developed an intuitive understanding of their labor as connected to a broader ecosystem.[116]

Focusing on the experience of workers and the ideals of manufacturers, historians have developed an extensive literature on the imposition of labor-discipline and time-discipline in the factory and the eight-hour movement. In many ways, we have an Englishman named Andrew Ure to thank for this misinterpretation—though the general boosterism of his era tended to

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[116] James Bessen estimates that in the late 1830s and early 1840s it took roughly one year to become a high-performing operative. Bessen, "Technology and Learning by Factory Workers," 33;

emphasize the claim as well. In 1835, Ure published the *Philosophy of Manufactures* in which he described the operation of an idealized, rational factory. This work, in combination with Charles Babbage's *On the Economy of Machinery and Manufactures* (1832), became primary sources – along with Frederick Engel's descriptions— for Karl Marx's interpretations of industrial labor systems encapsulated in *Capital*. Pursuing the ideal of the rationalized factory, Ure focused on the consolidation of the production process and "training human beings to renounce their desultory habits of work, and to identify with the unvarying regularity of the complex automaton."[117] As historian Lindy Biggs summarized: "Ure is saying quite clearly that the worker should become a part of the mechanical system."[118] However, many historians of timekeeping have failed to attend to Biggs' following observation: "he was, in fact, describing an idea far beyond anything that existed in his time."[119]

Ure's vision of the factory as automatic, regularized, fully standardized, and universal (independent of local environments,) "indicates a promise of future capitalist development more than the state of production in the 1830s," Steve Edwards argues, "[Ure's] argument is probably best understood as part description, part abstraction and part utopian wish-image."[120] It was certainly beyond the ability of Lowell and Lawrence to achieve, and in the 1830s and 1840s, they were the leading industrial seats in North America. In 1835 on average an operative tending the power looms of Lawrence, MA could anticipate a loom stoppage once every 2.5 minutes.[121]

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[117] Ure in Biggs, *Rational Factory,* 4.

[118] Biggs, *Rational Factory,* 5.

[119] *Ibid.*.

[120] Steve Edwards, "Factory and Fantasy in Andrew Ure," *Journal of Design History* 14, no. 1 (2001), 17-33, 20.

[121] Because this may seem like a shocking statistic, for context James Bessen found in a study of loom stoppages across the nineteenth century that the number of stoppages weavers had to tend actually increased across the century while total the stoppage time decreased. "Weavers spent the least time watching the Pacific Mills' plain looms in 1901-1903. Yet the weaver at the Lawrence Company in 1835 had to tend to a loom stoppage only once every 2.5 minutes on average while a plain loom weaver in 1901-1903 had to tend to a loom stoppage every 0.5 minutes. Thus the weaver in 1901-1903 had to monitor loom

Even if the factory could not operate with full regularity, many historians have assumed that at least the clocks that governed labor could be made to fulfill the ideals of capitalist manufacturing: to operate by regular units disconnected from local contexts. This literature treated the time of the factory clock as an external and constant register imposed up on the factory system, akin to the watches of Fredrick Taylor. However, as Babbage's tortured attempts to manufacture uniform parts for his difference engine demonstrate, this kind of regularity was an ideal unattainable in even the most closely managed manufacturing settings powered by steam. The chronometer may have been the ideal of factory designers like Barton Jenks, but that does not mean that the clocks designed for cotton factories aspired to work in the same ways as a ships' timepiece or the clock on the town green. Pursuing regular and continuous production in the water-powered mill, the time kept by the factory clock needed to fluctuate in relation to the flow of energy through the entire system. This requirement was, perhaps, highest in cotton mills, but was nevertheless present in all manufactories powered by a system of belts and gears.[122]

In the mid-nineteenth century, mills did not operate with perfect regularity. Given the ways that they channeled energy and transformed cotton into cloth, cotton mills could not operate with perfect regularity.[123] For mill managers, time was a dependent variable in calculations of the length of the working day, speed of the machines, and annual production. The time registered by the factory clock stretched and contracted in relation to a complicated set of relationships embedded in the factory itself and the wider ecosystem to which the mill was

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stoppages that were five times more frequent while actually spending substantially *less* time—one-third the time—monitoring the loom." Bessen, "More Machines, Better Machines," 67.

[122] James Bessen compared the broad-based improvements in power transmission and generation against specific improvements in weaving technology to arrive at a similar claim. Bessen, "Technology and Learning," 46, 70.

[123] Michael O'Malley echoes this claim in a more limited way: "True most mills listed precise hours of opening and closing. We have examples of these schedules, and in their typographical finality they make it seem to the modern observer as if the worker's days were strictly counted out in numbers on the clockface. But in fact those hours of work depended on fluctuations in consumer demand and, most notably, available sunlight." O'Malley, *Keeping Watch,* 38.

inextricably connected.[124] I do not mean this metaphorically. As I am about to explain, because the factory clock was also powered by the mainshaft, the time told on the factory clock's face depended on the flow of energy through the mill.

The energy of the river flowed through the factory building. Operatives spent their days immersed in its power, and machines communicated its rhythms in rattles and whirs and shrieks. Thoreau described the idea of encountering natural time as floating in the river, learning to hear and read a knowledge of nature through intuitive encounters in place. Thirty miles downstream from the place where Thoreau camped on the banks of the Merrimack and dreamed he met time elemental, mill operatives labored in the flow of natural time within a landscape organized by the periodic but not fully predictable rhythms of the broader environment in the Merrimack river valley. The two encounters with natural time and the flow of the river were not incommensurate: the goal of timekeeping in either setting was to bring about a greater synchronicity between human and non-human actors, machine or otherwise.

The Factory Clock

Mid-nineteenth century water-powered cotton mills operated on modern organic time. The building itself and specifically the mill clock registered local and regional environmental conditions, and communicated those conditions through indices like the twist in a cotton thread or through registers like the mill clock. Careful examination of the factory clock illustrates how the many technologies within the mill building were designed to synchronize human and machine labor with the periodic but not fully predictable processes of the natural world.

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124 In his historical analysis of output per man-hour among cotton weavers in the nineteenth century, James Bessen compiled a very useful table of the tasks performed by a power loom operator based on their duration and how frequently they occurred per yard. Bessen, "Technology and Learning," 51.

"The mill time is actually geared directly from the revolutions of a worm attached to the main rotator, set with a gear with sixty teeth," Robert H. Baird explained in *The American Cotton Spinner*. This system, which he describes how to construct to the layman, "goes round once in 12 hours; provided the engine or water-wheel loses no time, or has not too slow a motion." When the water rose on the Merrimack, as it did in Larcom's *An Idyl of Work,* not only the spindles turned slowly, but the mill clock's hands did as well. From Montgomery's perspective, the relative slowness or fastness of the mill clock was beside the point, because officially a workday was measured by the mill clock, however slow or fast it ran. "The machinery of the mill must be kept in motion until the hands of the mill clock arrive at the proper time," Montgomery instructed.[125] From a manager's or inventor's perspective this was only rational, because the mill machinery was calibrated to operate according to a ten-hour day. All calculations of speed relied on a standard "day" length, measured in rotations of the mill clock. Remember, Jenks' notebooks calculated output and revolutions per minute based on not only an assumed ten-hour day, but based on the *mill clock's* ten hour day.

Depending on the height of the river, the difference between the mill clock's recording of ten hours and the outside world's might differ widely. In *Keeping Watch,* Michael O'Malley cites several examples of contests over whether factory clocks told the "real" time—contests which O'Malley interpreted as disputes over who had the authority to establish and enforce temporal orders within a community. In one of O'Malley's examples, workers at the Hope Factory in Rhode Island protested that the factory time was "twenty to twenty-five minutes *behind* the true time."[126] Though mill managers certainly had the ability to tamper with the

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125 Baird, *The American Cotton Spinner,* 231.

126 O'Malley, *Keeping Watch,* 40.

operation of the mill clock, what is significant about O'Malley's cases was that in each of them, mill operatives, mill managers, and the reading public took it as a given that there were two temporal orders governing the time of the mill operative's lives. Montgomery indicates that these two temporal orders were kept by two clocks within a mill. There was the external-facing clock that kept local civil time and there was the internal-facing *factory* clock, that governed labor and mediated between the material process of production and the abstractions of regularized civil time.

Testimony from a British mill inspector in 1841 helps explain in detail how the time told by the external-facing clock and the time registered by the factory clock interacted in a mill. The respondent was attempting to gauge whether mills in the vicinity of Manchester had been complying with the new laws regarding shorter hours for mill labor. He was then asked by a member of the committee to address the allegations that mill owners and managers tampered with their clocks to artificially extend the working day.[127]

> Interviewer (I): "Do you find much difficulty in consequence of the hour of the mill clock not agreeing with the standard time in the country?"
>
> Respondent (R): "Yes; it throws a great impediment in the way of detecting offences."
>
> I: "What standard do you take as true time in most cases?"
>
> R: "Manchester time, the true time of the day."
>
> I: "Are you not aware that there is great difficulty in keeping clocks to one uniform time in Manchester; that it is sometimes as much as seven minutes difference between the 'change clock and the Infirmary clock?"
>
> R: "The difference in clocks in the country is from half an hour to 50 minutes."
>
> […]
>
> I: "With respect to clocks, when you speak of tampering with clocks, do you mean by making use of two clocks, the one connected with the machinery, and the other the time-piece of the mill; or do you mean that the time-piece of the mill is not kept in proper accordance with real time?"
>
> R: "I mean that the time-piece of the mill is not in accordance with real time."
>
> I: "Do you generally find that it is too fast, or too slow?"
>
> R: "Sometimes the one, and sometimes the other."

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[127] "Mills and Factories," *Reports from Committees: Six Volumes,* vol. IX (January - June, 1841), 28-29.

The factory clock was different from the ordinary clocks that governed civil time, and it was understood that it would operate differently from the civil clock. It was expected that the two systems did not always align. That time differed between factories was a source of frustration for mill operatives and inspectors, but as the Interviewer's questions suggest, it was still expected that the mill clock would represent a kind of time materially related to the actual operation of the mill. "These clocks have two hands and a dial, like a common clock, and are always placed beside one of the latter," Robert Baird explained. "The factory clock has "Mill time," painted on the dial; the dial of the other clock has "Clock time" inscribed up on it."[128]

The factory clock that governed labor did not tell time in regular units or uniformly throughout the building. Instead, the factory clock geared off the mainshaft operated with the same fluctuations and variations as the factory. When the water was high and the great wheel turned slowly, so too did the factory clock. When machines were taken off the line and more power flowed to other regions of the mill, the factory clock ran faster. Factory clocks located close to the mainshaft or on the lower floors ran proportionately faster than those located on the top floor or at a distance from the prime mover. Although all operatives technically worked the same number of hours, the minutes they tallied according to the factory clock stretched and contracted throughout the day and depending on their location within the factory. From what I can tell, at the end of the workday, when most machines were taken offline, the factory clock was also stopped.[129] Overnight, the civil clock continued to tick away, and in the morning as the machines were brought online, so too was the factory clock. The factory clock was then bench-

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[128] Baird, *The American Cotton Spinner,* 230.

[129] James Montgomery includes instructions for creating a networked watchman's clock that would record the movement of the night watchman through the building when the rest of the machines were offline. He says these clocks were common in some regions of the United States, but I don't know how many of these watch clocks were actually constructed nor do I know how they interfaced with the other two clocks employed in the mill. Montgomery, *The Cotton Manufacture of the United States,* 17-8.

marked against civil time at least once every day. At the same time, even this system also in incorporated elements of organic time, since start times fluctuated based on the quantity of light— which is why Montgomery included an almanac in his mill manual.[130]

The factory clock enabled mill operatives to fit their labor into the variable rhythm of the machines powered by the river. Like the drummer Thoreau imagined leading a country muster, the factory clock was intended to aid laborers and managers in finding and following the tempo of the environment they worked within. All of the participants in the process remained independent, and yet their labor was synchronized. To participate in the labor of the factory, the factory clock was not necessary, but it was a tool to enable a closer alignment between elements of factory production. Thoreau imagined communion with natural time as a participatory act, and suggested it was akin to riding a wild horse. Much the way that a saddle is not required to ride a horse but can make the action easier, the factory clock was not required to coordinate the labor of mill workers when inside the mill, but it made the it easier for mill operatives and managers to find and follow the rhythms of modern organic time.

The testimony of Philadelphia-area cotton mill operatives in an 1838 survey of mill schedules helps illustrate just how varied factory schedules could be, even when governed by a mill clock. "The hours vary in different establishments," spinner William Shaw reported of his experience working in four factories over nine years.[131] "The period of labor is not uniform; in some cases, from sun to sun. It is most common to work as long as they can see." Furthermore, ideas about regularized work schedules could mislead, explained Joseph Dean, who passed his twenty-five years in manufacturing mostly in the weaving room. Foremen might report that

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130 Along with a discussion of the quality and quantity of light available in New England compared to England. Montgomery, *The Cotton Manufacture of the United States,* 173-175.

131 "Report of the Select Committee," 12.

operatives generally worked a 72-hour week, but Dean reported that "it was also customary to require more hours in long days to make up for loss in other seasons, so as to produce an average of seventy-two hours per week for the year."[132] This method of averaged days was often known as the "long-day system." Philadelphia factory foreman John Thornily was not alone in finding the whole situation very frustrating. "By reason of a want of uniformity in the hours of labor," Thornily vented in his testimony, "when families are employed, they do not know what they have bargained for; they do not know how many hours make a working day, or how many a week."[133] In 1838, cotton factories around Philadelphia operated by civil calendars but also occasionally by lunar calendars—since it was the quantity of light, whether solar or lunar, that mattered in calculating the working day.[134] When Lowell issued an official, standardized labor schedule in 1851, the table not only showed the working hours for mill operatives fluctuating throughout the year according to the relative amount of sunlight, but it also stipulated that the timetable followed the rising of the sun in "the meridian of Lowell."[135] Mill designer, author, and manager James Montgomery included a table "compiled from the *American Almanac,* and adapted to the latitude of Boston" to help explain New England labor schedules to his British readers in his 1840 summary of American mill management.[136] When laborers in water-powered cotton factories were disciplined to follow the factory clock, we must not see this as necessarily alienating them from natural rhythms. The factory schedule and the mill clock held operatives

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[132] *Ibid.*, 14.

[133] *Ibid.*, 24.

[134] "Report of the Select Committee," 24.

[135] Table reprinted in O'Malley, *Keeping Watch,* 53.

[136] Montgomery, *The Cotton Manufacture of the United States,* 175.

close to local temporal schedules determined by the amount of sunlight, heat, humidity, and waterpower.

Conclusion: To March in Rhythm with the Universe

At the climax of his narrative journey on the Merrimack, Thoreau and his brother lay in their tent listening to the river flow past their heads. Waking from sleep as the wind breathed against the flaps of the tent and sang through the ropes that held it to the ground, Thoreau remembered this last and sweetest night of the journey as a moment of perfect communion with natural time. "Trees are but rivers of sap and woody fibre […] and in the heavens there were rivers of stars, and milky ways, already beginning to gleam and ripple over our heads," he wrote, "there were rivers of rock on the surface of the earth, and rivers of ore in its bowels."[137] Listing the myriad rivers surrounding his body, Thoreau was also listing all the currents he could immerse himself within in order to be drawn back to a sense of ultimate order. The rivers of natural time were the route to the middle landscape. All of these rivers, whether sap or star or stone, were trustworthy translators of the book of nature Emerson's rational holism promised to reveal. Feeling fully at home in the woods that night, Thoreau wrote as though he had joined the river: a moment of remembered transcendence.

To sleep beside the river, to labor on its shores, or to float upon its current—this was the ideal of timekeeping for Thoreau, as it was for many Americans steeped in the milieu of natural theology, romanticism, pastoralism and rational holism.[138] Other forms of regularized

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[137] In drafts of this monograph, portions of this passage were in fact attached the Thoreau's ruminations on melons discussed previously in this section. Thoreau, *A Week,* 215.

[138] On Thoreau's philosophical milieu, Walls explains that Thoreau's prose represent "less a departure from, than an extension of, the natural theology he had been taught at Harvard; and the science that was institutionalized at Harvard in the 1850s, and that Thoreau would come to reject, consisted largely of a mix of both. For Coleridge's romantic science, far from dwindling into obscurity, came to dominate British mainstream natural science through the idealist synthesis of Carlyle's friend […] Richard Owen. Louis Agassiz brought a related metaphysics to Harvard, where it settled in companionably with both the old-fashioned

timekeeping, like the garden calendar or the mechanical clock, were poor approximations of the cosmic current Thoreau hoped would order his life and activities. In this frame, the ideal of timekeeping lay within some technology that could induce human beings to live within the river's current, holding them closely to the periodic but not fully predictable patterns that ordered the natural world. The key to this sense of rondure with nature was time, and not just any kind of time, it was the synchronization between Thoreau's unthinking body (spirit, intuition) and the river.

For the most part, the role of organic timekeepers as communicators of information in *A Week* was theoretical, in service to Thoreau's philosophical and artistic purposes. However, downstream in the factory buildings of Manchester, Nashua, Lowell and Lawrence, powered by the very river that Thoreau slept beside, the organic timekeepers that organized mill operative's lives and labor actually *did* communicate information about distant environmental conditions, and actually *did* compel human and machine labor to align more closely with the rhythms of the natural world. In the very period when Thoreau was exploring visions of natural time while writing *A Week,* mill operatives downstream were living with technologies that seemed to operationalize those visions of natural time—not for any philosophical reason, but for coldly practical and money-minded reasons. Though arrived-at by such different avenues, the convergence of these two ideas about timekeeping suggests the scope of the broadly-held sociotechnical imaginary of modern organic time at mid-century. In this era Thoreau, Larcom, Montgomery, and Ure might disagree about nearly every point of cotton mill production except

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natural theology and the newfangled idealism of one of Boston's leading citizens, who would soon be Agassiz's close friend—Ralph Waldo Emerson." Walls, *Seeing New Worlds,* 33.

how time in the mill should be kept. The factory clock keeping time in variable units, shrinking and expanding with environmental conditions, needed no defense.

What was taken for granted here was concept of the universe as ordered, rational, and commensurate with human understanding. This mid-century incarnation of the old natural theology continued to teach Americans that the landscape was the face of a universal timekeeper, and that communion with natural processes would teach individuals to find and follow the "book of nature." This worldview extended the hope that laboring in the water-powered factory could immerse workers in a potentially transcendent landscape of synchronized human and machine labor aligned with the rhythms of the natural world. David Nye calls this the technological sublime, and at mid-century Lowell was a prime site for visitors to seek a close encounter with higher order.[139] What went without saying was that the factory building could be a reliable register of organic time, along with countless other registers. "The landscape contains a thousand dials which indicate the natural division of time," Thoreau announced in *A Week,* "the shadows of a thousand styles point to the hour."[140] Organic timekeepers could take many forms, including the cotton factory building itself. The key was that it must be a reliable translator of organic time, register periodic but not predictable patterns, connect labor to a wider ecosystem, and (a new addition) compel action.

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[139] Nye, *American Technological Sublime,* 109-142.

[140] Thoreau, *A Week, 208.*

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National Time and the Continuous Register

National Temporal Orders

By the 1850s, Americans were caught in a surveying frenzy. Captains, navigators, and insurers on American vessels the world over collected soundings and observations of water color, currents, and winds to send to Lt. Matthew Fontaine Maury at the U.S. Naval Observatory and Hydrography Offices for use in his *Wind and Current Charts*.[1] At the same time, hundreds of farmers, teachers, merchants, and churchmen across the American interior recorded the state of the weather thrice daily, and transmitted their reports to Joseph Henry at the Smithsonian Institution's Meteorological Survey. Pamphlets circulated through agricultural society journals and word of mouth sent an equal number of Americans, including a middle-aged Henry David Thoreau, into the woods to record vast charts of the first fruiting, flowering, and harvesting of native plants and the migrations or hibernation of local animals for the use of the Smithsonian's Phenological Survey.[2] Meanwhile, harbormasters and naval officers along the East, West, and Gulf coasts assiduously recorded the rise and fall of the tides and the phases of the sun and moon, communicating their tables to Alexander Dallas Bache at the U.S. Coast Survey. In offices scattered from Washington D.C. to Boston, from Michigan to California, scientists and

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1 Jason W. Smith, *To Master the Boundless Sea: The U.S. Navy, the Marine Environment, and the Cartography of Empire* (Chapel Hill, The University of North Carolina Press, 2018), 74-106, 85.

2 Henry David Thoreau, *Wild Fruits,* ed. Bradley P. Dean (New York: W.W. Norton & Company, 2000); The meteorological project was initiated by Henry but later passed to his deputy, Spencer Baird; phenological survey records are now stored with meteorological project records, however it seems that much of the phenological data collected during the early years was damaged in the fire in and above Henry's office in 1865; Smithsonian Institution, Meteorological Project Records, 1849-1875, RU 60, Series 1, 2, 3; Forms Circulars, and Announcements, SI RU 65, box 1.

computers labored over millions of statistical reductions, seeking patterns within the proliferation of data. These were only a portion of the nationally-focused surveying projects underway in the 1850s.

Each of these activities are essentially extensions of the kind of organic timekeeping practices I introduced in the previous three chapters, though at mid-century they were being carried out on a vastly larger scale and in more explicitly systematic ways. Maury's project, for instance, relied on the systemic keeping of standardized log books distributed free of charge to shipmasters, captain, shipowners, insurers, and merchants.[3] It was an analog project to Bowditch's small-scale effort in Salem, but embracing substantially larger scales, with a stronger emphasis on statistics, and with none of Bowditch's faith in the contributions of ordinary seamen.[4] Historian Jason W. Smith reports that by the 1850s Maury "bragged that he had at any one time several thousand ships taking observations for him in waters all over the world."[5] Dividing the seas into five mile quadrants, Maury set the goal of collecting at least 100 logs for every district for every month of the year. Maury's charts of winds and currents accomplished what the logbooks of Bowditch's scientific sailors had anticipated but been unable to fully realize—a pattern often repeated in the history of modern organic timekeeping. By the 1850s, Maury's new maps had successfully "turned navigation from chance, hard-learned experience, or reactionary decision making" Smith explains, "into calculations of probability."[6]

The Meteorological Survey, the Coast Survey, the Hydrographic Office surveys, and the Phenological Survey were not isolated endeavors. They were connected approaches, stemming

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3 Smith, *To Master the Boundless Sea,* 85.

4 *Ibid.,* 85-89.

5 *Ibid.,* 85.

6 *Ibid.,* 89.

from the flowering of Humboldtian science in the heart of American nation-building projects, and reflecting the sociotechnical imaginary of modern organic timekeeping.[7] These projects shared a fundamental assumption not only that the patterns that govern the natural world were ultimately ordered, but also that they were all interconnected. Those influenced by the paradigm, named for its most famous popularizer and exemplar, Prussian scientist Alexander von Humboldt (1769-1859), believed that understanding environmental phenomena in greater depth would reveal unexpected correlations that illuminated ecological relationships in other arenas. Humboldt began to focus his attention on the idea of organism and interdependence in the late eighteenth century after reading Emmanuel's Kant's *Critique of Judgement*.[8] Rejecting vitalism—and with it ideas about nature as pure mechanism extrinsically assembled—Humboldt began a project to write a description of the physical world that would assist him and others in understanding the interdependence of nature and the ways that life assembled itself from within. His fundamental claim was this: "The parts cannot be deduced from the whole. However, knowledge of the whole can be built up through a comprehensive understanding of its parts."[9]

The consequence of this approach to scientific inquiry was far-reaching. As Aaron Sachs, Laura Dassow Walls, Donald Worster and many others have argued, Humboldt reshaped how science was pursued around the world. Humboldtian science flourished in the United States particularly in the wake of Humboldt's speaking tour in the first decade of the nineteenth

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[7] For a succinct discussion of Humboldtian science see: Laura Dassow Walls, *The Passage to Cosmos (*Chicago, The University of Chicago Press, 2009), 120-129; Donald Worster, *Nature's Economy: A History of Ecological Ideas* (Cambridge: Cambridge University Press, 1977); Aaron Sachs, *The Humboldt Current: Nineteenth-Century Exploration and the Roots of American Environmentalism* (Oxford: Oxford University Press, 2007).

[8] Laura Dassow Walls, *Seeing New Worlds: Henry David Thoreau and Nineteenth-Century Natural Science (*Madison: University of Wisconsin Press, 1996), 77.

[9] Walls, *Seeing New Worlds,* 78.

century.[10] During this tour he taught American audiences that "facts do not fit into, but rather generate, the whole. Order is produced by the interaction of differences, not the law of the same."[11] Through his writing, mentorship, and the speaking tours, Humboldt taught American and European scientists "to see each region as a unique ecological assemblage dependent on local or regional conditions, and to study these by placing them side by side."[12] For the projects involved in this chapter, their participants and organizers further believed that revealing interconnected periodicities within the environmental phenomena they studied would allow for the expansion, rationalization, and democratization of the American market.[13]

As part of this wave of Humboldtian science carried out by newly created or invigorated national institutions like the Coast Survey, the Smithsonian Institution's Meteorological Survey, and the United States Department of Agriculture (USDA), scientists, observers, and inventors across the country attempted to create new technologies to collect and organize organic time on a national scale. Unlike melon clocks or ships' logs, the organic timekeeping technologies they invented between 1850 and 1870 remain in wide use today, though much modified. Technologies Americans use in everyday life today, like the weather report I check each day, the map on a seed packet that tells me when to plant, or the quipy explanations on NPR's Marketplace explaining that commodity markets are down today due to reports of a bad harvest in the Midwest, are all examples of modern organic timekeepers invented or adapted by these institutions in the mid-nineteenth century. Mid-nineteenth century technologies like the Signal Service's (and later USDA's) daily weather report and monthly crop report—as much as the

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[10] Sachs, *The Humboldt Current,* 2,

[11] Walls, *Seeing New Worlds,* 78.

[12] Worster, *Natures Economy,* 135.

[13] Walls argues that this economic emphasis was not atypical of Humboldtian science either— when "economic" is understood within its Greek root, *oikonomia*. Walls, *Passage to Cosmos,* 122.

clock—played a determining role in standardizing time on first a national and then international scale. On Sunday, November 18th, 1883, North American railroads adopted a national clock-based system of Standard Time.[14] They did so only after the repeated shortcomings of attempting to root a national standard time in organic timekeeping inspired some scientists and administrators within the Meteorological Survey, Coast Survey, and the Smithsonian to insist on a clock-based standard. Those scientists' arguments convinced the railroads, who had been resistant to the change for many decades, of the necessity of adopting a clock-based national standard time.

To make this case, this chapter will first introduce some of the underlying assumptions and important characters in the search for national organic time by introducing three projects that attempted to anchor universal time in local place. Alexander Dallas Bache made a name for himself in the world of international science in the 1840s as the only American to participate in a global survey of magnetic variation—a pattern some hoped in the 1840s would hold the key to universal timekeeping. In the next decade, Bache's friend and employee at the Coast Survey, Benjamin Apthorp Gould, strained his eyes to follow the orbits of Jovian moons, a project which he hoped would help him create an automatic register to dispense universal time across the telegraph wires. The projects coalesced in the 1850s when Bache and another Coast Survey astronomer, Sears Cook Walker, jointly determined the speed at which time signals could be sent by telegraph, developing a system of surveying known as "the American Method." In this method, longitude was determined by telegraphed time signals from electric clocks connected to "timekeepers" that registered the oscillations of celestial bodies. This was an organic

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[14] The most comprehensive account of this process in the United States can be found in Ian Bartky's writing. Ian Bartky, *One Time Fits all: The Campaign for Global Uniformity* (Stanford, Stanford University Press, 2007); Ian Barkty, *Selling the Time True: Nineteenth-Century Timekeeping in America* (Stanford, Stanford University Press, 2000).

timekeeping distribution system organized on a national scale but rooted in periodic changes in observable phenomena.

But the American Method wasn't the only example of a new technology created to find and follow modern organic time on a national scale. In the second section of this chapter, I will examine in detail the creation and early history of the USDA's monthly crop report. The crop report was a national organic timekeeper that collected and registered information about crop conditions around the country, integrated crop forecasts with weather reports, and then worked to modify farmer's perceptions of the relationship between their crops and local weather and climate conditions. In the long run, the stated objective of the monthly crop report was to rationalize and democratize the national market by revealing and then teaching farmers to perceive foundational periodicities in crop production and consumption. As we will see, Thoreau's attempts to guide his readers to follow a naturalized marketplace in *A Week* and *Walden* were symptomatic of a much larger discussion about how national markets could be rationalized by being brought into closer alignment with environmental patterns, a project ultimately championed by the nascent USDA. However, unable to compile national reports of a higher statistical reliability and publish and distribute them faster than once a month, the USDA discontinued the monthly preharvest crop reporting service in the 1870s.[15]

By the 1870s, not only the USDA's crop report, but many other national surveying endeavors also ran into the problem of temporal accuracy and timely delivery. In the third and

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15 State-based networks of crop, weather, and market reporters took it up, and were able to publish state-based weekly "Weather, Crop, and Market" circulars by the 1890s. In this case, the national organic timekeeper, the USDA's monthly crop report, worked, but it worked to such an extent that consumers demanded a temporal specificity the project could envision but not practically accomplish. Like Bowditch's logbooks realized in Maury's surveys, the national crop report represented an early effort at national organic timekeeping that would not be realized by the USDA in practice until the 1920s when a vastly larger budget, a national weather service, and the use of analog computers made the process of collecting and interpolating data much faster than could have been accomplished in 1860.

final section of this chapter I briefly explore the internal debates about temporal standardization present within the Smithsonian's Meteorological Survey, debates that culminated in meteorologist Cleveland Abbe beginning his successful campaign for national Standard Time.[16] Abbe was not the only Standard Time crusader in the 1870s, but his was the first project that could point convincingly to a material problem for which standardized clock time was a solution. By placing Abbe's drawn-out campaign in historical context, we can see how the previous national organic timekeeping projects like crop reports and weather reports helped Americans to imagine and adopt Standard Time. Organic timekeepers can be found at the juncture of cultural abstractions of time and the fluid unfolding of the material world. Standard Time and the organic timekeeping technologies I discuss in this chapter are not oppositional. They were integrally related. It was organic timekeeping technologies like the crop report that enabled Americans to "think" national standard time.

Bache and the Coast Survey

In 1838, as Nathaniel Bowditch lay dying, Benjamin Franklin's great grandson, Alexander Dallas Bache, completed a tour of Europe and established several of the scientific connections that would make him one of the most popular and respected American scientists of the next several decades. Bache's projects in Philadelphia and in Washington, D.C. illustrate the way the sociotechnical imaginary of modern organic timekeeping animated a wide range of interconnected national projects. Returning to his post at Girard College in Philadelphia, Bache took up teaching again and became the only American to participate in the international magnetic survey. For this endeavor, Bache observed the oscillations of the compass needle every two

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[16] Bartky, *One Time Fits All,* 59-67; Bartky, *Selling the Time True,* 76-136.

hours, day and night, across three years.[17] Because the observations needed to be carried out at "the same moment in absolute time," Bache also operated an amateur observatory in his garden.[18]

Described by one scholar as "self-conscious, even militant[ly]" Humboldtian, Bache made his nearly 18,000 yearly observations of the compass needle with an appropriately Humboldtian object in mind.[19] He believed that previous observations of the magnetic needle indicated a relationship between weather and the variation of the needle.[20] As a consequence, Bache expected his thousands of observations to reveal that the patterns of storms could be predicted by the variation of the compass. But that was only the beginning of the fruit Bache and this global survey of compass variation hoped to harvest. Anticipating that the variation of the needle was predictable and place-specific, Bache likewise looked forward to the time that the variation of the needle might also be used to determine longitude. Thus, in 1840 Bache and observers around the world recorded the minute variations of the needle twelve times a day, eagerly anticipating that their labor might reveal a portable and fully universal system of time measurement as well as weather prediction, a standardized and universalized organic timekeeper.

Unfortunately, one year into the project, Bache admitted to Irish physicist Humphrey Lloyd that his results were disappointing. "I am sorry to say that all that we have obtained is the negative results," Bache wrote to Lloyd, "that the small movements of the needle are not similar

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[17] *Report of the Commissioner of the Patent Office* (Washington, 1855), 368.

[18] *Report of the Commissioner of the Patent Office,* (Washington, 1855), 368; Benjamin Apthorp Gould, *An Address in Commemoration of Alexander Dallas Bache, delivered August 6, 1868 before the American Association for the Advancement of Science* (Salem, Essex Institute Press, 1868), 9.

[19] Walls, *Passage to Cosmos,* 142.

[20] Gould, *Commemoration of Alexander Dallas Bache,* 13; James Rodger Fleming, "Storm Controversy," *Meteorology in America, 1800-1870* (Baltimore: The Johns Hopkins University Press, 1990), 23-54.

on the opposite shores of the Atlantic."[21] Hoping to find universality by digging into the minutia of local variation, Bache explained, "it was on the small movements I relied."[22]

Though it failed to contribute within the short term, the magnetic survey operations in Philadelphia continued for another four years. Bache himself left the project in 1843 when he was appointed head of the U.S. Coast Survey, a post where his experience with observing both compass needles and stars placed him in good standing to lead the office responsible for mapping the US harbors and coast lines as well as conducting the geodetic survey. Bache was the second superintendent of the Office of the Coast Survey, and brought his impulse to seek universal patterns in the particulars of local place and time to the Coast Survey.

With Bache as its head, the Coast Survey was intimately tied to the American scientist Joseph Henry, and through Henry to the soon-to-be-created Smithsonian Institution for which Henry served as the first Secretary. Bache, Henry, and Nathaniel Bowditch's apprentice and Harvard mathematician, Benjamin Peirce, were close friends and shared many intellectual projects. Both Bache and Pierce, for instance, would lead the Coast Survey during their lifetimes. In another example, during their tours of Europe in the 1830s Bache and Henry coordinated their messages to European scientists about what is known as the 'storm controversy' in American meteorology while Pierce lambasted the author of the theory for mathematical errors in the domestic press.[23]

This coordination extended across the next decades, as the three developed a network of Humboldtian-minded assistants working at both the Coast Survey and the Smithsonian

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21 Alexander Dallas Bache to Humphrey Lloyd (May 6, 1840), Huntington Library, Rhees Collection, RH 1753.

22 *Ibid.*.

23 Fleming, *Meteorology in America*, 23-53, 45-49, 53.

Institution.[24] For instance, when a Harvard-trained civil engineer working in Lawrence, Massachusetts named John Montgomery Batchelder showed promise, Bache worked with Pierce to find him a position working with the Coast Survey's calculating machine in Albany.[25] When Alexander von Humboldt's apprentice, astronomer Benjamin Gould, returned to the United States, the triumvirate coordinated to find him a position with the Coast Survey.[26]

Scientific networks such as this were hardly unusual, but the Bache's intellectual circle was particularly known among mid-century American scientists for its cliquishness and shared scientific agendas. Bache, Pierce, Gould, and Louis Agassiz were the core of the group that established the American Association for the Advancement of Science (AAAS), a group that even had a tongue-in-cheek name for itself, "the Scientific Lazzaroni" but was sometimes disparaging referred to as "Bache & co." The group later evolved into the National Academy of Arts and Sciences, still dogged by complaints of cliquishness and insularity. Though they pursued their own specialties, members of Bache's circle shared a broad agreement about scientific questions, and when they did not – such as when Harvard-based biologist Louis Agassiz failed to accept Darwin's theory of evolution – Bache and his circle policed members' views or ostracized non-conforming members. So influential was Bache within this group, that to a certain extent his views can be taken as representative.[27]

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24 Sachs argues that "it does not seem a stretch to think of almost all official American exploration, at the time of *Cosmos'* publication, as essentially Humboldtian." Sachs, *The Humboldt Current,* 93.

25 *Proceedings of the American Academy of Arts and Sciences* (1893), 306.

26 Huntington Library, Rhees Collection, box 16, RH 1986.

27 Mark Beach, "Was there a Scientific Lazzaroni?" *Nineteenth Century American Science: A Reappraisal* (Evenston: Illinois Northwestern University Press, 1972), 115-132; Lillian B. Miller, *The Lazzaroni: Science and Scientists in Mid-Nineteenth-Century America* (Washington: Smithsonian Institution Press, 1972); Paul Lucier, "The Professional and the Scientist in Nineteenth-Century America," *Isis* 100, no. 4 (2009), 699-732, 709-712, 715.

As I argued in the previous chapter, in the middle of the nineteenth century, there was a widely held consensus about what temporal order looked like and how modern organic timekeeping technologies could make that order visible and legible. Bache's dream that the oscillation of the compass needle might lead to a universal organic timekeeper met with disappointment, but that disappointment in the magnetic survey did not dampen his expectation that it would be possible to find universal timekeepers based on observable patterns in the natural world. And to the extent that Bache was both representative of and policing the agenda of American science during the middle decades of the century, it is possible to argue that the sociotechnical imaginary of modern organic timekeeping was widely-accepted.

The American Method

Perhaps the best example of this network anchored by Bache, Pierce, and Henry is the career of Sears Cook Walker. Walker graduated from Harvard and worked as a math teacher before becoming an actuary with the Pennsylvania Life, Fire, and Marine Insurance Company. While in Philadelphia, Walker befriended Bache and Henry, likely through his work with the American Philosophical Society. As a talented mathematician, amateur astronomer, and actuary, Walker's peers explicitly conceived of his work as treading in the footsteps of the recently departed Bowditch.[28] As chair of the Astronomical Committee for the American Philosophical Society, Walker solicited observations from around the country in order to determine more precise points of longitude. After spending six years computing occultations in his free time,

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[28] For instance, Alexander Dallas Bache discusses this is in his obituary for Walker, Huntington Library, Rhees Collection, RH2475; as well as a later letter to Benjamin Pierce, letter December 19, 1858, Huntington Library, Rhees Collection, RH 1999.

Walker had made a name for himself as an astronomer as well as a mathematician.[29] For this reason, when Bache at the Coast Survey wanted to experiment with using the electric telegraph to determine longitude, he turned to Walker for assistance.

Because Bache, like Bowditch, believed that the most precise way to determine longitude was through lunars, he hoped to directly link the surveying work of the Coast Survey to astronomical observations. Invented by Samuel Morse in 1844 based on discoveries made by Joseph Henry in the late 1830s, by the end of the 1840s the telegraph had begun to make rapid communication possible between distant cities on the American map. Bache and Walker hoped that this new technology would enable a central observatory to rapidly communicate astronomical observations to distant points, making accurate longitude calculations possible. This system would have the added advantage of allowing Bache to avoid using chronometers for the geodetic survey. While Bache had originally hoped that the oscillation of the needle would become the key to place-based universal timekeeping, with the spread of telegraph wires, he began to imagine a place-based timekeeping system anchored by a celestial metronome instead. The beats of these star-signals would be measured by the kind of occultations Walker had spent so many years observing and predicting. Though star-signals were only visible through a telescope, the system Bache envisioned would still represent universal time based on observable phenomena in the natural world.

Working with Bache at the Coast Survey to determine exact longitudes by telegraph proved more difficult than Walker anticipated. The core of the problem was that a human was needed on one end to connect the observations of the star-crossings with the telegraph signal, and

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29 Bache, RH2475; Benjamin Apthorp Gould, Jr., *An Address in Commemoration of Sears Cook Walker, Delivered before the American Association for the Advancement of Science* (1854).

on the other end, another human was required to record the beats of the star-signal and simultaneously compare them against the sidereal time shown on a clock (in order to correct the local timekeeper used for local longitude calculations). Though Bache and Walker experimented with reducing human error somewhat, neither of them felt that the system was sufficiently reliable to be used for calculating longitudes. Walker began to search for a technology that could connect the telegraph to the register directly, reducing the human error by half. Eventually he commissioned a self-registering apparatus which the designer referred to as a "clock or other timekeeper."[30] This new timekeeper was built around a circuit-interrupter that registered beats sent over the wire by astronomers as they observed star-crossings.[31] Originally the timekeeper recorded the time on a ticker tape, but later versions marked the time in ticks on a rotating cylinder. Frustratingly for Walker, electric clocks did not yet run smoothly enough in 1850 for a circuit-interrupter to be attached directly to the clock face. Doing so, clock-makers warned, would only exaggerate pre-existing irregularities in the clock.[32] Though imperfect, the practice of using a central observatory to communicate time-signals based on observable phenomena in the environment to distant points by telegraph came to be known as "the American Method."[33]

Still, neither Walker nor Bache were satisfied by the time signals sent from the device. They remained convinced that the human error in transmitting the star signals was too great and fretted that they had not yet determined the velocity at which electricity travelled along telegraph wires. Rather than seeing the system they had organized as universal, Walker lamented that the star signals created through the American Method were merely "a personal visible register." In

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[30] Bartky, *Selling the Time True,* 37.

[31] *Ibid*., 39.

[32] Charles Shepherd, *On the Application of Electro-Magnetism as a Motor for Clocks* (London, 1851), 4.

[33] Bartky, *Selling the Time True,* 37-39; Gould, *Address in Commemoration of Sears Cook Walker,* 15.

1850 he still hoped “to connect an astronomical clock with a telegraph circuit, in such a manner that the clock [timekeeper] would give its own signs.”[34] Completing the circuit between celestial observation and the beats of a clock would, in Walker’s view, transform the “abstract” time shown on public clock faces into automatic registers that made the “true” organic time of the cosmos visible.

Although it was most famously identified with star signals, Bache and Walker’s American Method was an approach to timekeeping applied more broadly than just the Coast Survey. The outlines of this method can be seen in the melon clock, the log-book, and the factory clock, as well as the star-signals and other continuous registers that will appear in this chapter. Each of these technologies relied upon continuous automatic registers like seeds, bodies, buildings, or electrical circuits to make changes in observable, periodic but not fully predictable phenomena legible. In this sense, they are the definition of analogue technologies: they tell time by registering and interpreting continuously variable physical quantities like heat, humidity, and position. In this sense, the organic timekeepers created through the American Method are part of the history of analog technology.

Bache and Walker eventually determined the velocity at which electricity moves through telegraph wires. This discovery made it possible for observatories around the United States to begin selling telegraphed time services to urban jewelers and railroads. The system was still not accurate enough for Bache to use for the Coast Survey, however.[35] The project might have continued, but in 1852 Walker’s health and sanity began to decline as he became consumed by

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[34] Gould, *Address in Commemoration of Sears Cook Walker,* 16.

[35] Another important component of time services involved advances in electrical networks, first developed through urban fire alarm systems.

an attempt to use the telegraph to determine the exact longitude of Halifax, Bangor, and Cambridge.[36] Walker suffered a mental health crisis after completing the project, and spent many months in a hospital outside of Baltimore. Eventually "his disordered brain gradually regained its normal tone," and Walker began to work again, this time calculating the ephemeris of Neptune for 1855. Unfortunately, the return to work triggered a relapse, and Walker increasingly found himself unable to do anything beyond compulsively reworking his calculations.[37] Walker died "of math" in early 1853, and Coast Survey astronomer Benjamin Apthorp Gould succeeded him in attempting to use star-signal telegraphs to communicate place-specific organic time to distant places.[38]

Gould eventually designed and operated the first time signal service in the United States. For this service, he sold the beats registered by star-crossings observed at the Dudley Observatory in Albany to New York City's central station. Largely due to poor administration, the project ended in failure and Gould's dismissal from the Dudley Observatory, however the idea of telegraphed time signals as a method to bring civil time into closer alignment with the "true time" of observed celestial movements caught on. Gould referred to this method as the first step in the process of "substituting transits of stars for arbitrary signals coinciding with the beats of a time-keeper."[39]

The time signal service offers another example in which nineteenth-century bureaucrats and private agents of the state stridently resisted national temporal consolidation, homogenization, or standardization. Until the adoption of Standard Time, and even for some

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[36] "Sketch of Sears Cook Walker," *Popular Science Monthly* 46 (November, 1894), 121.

[37] Later official accounts describe Walker's death as suicide.

[38] Bartky, *Selling the Time True,* 61,

[39] Gould, *Address in Commemoration of Sears Cook Walker,* 15,

time after it, American observatories made most of their money by selling accurate time signals to railroads and cities.[40] The accuracy of commercial time signals would be backed by the reputation of the observatory, while the relative proximity of the observatory to its customers became a selling point. Why buy Boston-time when you lived in Pittsburgh?

At midcentury, Bache, Walker, and Gould were three of the most distinguished people trying to root American timekeeping in observable features of the regional environment, but they were far from the only people using the American Method to create organic timekeepers. Across the United States ordinary Americans also experimented with inventions they hoped would bring their lives into a closer alignment with organic time. In 1845, for example, *The American Horticulturalist* reported that an "ingenious clock-maker" in New York State had buried a network of wires in his garden and connected the wires to plates on either side of a pendulum on a clock. He advertised that the clock told *true* time because the motion of its pendulum was regulated by the repelling and attracting electrical currents in the plates.[41] The following year, a farmer reported to the New York Agricultural Society on his attempts to use the same method of buried wires and metal plates to regulate the growth of his potato crop.[42] Meanwhile, the letters sent to Joseph Henry through the Smithsonian's Meteorological Survey were filled with observers' designs for self-registering apparatuses that would measure time against the rise and fall of the barometer, thermometer, and wind direction.

These letters and inventions attest to the broadly held belief that by closely recording observable phenomena in the local environment, Americans would in time discover a small

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[40] Bartky, *Selling the Time True, 59-73, 83-89.*

[41] *The American Horticulturalist: Designed to Improve the Planter, the Farmer, the Stock-Breeder, and the Horticulturalist,* ed. A.B. Allen *(*New York, 1845), 124.

[42] *The American Horticulturalist: Designed to Improve the Planter, the Farmer, the Stock-Breeder, and the Horticulturalist,* ed. A.B. Allen *(*New York, 1846), 92-93.

number of universal patterns—the key to a modern organic timekeeper. Though star signals were gaining momentum in urban areas, the fact remained that a clock was not the most useful type of timekeeper for a farmer. During the middle decades of the nineteenth century, each industry and each region experimented with a wide variety of modern organic timekeepers. As a sociotechnical imaginary, this vision for the future of national timekeeping was largely insulated from the setbacks or failures of individual projects. Bache and surveyors at the Coast Survey, for instance, never fully set aside the hope that the oscillation of the needle might hold the key to a universal timekeeper. In 1866, his office created a national map of needle oscillations so the geodetic survey could correct the time used in longitude calculations. A computer in his office named Charles A. Schott then used that map to sketch a national network of magnetic observatories.[43]

In addition to their faith in the idea of foundational periodicities governing large portions of environmental phenomena, the imaginary of modern organic time remained durable because of the sheer volume of data these surveying projects generated. Just as it took years to prove correlations between phenomena, it also took years to *dis*prove ideas about correlations. Robert Stanton Avery, the chief of the Tidal Division in the Coast Survey, estimated that the smallest period that seemed likely to govern the rise and fall of the tides (which would seem to be among the more predictable environmental patterns) was no less than eleven lunar years. Diving into the minutiae of local observations required burying oneself in millions of exacting calculations. Between 1858 and 1860, the human computers for the Meteorological Survey worked roughly

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[43] In 1866 Charles A. Schott used a map of magnetic declinations for the years 1870 in the United States produced by the Coast Survey to create a hypothetical system of magnetic observatories stretching from the tip of Maine to the top of the Florida Keys to San Francisco. Library of Congress, Manuscript Division, Schott Collection, Box 2.

200,000 hours.[44] Henry estimated that it took about one minute to complete each calculation. Even the papers of those who seemed to thrive on a surfeit of data and complicated equations, like Avery, occasionally offer suggestions of minds overwhelmed. The back of one of Avery's notebooks holds over a hundred scribbles of "Bowditch, Bowditch, Bowditch" and strings of numbers—all seemingly written in one sitting.[45]

As I will show in the case of the USDA crop report, the scale of the surveys themselves was often the largest obstacle for their utility. It was difficult for these small institutions with limited budgets to process the data fast enough to make it useful for American voters and Congressional budget committees. Walker's descent into mathematical madness lingered as a cautionary tale among his peers. However his final illness might be interpreted in the present, at the time it was directly associated with the compendious tables of astronomical observations he had been compiling, a gargantuan task that ultimately broke his mind. Walker soon had company on this list. In 1867 Bache died after his brain "gave way." Death arrived, Gould explained in his eulogy, "in the form which he had himself dreaded; as it had come to Walker before him, as it came to Faraday with him, and as the activity of nervous and mental energy in our own country especially invites to so many of our intellectual workers."[46]

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[44] This is a low estimate—Coffin employed between 12 and 15 computers who averaged 8,276 hours a year. Fleming, *Meteorology in America,* 126.

[45] Of course, it is also possible Avery was testing a pen nib (or several) for a very long time. In either case, Bowditch was clearly on his mind.

[46] Gould, *Address in Commemoration of Alexander Dallas Bache,* 45; I don't have a good sense whether nervous exhaustion from math was considered a very widespread malady among the statisticians of Washington, DC, but Amir R. Alexander suggests that an antiheroic myth surrounded the memory of many antebellum mathematicians which may have contributed to the perception. Amir R. Alexander, "Tragic Mathematics: Romantic Narratives and the Refounding of Mathematics in the Early Nineteenth Century," *Isis* 97, no. 4 (2006), 714-726; Additionally, Gould's dark mood may have been influenced not only by Faraday's death in 1867, but also the early death of Bernhard Reimann in 1866—Reimann died of tuberculosis, but during his life suffered a series of mental breakdowns.

“To Regulate, not Regularize”

In the 1860s, it was clear that the approach to problem-solving represented by modern organic timekeeping technologies worked on small scales. And it was likewise clear that this approach *should* also work on a national scale, and yield a set of organic timekeeping technologies capable of standardizing temporal perception for large groups of people and across vast distances. However, by the late 1860s, there was a growing concern among scientists, bureaucrats, and congressional budget directors that the human minds behind these projects might be too fragile, too slow, or too error-prone to process the information flowing into the projects they had established. This was the case for the USDA Crop Report, which began as a national organic timekeeping technology but was later devolved to the states when farmers demanded faster response-times and more accurate local data.

Before the Department of Agriculture was established in 1862, the US Patent Office’s Agricultural Division collected agricultural statistics and issued an annual report on the status of American agricultural production. Though agricultural and horticultural societies across the country had urged the creation of a Department of Agriculture for several decades, political resistance from southern congressmen left the oversight and reporting on American agriculture in the hands of the Patent Office from 1840 to 1862. The Office’s annual reports at first tried to make yearly estimates of crop production, drawing from agricultural society reports, journals, and correspondence, but that project was abandoned in 1848. Although the editor of *The American Agriculturalist* made some attempts at pre-harvest forecasting, until the USDA began issuing monthly agricultural surveys and reports, all reports made by the Patent Office were after-the-fact.[47] This was not for lack of effort: across the 1850s the Patent Office tried multiple times to initiate a system for collecting and distributing timely pre-harvest crop statistics. Like other Humboldtian-inspired projects, the Patent Office sought a comprehensive understanding of the state of American agriculture though the careful study of its parts. However, many of the component parts of agriculture – information about weather and climate for example—were beyond the Patent Office's abilities to collect. Moreover, assembling a register that could represent the whole of agriculture on an on going basis, the statisticians at the Patent Office and later at the USDA were never sure where to draw the frame around their project.

Beginning in 1855, Charles Mahon, the Commissioner of the Patent Office, offered the Smithsonian $700 to publish the condensed annual statistics collected by Joseph Henry's meteorological survey.[48] Starting in 1849, Henry had begun developing a network of weather observers around the US, many of whom were telegraph officers, and by 1854 Henry received reports from over 300 stations located around the United States.[49] In his request to Joseph Henry, Mahon suggested that although his primary purpose was to publish retrospective data on recent weather conditions, his office would be interested in any information from the Meteorological Survey that might point towards crop prediction. For instance, he indicated that he would gladly reprint "infallible signs, if any, for the prediction of weather or seasons" and other phenological information such as regional patterns in sowing and planting, and the fruiting and flowering of plants.[50] Mahon's letter to Henry, which started with a limited request for condensed annual

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[47] The Statistical Reporting Service, Appendix B, "Statistical Reporting Service of the U.S. Department of Agriculture, Scope & Methods," Misc. Publications No. 967 (1964).

[48] Charles Mahon to Joseph Henry, Doc. 74, RU 60, Box 2, Smithsonian Institution.

[49] Table in Fleming, *Meteorology in America,* 82; also Office of Public Affairs, NOAA, "U.S. History-making Weather 1849-1990," 1.

[50] Doc. 74, RU 60, Box 2, Smithsonian Institution.

statistics, ended with an expansive list of phenological and meteorological associations, all of which point more towards prediction then post hoc explanation for crop yield. As if recognizing that this material seemed to tend towards a different type of publication, Mahon closed his request by suggesting a joint circular issued by both institutions. In the meantime, Henry promised to send the condensed tables of annual weather for publication, and wrote a lengthy primer on weather observation and the basics of meteorological science that was serialized in the Patent Office annual publications from 1856 and 57.[51]

In their first joint publication, Mahon tried again to develop a national method for collecting and distributing pre-harvest crop statistics. This time, he called for county tax assessors to record crop yields and transmit that information to his department for publication. The tax assessor scheme did not materialize, however many farmers across the United States read the Patent Office Report and volunteered their services to Henry's Meteorological Society. Henry's network of informers increased by 25% the first year it coordinated with the Patent Office, an expansion driven not by additional telegraph stations but by expanded participation among American farmers.[52] By 1860, Henry counted approximately 600 stations located across the United States, each operated by people who had committed to observe and record an extensive list of weather and atmospherical phenomena three times daily. The time and labor involved in maintaining these stations testifies to the widely-held belief among ordinary Americans that statistical reporting on meteorology and phenology would ultimately help farmers better anticipate what crops to plant, when to sow, and when to harvest.[53]

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51 The publications are retrospective, so the one published in 1856 covers events from 1855.

52 Graph in Fleming, *Meteorology in America,* 82.

53 For example, a farmer in Iowa, Townsend Cormel [unclear]'s letter from 1855. After reading his name as a weather observer in the Patent Office Report of 1854 (published, 1855), he promised to be more attentive to his observations now that he understands how they are being used and how it will help him in the future. RU 60, Box 2, Smithsonian Institution.

Writing from outside Hannibal, Missouri in 1853, farmer A.H. Lear expressed the typical view of such national surveying projects in a letter describing his expectations for the Meteorological Project. "I never expect to discover any *new* truths [as a weather observer] yet I may be the means of others doing so," Lear begins, "I am satisfide [sic] that if the Patent Office Report was placed in the hands of every Missouri farmer it would add two percent to the amount of produce the State yields."[54] To support this ideal, three times a day for a year Lear recorded the force of the wind, the temperature of the day, the state of the skies, his work on the farm, the times of planting and flowering, frosts and thaws, as well as the progress of his orchard trees and of the surrounding forests. As he and other weather observers noted, taking time during a busy day of farm work to record these observations was not a small investment. And yet, Lear believed the work was worth the cost in the long run. In fact, the meteorological and phenological records for the project were so necessary and valuable that Lear estimated, "I anticipated dear *money* could not buy it."[55]

In 1860 the Patent Commissioner again tried to create a system for pre-harvest crop reporting, this time prefacing his call with a rousing populist economic appeal. The idea to preserve the fertility of the nation's soil through the collection and collation of agricultural statistics pushed the Commissioner to rhetorical heights. "The land is for the good of all," Mahon's second attempt began, "fertile soils are given to the nation as a trust, and are dispensed by the nation to the people to be used, but not abused. Fertility, the nation's endowment and hope, should hence be maintained."[56] But Mahon's vision was larger than his ability to realize. This time, he proposed that the Agricultural Division of the Patent Office, composed of four

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[54] AH Lear, Document 455, RU 60, Box 1, Smithsonian Institution.

[55] *Ibid.*.

[56] *Report of the Commissioner of Patents for 1860* (Washington, 1861), 21.

clerks, a gardener, and various assistant gardeners, would collect quarterly national statistics from local agricultural societies and then use their birdseye view of the national scene, in turn, to guide and advise those local societies on the planting and marketing of crops.[57]

Sociotechnical imaginaries are ideas about what order looks like and how it can be achieved. As a result, the visions built upon them can be remarkably buoyant. The Commissioner of Patents—along with many others— nurtured an idea that some kind of technology could be created capable of communicating relatively timely agricultural statistics to every region of the United States for the use of farmers in order to regulate the national market. Seeing the fertility of the nation as a "endowment" that must be managed for the future by 1861, Mahon made clear that the pre-harvest collection of agricultural statistics was explicitly part of an effort to create and maintain a new kind of order and predictability in the national economy. Whether this goal was achieved by a system built upon local tax assessors collecting and communicating data, or a network built on agricultural societies collecting data, was not a crucial point for Mahon. The Patent Office was prepared to pursue many formations until they found something workable, just as eighteenth-century garden book authors were prepared to write gardening guides in many genres. Despite repeated setbacks, the Commissioner of Patents, backed by several northern and midwestern agricultural societies and agricultural journals as well as the Smithsonian, continued to push for some method to collect agricultural statistics and interpret and distribute them rapidly.

Mahon's failures likewise should not be taken as a signal that there was no national appetite for pre-harvest crop reporting. Orange Judd, the editor of the *American Agriculturalist*, recruited over 1,500 correspondents to produce monthly yield estimates for twenty states during

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[57] *Report of the Commissioner of Patents for 1860* (Washington, 1861), 11.

the primary growing months of 1862.[58] Judd had been a staunch advocate for national crop reporting and believed the project should be spear-headed by the federal government.[59] His short-lived project should be understood as a kind of proof-of-concept test that was then widely publicized by the magazine which he edited. Judd's experiment demonstrated that there was a viable network of crop reporters, that it was possible for a small office to compile the reports in a timely way, and that the reports would be understood by readers to be useful.

With the political opportunity created by the departure of Southern congressmen following the advent of the Civil War, and with the financial pressure created by the war, calls for a new department of agriculture gained traction. From the beginning, statistical collection and the regulation of the American economy were understood to be core projects of the soon-to-be-created USDA. Their role was stated outright in the Patent Office's call for the department, published in its annual report of 1861. "While the republic remained in peace, out of debt, and prosperous," the Commissioner explained, the lack of attention to agriculture from Congress might be tolerated.[60] However, under the new circumstances of war and debt, the need for a well-regulated and well-understood market necessitated a new department. The issue was pressing, according to the Commissioner: "We are in the midst of a great revolution, not only social and political, but industrial and economical." Though in 1861 the first two revolutions took precedence, the Commissioner warned of a future when the political and military victory of the Union would be threatened by the burden of agricultural debt farmers had amassed during the war.[61] To avoid post-war financial disaster, Mahon insisted that a department with powers to

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58 Jamie L. Pietruska, *Looking Forward: Prediction and Uncertainty in Modern America* (Chicago: University of Chicago Press, 2017) 47-48.

59 Peitruska, *Looking Forward,* 48.

60 "Report of the Commissioner of Patents," *Patent Office Annual Report* (Washington, 1861), 5

61 *Ibid.,* 9, 10.

survey and regulate national markets was absolutely necessary, and its sights should be squarely fixed on the needs of ordinary small famers rather than wealthy landowners or industrialists.[62] Regulation of agricultural markets would save the economy; an unregulated market would harm American democracy by devastating agriculturalists. In the first year of the war, US national debt rose from $64.8 million to $90.5 million, and by 1862 it would quintuple to $524 million—a debt to be shouldered by an economy still deeply rooted in agriculture.

Congress established the USDA in May of 1862, with the explicit instructions to collect and distribute annual and current agricultural statistics in the interest of regulating the market. The vision outlined by the Patent Office reports, continued in the first publications of the newly-founded USDA and helps explain the shift from after-harvest reports to an attempt to generate real-time crop reports and pre-harvest predictions. The monthly crop report published by the USDA was a modern organic timekeeper intended to bring order to the American economy by standardizing perceptions of the relationship between crop production, weather, and markets.

The 1863 Crop Report

Like the logbook in the hands of a scientific sailor, the USDA's new monthly crop report relied on the perceptions and judgement of non-scientific practitioners: farmers. While Mahon was prepared to accept reports from whatever source was available to make them, the new Commissioner of the USDA, Isaac Newton, was more stringent. In Newton's opinion, only local farmers, communicating face to face with each other and with a general knowledge of regional averages could truly understand and honestly report the condition of crops.[63] With so much

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[62] "Report of the Commissioner of Patents," (1861)*,* 10.

[63] *Ibid., 3.*

unknown about American climates, weather, and soil, the USDA organized its first foray into statistical reporting on the premise that agriculture, like navigation, was a science of approximations best known through the combined intuition of long-time practitioners. The new crop reports, meanwhile, continued to publish the Smithsonian's Meteorological surveys alongside their new monthly reports on crop production. The USDA attempted to recruit at least one crop observer per county in the Union, while the Meteorological Survey collected weather reports from roughly 600 observers across the Union, but also scattered through the Confederacy and the Far West.[64] This was the first time that the Meteorological Survey was able to publish its reports in such a timely and regular manner, since its own budget could not cover the publishing costs for more than annual reports.

In 1863, when the first monthly crop reports were printed, it was obvious that there was a close relationship between crops, weather, and markets, but the specifics patterns governing that relationship had not yet cohered. The monthly crop reports presented information on all three side-by-side with suggestions on how they might be correlated in the short term, and with the long-term goal of rendering their relationship predictable— and through prediction, controllable. As a result, the monthly crop reports sprawled and encompassed a wide variety of information. Though their contents shifted slightly from month to month, the basic format of each crop report included a brief review by Jacob R. Dodge, the USDA statistician, tables representing the crop estimates for each state, a list of notes reporting if anything notable occurred not represented in the numerical reports, the meteorological survey data for the same month with an appendix of significant meteors over the previous month, and notes or correspondence on exports, or the state of foreign markets.

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64 Fleming compiled a map from the list provided in each monthly crop report, in Fleming, *Meteorology in America,* 80.

The heart of the new crop reports was a survey distributed to farmers across the United States and to diplomats at embassies in Europe, South America, and Asia. The survey asked farmers to report on the state of their crops across the nine productive months of the year, and the USDA published monthly installments based on the previous month's data. At the close of the year, when few crops were in season, Newton, Dodge, and their clerks proposed to dedicate the monthly crop report to more refined reports on correlations between weather, credits, and crops as well as detailed reports on miscellaneous topics of interest to farmers. The survey was distributed by local agricultural societies to farmers in their region. The survey asked farmers to rate the state of their crops (in yield) on a scale of 0 to 20, with 10 representing "an average appearance" compared to the previous growing season.[65] "Crop reporting," Dodge explained, "is counting in advance by instantaneous generalization."[66]

Newton was aware that each mark below or above average would reflect primarily the farmer's subjective interpretation of his crop, and fretted that this potential reporting error could lead to erroneous reports. Crop reporting was part intuition, part science, and part geometry. His problem was similar to Walker's issue with the star-signal service, except Newton could not create a system that circumvented his human crop interpreters. Instead, he and Dodge spent many years trying to standardize farmer's perceptions of their crops. In this sense, the monthly crop reports operated somewhat like the ships' logbooks, through an iterative process of approximations, calibrations, and after-the-fact validations. When the rumbling of the New Madrid fault line shattered church windows, Newton urged Missouri farmers not to let the foreboding atmosphere from the earthquake influence their estimates of the crop. Based on the

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[65] Quoted in United States Department of Agriculture Statistical Reporting Service, *The Story of U.S. Agricultural Estimates,* (Washington: United State Department of Agriculture, 1999)*,* 36.

[66] *U.S. Commissioner of Agriculture Report* (Washington, 1887), 22.

weather observers, Newton suggested the Missouri corn crop should still be doing well—despite farmers' reports to the contrary. The crop reports worked to standardize farmer's environmental perception in more subtle ways as well. It listed county estimates side by side, and placed the weather reports directly following crop reports for easy comparison. Occasionally, Dodge would reflect on terminology—reminding farmers that the abstract concept of "yield" was itself imprecise. Just because the corn crop sprouted nicely and appeared to be doing well by late-summer, it was still possible that the cobs themselves were small, damaged, or otherwise limited. Through this iterative process, the USDA was attempting to assemble a standardized *national* organic timekeeper used to identify and shape the periodic but not fully predictable activities of agriculture.

Whatever the short-term failures of the system, Newton and Dodge hoped that in the long run the practice of keeping these records and reading the monthly crop reports would train farmers across the country to read their own crops more accurately while also teaching them to interpret the rise and fall of the market with greater skill. "It is obvious that as our correspondents better understand the general character of the information this department needs," Newton assured his readers, "their replies can be given clearly, and at the desired time."[67]

Farmers' replies became more timely in part because across the 1860s they began to see material benefits from the crop report. "These columns of dry figures are eloquent," one farmer wrote from Massachusetts in 1864, "just see what they have done this season. When your last monthly came our corn was selling here at $1.10; strait away it rose to $1.30, and no one wants to sell at that. Those little bulletins are going to regulate the market."[68] In 1866, the first year

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67 *Department of Agriculture Monthly Reports* (Washington, 1863-64), 3.

68 "December," *Department of Agriculture Monthly Reports* (Washington, 1864), 3-4.

after the Civil War that the USDA could report statistics from the southern states, Newton and Dodge announced that Texas had been overrun by cattle when markets dried up over the war, while the southeastern states had produced, at best, only 65% of their 1860 cattle herd.[69] Sending both a warning to eastern farmers that one way or another a large herd of cheap cattle would be arriving soon, Newton announced "it had been estimated that $1,000,000 worth of stock is ready to go to market from Texas at the present time."[70]

The iterative nature of the report invited farmers to correct errors they saw in the report, and this in turn, helped force to the surface economic and ecological choices farmers across a region were making. In 1866 farmers wrote to argue that the 1865 report, for example, seemed to have underestimated the Minnesota wheat crop. The farmers argued they sent much more to market than the crop report recorded having arrived. In the following report, Newton wrote back, publishing a letter from a businessman in southern Minnesota. The letter explained that because the Mississippi River had been low for the previous three years, owing to drought, "immense quantities" of wheat had not been shipped down the river.[71] Like the cattle waiting for a route to market in Texas, Newton warned that huge quantities of wheat were stockpiled in southern Minnesota, waiting for the river to rise. Knowledge of this stockpile had, apparently, not been common even across the state, much less the region, but through the crop report it became possible for farmers downstream to anticipate the arrival of that wheat at market by following the regional weather reports published in the crop report. In this way, the crop report taught farmers to see their local environments, their fields and livestock, as materially connected to environmental processes taking place at great distances.

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69 *Department of Agriculture Monthly Reports* (Washington, 1866), 350, 328.

70 *Ibid., 343.*

71 *Ibid.,* 3.

In addition to tracking and making public the movement of herds of cattle or the imminent arrival of bumper crops of wheat, the crop report also called into being and mapped the edges of emerging environmental phenomena like droughts. The crop report focused on movement. Crops were shipped to markets. Cattle walked to train depots to travel east, while disease spread northward among hogs. The Mississippi River fell from drought, while storms chased up the edge of the Great Valley. Teaching farmers to see and follow these dynamic flows unfolding overtime was part of the crop reports purpose. Newton and Dodge self-consciously wanted to cultivate a regional and national geographical awareness among their readers. They wanted operatives in New England to see their income as materially connected to the health of the soil in Georgia and the state of the weather in Texas.

Though the majority of the crop reports' contents were conveyed in tables during their tenure, both men envisioned a time when the variation in the crop reports would settle out into a few rules of thumb that would obviate the need for elaborate tables and make it possible for the report to rely on maps instead.[72] Inspired by the isothermal maps the Smithsonian Meteorological Project was beginning to produce (and which the USDA was beginning to print in the crop reports), Newton called for even more detailed maps that could capture the changing temporal features of agriculture in different regions.[73] In addition to pre-harvest estimates, Dodge began to collect information on wages and hours for day laborers in different industries, as well as information on the dates of sowing and harvest, fruiting and flowering, and other phenological information that seemed directly relevant to agriculture. But, building from the particulars towards a vision of the whole, assembling the kind of detailed isochrone maps Newton had

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[72] Dodge was particularly committed to conveying the crop reports graphically, *The Story of U.S. Agricultural Estimates,* 36.

[73] *Department of Agriculture Monthly Reports* (Washington, 1863-1864), 7.

called for was time-intensive. Dodge began by collecting basic information on the range of different crops, and advising readers on which varieties of vegetables, fruits, and grains would thrive best in their region. It is easy to imagine that in 1860 Americans must have had a general sense of regional climates and would have known the geographical range of dent corn or German rye, but the handy maps of crop zones now published on the back of seed packets were not generated until the late 1890s.[74]

Newton, like Bache, died in office from what was understood to be a work-related injury. In July of 1866 he spent a long afternoon in the USDA's experimental garden and collapsed from sunstroke. He never fully recovered, and died in 1867. Though Newton was a controversial figure within the agricultural press—many considered him unqualified for the position—he had been a staunch advocate for the crop reports and for the kind of Humboldtian science they represented. With his death, the crop reports continued under Newton's chief statistician, Dodge. With new leadership however, the crop reports did not always enjoy the centrality to the USDA's mission that they had under Newton. Though the standardization process took longer than Newton and Dodge may have anticipated, by 1870, Newton's successor, Horace Capron, condensed the qualitative portion of the monthly report to a bare minimum, and expressed confidence in the primarily numerical report. Even the county-level correspondents, who tended

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74 Crop zones ("natural crop belts") emerged from C. Hart Merriam's work on lifezones with the Smithsonian's Biological Survey. Applying lifezones to crop zones was, like the crop report, explicitly intended to regulate the market. "The farmers of the United States spend vast sums of money each year in trying to find out whether a particular fruit, vegetable, or cereal will or will not thrive in localities where it has not been tested. Most of these experiments result in disappointment and pecuniary loss. It makes little difference whether the crop experimented with comes from the remotest parts of the earth or from a neighboring State, the result is essentially the same, for the main cost is the labor of cultivation and the use of the land. […] What the farmer wants now is *how to tell in advance* whether the climatic conditions on his own farm are fit or unfit for the particular crop he has in view, and what crops he can raise with reasonable certainty. It requires no argument to show that the answers to these questions would be worth in the aggregate hundreds of thousands of dollars yearly to the American farmer. The Biological Survey aims to furnish these answers." C. Hart Merriam, *Life Zones and Crop Zones of the United States* (Washington: U.S. Department of Agriculture, 1898), 12.

to submit more subjective descriptions of local crops, had also begun to adopt the standard rating system as a common language.

In the late 1870s the USDA's monthly project had grown so popular, that it began to crumble under its own success. Farmers and congressmen wanted the reports to be more frequent and more accurate. The crop reports still published monthly weather surveys from Henry's Meteorological Survey, but by 1870 the Signal Service had begun using the same network to telegraph local weather observations to Washington, D.C. and produce daily "probabilities" for farmers.[75] This service was absorbed into the USDA two years later. Thus, even as one arm of the USDA began to issue daily weather probabilities by telegraph, another arm continued to take a full week each month to calculate the crop report, and then more time to print and ship the report. As farmers grew more confident in their crop estimates and perceptions of regional climate and weather—trained in a new shared vocabulary by the crop report and the daily probabilities—they also grew more adept at reading the crop report for errors. To meet the demand and produced more accurate reports, Dodge requested an expanded budget for his Statistical Office, a request that was repeatedly denied.[76] Unable to expand, and increasingly concerned that the reports contained erroneous data, Dodge and the new USDA Secretary William Gates LeDuc met in early 1877 to discuss the future of the crop report. Mentioning the declining budget, Dodge proposed to leave the crop reports to the state agricultural societies to produce while transitioning the monthly reports of the USDA to more topical subjects.[77] The USDA

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75 Pietruska on probabilities, *Looking Forward,* 84.

76 *The Story of U.S. Agricultural Estimates,* 33.

77 Minnesota History Center, Vol. 184, Committee on Agricultural testimony, 1877, 144.G.3.10 (F).

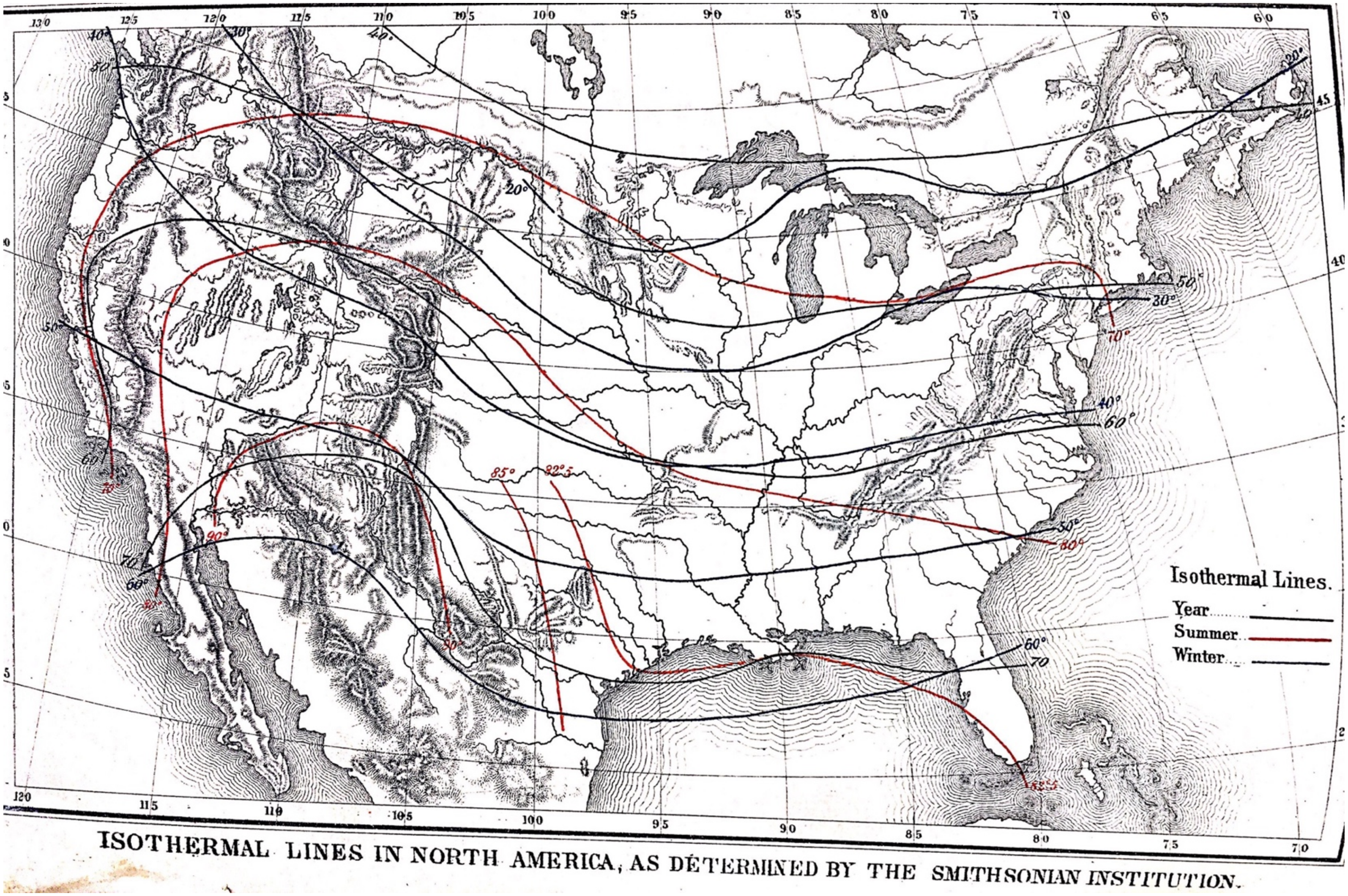

Figure 13: An isothermal map of the United States produced by the Smithsonian Meteorological Project and printed in the USDA Monthly Crop Report for 1864.

would continue to produce the daily weather probabilities and would also maintain its network of county-level crop reporters, but regional reports themselves would be produced voluntarily by individual state agricultural societies.

The USDA's monthly crop report is one example of a standardized, national timekeeping technology that was developed on a federal level and then devolved to the states because it had been so successful that readers demanded a timeliness and level of accuracy the federal office in charge of the report could not meet. This illustrates one of the ways in which a centralized and national timekeeping project was deliberately made more heterogenous at exactly the moment when – theoretically—national temporal standards seemed to be coalescing in the movement towards Standard Time. Much like the Coast Survey data collection problem, the USDA's statistical reports suffered from problems of scale. Dodge could imagine a national organic timekeeper capable of influencing the American economy, but he could not bring it into being. He had a method, but lacked the practical ability to execute his plan. In many ways, the errors in the crop report that convinced Dodge to send the project to the states were also connected to the first successful bid to create a national clock-based time standard.

Standard Time

In 1874, a Smithsonian meteorologist named Cleveland Abbe attempted to combine observations of the aurora borealis submitted by Meteorological Project observers after a particularly spectacular display. Abbe hoped to use the reports to determine the height of the aurora, as well as establish the aurora's relationship with local weather and magnetic variations.[78] Instead, Abbe discovered that he could not reliably draw any correlations between the

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78 Bartky, *Selling the Time True,* 101.

phenomena because the times recorded by weather observers varied so widely.[79] Some reporters listed their observations and measurements according to mean local time, some from clocks regulated by local solar time, others according to the time kept by the nearest railroad station, still others from clocks kept in jewelry shops and regulated by star-signals.[80] There was no way of knowing which type of time the observers employed, so none of their observations could be usefully compared. Abbe's crusade to standardize the times employed by the meteorological observers became a major catalyst for the first successful effort to adopt a national Standard Time.

Although the history of Standard Time is often told in reference to the challenges of operating national railroads with complicated time schedules, Abbe's work illustrates a point often overlooked by clock-centric histories of Standard Time. After nearly four decades of unsuccessful attempts to impose a clock-based national standard time on the railroads, in the early 1880s, Americans and American railroad companies, were finally able to understand the utility of a clock-based national temporal order. They learned to see the utility of this order only after Abbe revealed the endemic flaws that made organic timekeepers like the daily weather probabilities provided by the USDA unreliable. In order to fix the flaws in their organic timekeeping systems, Americans and American businesses slowly agreed to adopt the expedient compromise of a national temporal order based on the clock.

The irony of Abbe's discovery is that in the early years of the Meteorological Survey there had been a move to standardize observers' temporal references, and it revealed the very

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[79] Bartky, *Selling the Time True,* 101.

[80] Describing the situation many years later, Abbe explained, "the numerous correspondents had used such a great variety of standards of time, many of which could not be identified at all … the words 'railroad time,' 'local time,' or 'standard time' seemed to have no definite meaning." Cleveland Abbe (anon.), "Standard Time in America," *Science* 22 (1905), 316.

wide disagreements among the observers about what a standard time should look like. Should it be based in a clock-based abstraction or observable features of the local environment? In 1841 one of the predecessors to the Smithsonian's Meteorological Survey, led by the Surgeon General, had instructed its weather observers to record their observations based on the "variable hours" of sunrise and sunset. This systems was arguably more universal then one based on the clock, but proved "too great an amount of labor," to adjust the columns of sunrise and sunset to numerical values once the forms were submitted.[81] In the late 1840s, when Henry began developing his network, he designed a new standardized blank for observers to fill out and chose not to use sunrise and sunset as his standards.[82] The new forms listed specific times for observations instead.

After receiving the new forms, many observers wrote to contest the temporal assumptions reflected in the new forms. Sunrise and sunset, they argued, were universal categories, while 6am could vary place to place depending on the way each observer measured local time. And if Henry's purpose was to find universal patterns in meteorological phenomena, his observers believed that the variable hour system better correlated with shifts in weather, humidity, and temperature.[83] Some grudgingly accepted the new times, but recorded them provisionally alongside sunrise/sunset readings.[84] Others seemed almost incredulous that Henry would ask them to observe weather by the clock. "In order to have the full benefit from daily observations, you must record the coldest & the hottest point of each day; which are about sunrise & 2 o'clock

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81 *Report of the Commissioner of Patents (*Washington, 1855), 368.

82 *Ibid.*.

83 Correspondence from Jos. E. Willet to Smithsonian Meteorological Project, Sept. 7, 1852, SI RU 60, Box 1, Document 175. Smithsonian Institution.

84 Correspondence from Dan'l M Cready to Smithsonian Meteorological Project, March, 29, 1853, SI RU 60, Box 2, Document 147, Smithsonian Institution.

PM; 7am is too early in winter to take a minimum," one observer wrote in response to the new forms.[85] On a practical level, several authors reminded Henry that farmers worked sunrise to sunset, and the new hours conflicted with that schedule in ways that made their ability to continue as observers uncertain.[86]

Explanations from Henry about seeking "simultaneous times" in observations only complicated the matter for observers. The confusion was enough to encourage observers to write back to Henry proposing what they considered improved methods for standardizing time across the Meteorological survey. One observer, for instance, proposed a system of simultaneous reporting based on longitudes (as an indicator of absolute time).

> I did not make myself understood as to "Simultaneous time" of observing. I meant to have <u>all</u> to be taking the observations at the same <u>moment</u> of time, at each observation by allowing the difference of Longitude. So say if I observe at 9 AM these in Wiss. To observe the same moment would by their time, be about 8 AM - & — you say the Sunrise observation is to be changed to 7AM. This is to us, at this season of the year, sometime <u>before</u> Sunrise. —
>
> J.D. Parker, 1853[87]

The meteorological observer's response to Henry's new form suggests that in 1850 Americans considered time kept by the sun or by longitude as universal, while time recorded by clocks seemed to vary so widely that they could hardly accept it as a standard for a national project like the Meteorological Survey. Of course, as Bache's work with the Coast Survey suggests, during this period exact longitudes were also not well-established for most regions of the United States.

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[85] Correspondence from Chas. M. Meriwether to Smithsonian Meteorological Project, March, 1853, SI RU 60, Box 2, Document 86, Smithsonian Institution; Correspondence from Henry Roe to Smithsonian Meteorological Project, Sept. 27, 1852, SI RU 60, Box 1, Smithsonian Institution.

[86] Correspondence from Dan'l M Cready to Smithsonian Meteorological Project, March, 29, 1853, SI RU 60, Box 2, Document 147; Correspondence from B. Gould Brown to Smtihsonian Meteorological Project, Sept. 13, 1855, SI RU 60, Box 2, Document 149, Smithsonian Institution.

[87] Correspondence from J. D. Parker to Smithsonian Meteorological Project, January 1, 1853, SI RU 60, Box 1, Smithsonian Institution. Parker would write again five years later with further suggestions on how to improve timekeeping for the project. Correspondence from J.D. Parker to Joseph Henry, October 2, 1858, SI RU 60, Box 4, Document 67, Smithsonian Institution.

Henry skated over these protests and insisted that a clock-based standard for observations was necessary. However, as historian Ian Bartky explains, Abbe's aurora study revealed that the weather probabilities and warnings generated by the Signal Service, the Weather Bureau, and the USDA were "fundamentally in error" by illustrating the ways that the weather reporting service was "neither synchronous nor simultaneous."[88] Worse yet, the variation between the different time standards employed by observers was inconsistent in exactly the way that Henry's 1853 correspondents feared. In response to the spiraling fear that all meteorological observations might be inaccurate, Abbe joined a group of scientists and educators interested in metrology, in turn, established the Committee on Standard Time to recommend a solution to the dilemma of national temporal standards.[89]

The committee spent a leisurely five years considering alternatives—a pace that Bartky believes reflects the lack of urgency behind the matter—and eventually published a "Report on Standard Time" in 1879.[90] In the report, Abbe's committee recommended that all towns peg local time to the meridian running through the town, while all railroads and telegraph stations would use the time established by five proposed time zones. The time zones would be roughly two hours across, based on the Greenwich meridian. The proposal did not limit itself to the United States, and soon the Canadian Pacific Railway began to push for the shift in Canada as well. This, in turn, brought the proposal to the attention of the British Astronomer Royal, George Airy, who soundly rejected it on behalf of the British Navy.[91] Because the Astronomer Royal and the

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[88] Bartky, *Selling the Time True,* 102.

[89] To clarify this timeline: the American Metrological Society was founded in 1873. Abbe discovered the errors in the observations in 1874, and approached the Metrological Society to support his proposal for clock-based Standard time in 1875. The Metrological Society then established the Committee on Standard Time.

[90] Bartky, *One Time Fits All,* 60.

[91] *Ibid.,* 63.

Greenwich observatory still produced the majority of the world's nautical almanacs, their rejection carried international sanction. In 1881, Abbe's proposal for national standard time enjoyed only limited public interest and decidedly negative institutional endorsements.

Although there had been previous proposals to establish a national standard time, Abbe's was the first proposal to gain even this limited traction.[92] Because railroad companies led the push in 1883 to adopt Standard Time, it is easy to infer that railroads would have seen the advantage of standard clock-based time from the beginning. This is very far from the case. By 1840s, twenty-two states boasted railroad systems, creating an interlinked system of nearly 3,000 miles of tracks.[93] Within these systems of tracks and stations, a proliferation of local times prevailed. Only careful coordination could prevent two trains from meeting nose to nose on a single track. Because early trains did not typically have breaks, once a scheduling-error occurred on the tracks, it was generally too late to correct it—even if the engineer realized the error in advance.[94]

Errors in timing on railroads produced catastrophic results. This surfaced most notably in the 1853 "collision crisis," a period where a series of railroad accidents occurred, all of which stemmed from trains operating before or behind time.[95] In the space of one month 80 people died in three separate preventable accidents. Public outcry forced the railroads, reluctantly, to adopt

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[92] For more on previous and allied projects, see Bartky, *One Time Fits All;* O'Malley, "Celestial Railroad Time," *Keeping Watch, A History of American Time* (New York: Viking Penguin, 1990); McCrossen, "Noon, November 18, 1883," *Marking Modern Time: A History of Clocks, Watches and Other Timekeepers in American Life (*Chicago: Chicago University Press, 2013).

[93] Arwen Mohun, *Risk, Negotiating Safety in American Society* (Baltimore: The John's Hopkins Press, 2013), 95; Carlene Stephens, "The Most Reliable Time: William Bond, the New England Railroads, and Time Awareness in 19th -Century America," *Technology and Culture* 30, no. 1 (January, 1989), 1-24; McCrossen. *Marking Modern Time.*

[94] Mohun, *Risk,* 96-97.

[95] *Ibid.,* 101.

more uniform timekeeping standards and timetables along their lines and among their conductors. However, even the zeal behind these reforms had waned by 1860.

One of the things that the reaction to the collision crisis reveals is that Americans' concern with railways running according to strict schedules was a question of safety independent of their interest in a national temporal standard. Navigating a multiplicity of institutional times was part of midcentury Americans' everyday lives. It was a fact of daily life that factories operated on one time, the city of Pittsburgh on another, and the Alleghany railroad on a third. Americans wanted railroads to keep careful schedules, but they did not expect, much less insist, that the time kept by the railroad would align with the times governing other facets of their lives. "Surely these long-standing differences in railroad times must have annoyed some passengers," Bartky observes, "but no evidence suggests very many complaints, much less a ground swell of indignation as the railways grew."[96] Railways, likewise, did not see a strong reason to adopt a new abstract national temporal order to coordinate between their lines. When faced with one proposal in 1873, one American railroad association responded, "the disadvantages the system seeks to avoid are not of such serious consequences as to call for any immediate action."[97] In short, until Abbe realized the error embedded in the Smithsonian's meteorological data, there had not been a problem for which a national standard clock-based time was a necessary solution. Abbe's discovery that weather reports could not be reliably compiled any longer due to the proliferation of local timekeeping standards, was a sufficiently large problem to motivate national institutions to (slow, reluctantly) consider a clock-based national standard.

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[96] Bartky, *Selling the Time True,* 94.

[97] Quoted in Bartky, *Selling the Time True,* 100.

A much-contested joint resolution in 1882 granted President Chester A. Arthur the authority to convene an international conference on standard time to address the proposals raised by Abbe's group and its allies. While Abbe's allies were drafting legislation, convincing the Signal Corps to back their proposal, and battling the opposition of the National Observatory, a railway man named William F. Allan became involved in the committee. Allan was the secretary of the General Time Convention, a working group made necessary because of the proliferation of time schedules operating along different rail lines. The General Time Convention met annually and attempted to harmonize—or at least make sense of—the time schedules employed across north American rail lines.[98] Citing the recent federal legislation and pending convention, in April 1883 Allan convinced members of the General Time Convention to adopt Abbe's proposal. In November of that year, all American rail lines switched to the new system for clock-based standard time, a modified version of which we still use today.[99]

Conclusion: Homogeneous National Time

Ultimately, what the creators of the national temporal projects in this chapter sought was a way for the emerging nation, or branches of it at least, to know itself through detailed and frequent reports on local environmental variation. After all, we know environments *in* and *through* time. Like the mill operatives and managers of previous chapters, the scientists and bureaucrats in this chapter attempted to create self-reporting systems that would register and

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[98] To me, the fact that for many years the major rail lines would rather hold an annual convention to hash-out the most important differences between their schedules rather than adopt a single clock-based standard speaks to the lack of urgency the issue seemed to hold for both customers and owners.

[99] Bartky, *One Time Fits All,* 70-72.

correlate changes in activities within American government, civil society, the environment, and the market. In effect, they wanted something like a national ticker tape. Seeking such a "continuous register," what these linked projects produced was more often a series of very complicated isochrone maps.

The story of the consolidation and standardization of national temporal orders is rarely told as a narrative of heterogeneous local organic maps of time. Instead, historians considering the development of the modern nation state or global capitalism tend to adhere to Benedict Anderson's claim in *Imagined Communities* that nations cohered through the homogenization of temporal perception.[100] "What has come to take the place of the mediaeval conception of

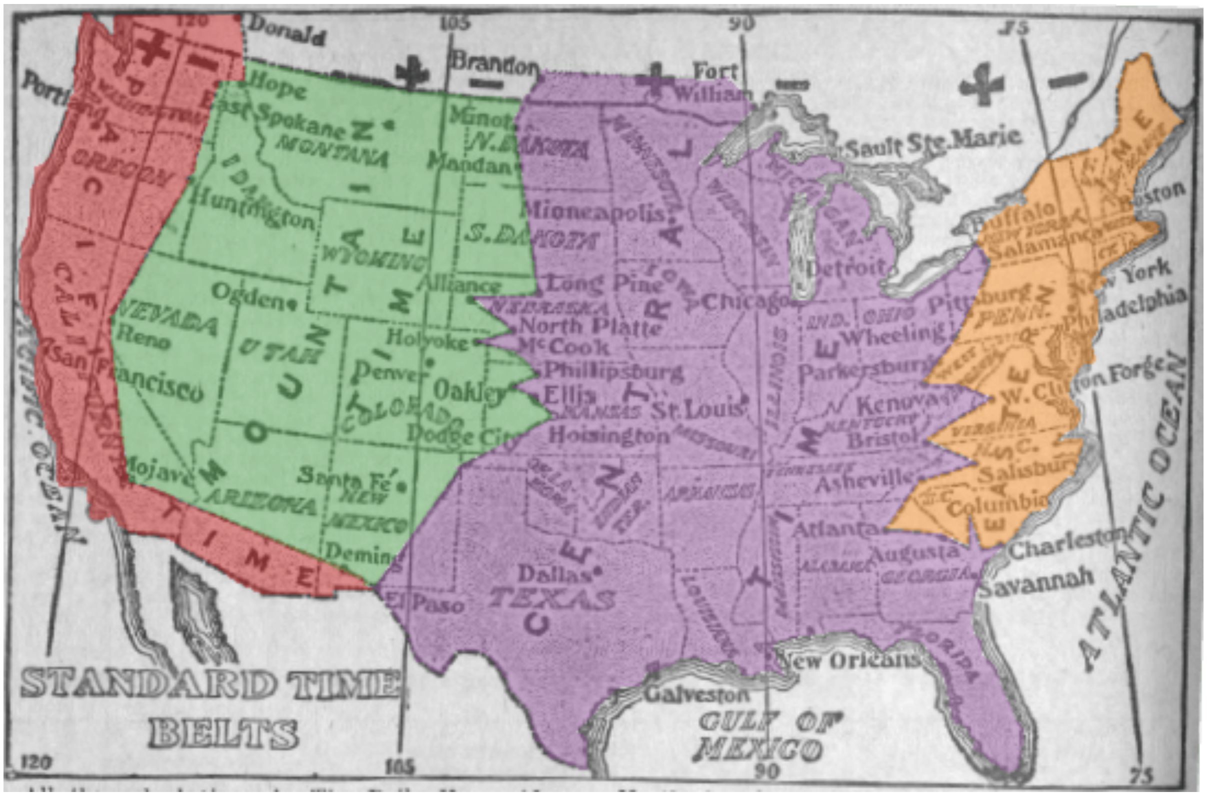

Figure 14: The first maps of Standard Time zigzagged between railroad hubs, with little expectation that the territories between hubs would necessarily follow the new time standards. The new map also left cities like El Paso or Columbia, SC with more rather than fewer temporal standards since they were located either at the junction of multiple time zones or in peninsulas within another time zone. Time Zone Map of the United States *(1913), image from Wikimedia Commons,*

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[100] Vanessa Ogle, "Whose Time Is It? The Pluralization of Time and the Global Condition, 1870s-1940s," *American Historical Review* 120, no. 5 (December 2013), 1376-1402; Vanessa Ogle, *The Global Transformation of Time: 1870–1950* (Harvard University Press, October 2015).

simultaneity-along-time," Anderson argued, applying a concept from Walter Benjamin, "is an idea of 'homogeneous, empty time' in which simultaneity is, as it were, transverse, cross-time, marked not by prefiguring and fulfillment, but by temporal coincidence, and measured by clock and calendar."[101] The time of the modern nation aimed towards homogeneity, integration, and synchronicity. Anderson emphasized the necessity of clocks and calendars in establishing the perceived synchronicity of activities like newspaper reading that seemed to bind people together across vast distances in an imagined polis. This "fundamental change" in time perception, Anderson argued, "made it possible to 'think' the nation."[102] From Anderson's highly influential essay flowed a generation of literature that assumed, first, that the time of the modern nation state was necessarily homogenous (in order to "think nation" citizens needed to hold standardized temporal references), second, that synchronicity led to homogeneity, and third, that only the two technologies that Anderson specifically mentions, the clock and the calendar, could convey this homogenous "empty" time.

Anderson's reasoning emphasizes the idea that synchronicity and standardization required an external referent, and that reference point, he insists, was a regularized timekeeper. Supported by aligned ideas from Michael Foucault about how temporal orders entered the body and disciplined it through a "microphysics of control," scholars after Anderson became adept at interpreting the processes, obscure and explicit, through which a clock-based hegemony seemed to be fundamental to the power of the nation-state over groups and individuals. In *Seeing like a State,* James Scott further developed this line of thinking by arguing that "the more static, standardized, and uniform a population of social space is, the more legible it is, and the more

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[101] Benedict Anderson, *Imagined Communities: Reflections on the Origin and Spread of Nationalism,* (New York: Verso, 1983), 30.

[102] Anderson, *Imagined Communities* 28.

amenable it is to the techniques of state officials."[103] Pursuing the legibility of "closed systems," Scott argued, modern planning states relied on oversimplified and generalized categories and in the process, "[bound] citizens' whole existence, not just their imaginations, to the service of the state's grid-like vision."[104] Citing Scott, temporal historian Alexis McCrossen concludes her history of Standard Time by arguing, "the new national time's legibility depended most heavily on public clocks, multitudes of them, consistently announcing standard time."[105] By the end of the twentieth century, the clock—that "hegemonic metronome"—had become not only the "master machine" of capitalist production, but also the technology that underwrote and enabled the homogeneous empty time and oversimplified categories that seemed so necessary for the emergence and maintenance of modern nation-states.[106]

Because of the dominance of this assumption, historians have often failed to perceive the broad-based historical reconsideration of what non-regularized, modern, national time might look like that was taking place in the United States and Europe across the nineteenth century. Failing to hear this debate, we also cannot perceive its impact, and so have developed a line of reasoning that assumes the nearly inevitable appeal of the clock to modern nations. In that context, the appeal and spread of regularized timekeeping is overdetermined, and meanwhile, the literature built on this assumption is, as one STS theorist explains, "less well suited to exploring how diversity keeps reappearing and reasserting itself, even in the most entrenched institutions of

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[103] James Scott, *Seeing like a State,* (New Haven, Yale University Press, 1998), 82.

[104] Sheila Jasonoff, ed., *States of Knowledge: The Co-Production of Science and Social Order,* (New York: Routledge, 2004), 26.

[105] McCrossen, *Marking Modern Time,* 109.

[106] "The consensus view that emerged over the course of the twentieth century," historian Thomas Allan explains in *A Republic in Time: Temporality and Social Imagination in Nineteenth-Century America,* "understood temporal homogeneity to be an ideal worked towards by both capitalist modes of production and the bureaucratic activities of modern nation-states;" Thomas Allen, *A Republic in Time: Temporality & Social Imagination in Nineteenth-Century America* (Chapel Hill: University of North Carolina Press, 2008), 8.

modernity, such as expert bureaucracies."[107] Why, for instance, would the British Admiralty, whose ships covered the globe in the mid-nineteenth century, repeatedly reject the idea of standardized global time? Why would the North American railroads dismiss the idea of Standard Time for nearly forty years before, with no particular sense of urgency, adopting it in 1883? Scott and Anderson cannot help us understand what led national bureaucracies to reject clock-based national standards and instead go diving in the particulars of local place and time in search of a national temporal order.

Recent work by historian of science Deborah Coen helps explain why Benjamin, Anderson, and Scott's theories of the "homogenous empty time" of modernity often break down when considered at different scales. Coen's work on Prussian imperial climate science reveals the normative assumptions about scales of space and time inherent in Anderson's and Scott's formulations, not just about time, but also about space. In the nineteenth century, Coen explains,

> New intervals of space and time were introduced: a tenth of a second, an electro-width, a light-second, the higher of the stratosphere, the depth of the earth's crust. Meanwhile, new political entities were emerging in an unprecedented variety of sizes and forms. Circa 1850 may well have been a high point for the diversity of state forms .... Thus the political imagination was not confined to the spatial scale of nation-states and the temporal scale of their historical memory. In all, there was a wide variety of ways to envision relations between the individual and the state, between nation and empire, between small and large scale. Today we have been so conditioned by statistical reasoning that we tend to view the micro solely as an instantiation of, or an exception to, the macro. Alternatives proliferated in the nineteenth century.[108]

Histories of national temporal homogeneity assume that a uniform clock-time—a singular and regularized schedule— was the goal of temporal standardization, and that this goal was achieved through the imposition of a unitary temporal system across the entire territory controlled by a

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[107] Sheila Jasonoff, "Ordering Knowledge, Ordering Society," in *States of Knowledge: The Co-Production of Science and Social Order,* ed. Sheila Jasonoff (New York, Routledge: 2004), 18.

[108] Deborah R. Coen, *Climate in Motion: Science, empire, and the Problem of Scale* (Chicago, The University of Chicago Press, 2018), 17.

national government. And this would make sense if the people imposing national temporal orders were twentieth-century metrologists thinking about time on the scale of the modern nation-state, after the revelations of relativity, and following the death of Newton's clockwork universe. However, in the mid-nineteenth century, the basic outlines of a clockwork universe pervaded ordinary American life and permeated upwards into the bureaucracies and institutions that would be charged with rationalizing agriculture, commerce, and transportation. Like Coen's Prussian climatologists (and sometimes directly in correspondence with them, in fact), mid-nineteenth American bureaucrats and scientists imagined scalar relationships between local and national temporal patterns that were "emblematic, metonymic, and ecological."[109]

Coen's list of overlooked scales suggests one additional insight that the history of modern organic timekeeping might contribute to our understanding of the nation. The language of modern organic timekeeping was rooted in metonymy. Organic timekeepers drew connections between phenomena operating on different scales. The clock face regulated by star signals visually represented the distant passages of planets around stars through its direct connection by telegraph to the observatory; the growth of a melon seedling made visible and legible the myriad subtle environmental changes taking place around the kitchen garden through its direct connection to those conditions by root, leaf, and flower. The crop report made the stockpiling of wheat in Minnesota or the passage of storms in Georgia visible and materially significant to readers around the country. Modern organic timekeepers like the crop report brought phenomena like climate or nation into sight and made them directly relevant in Americans' daily lives. Organic timekeepers, seen this way, seem to be essential to the formation of the United States

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[109] Coen, *Climate in Motion,* 18.

because they gave the abstract concept of the nation form, effects, and voice; they made the nation legible to its occupants.

By reading the history of modern organic timekeeping back into the history of national temporal orders, we can see how organic timekeepers helped direct connections between Americans' daily lives and the inchoate phenomena of climate, nation, and market. Modern organic timekeepers helped Americans "think" abstractions like national standard time into being. In the 1870s Cleveland Abbe made one of the most influential cases for a national clock-based time standard by pointing to the errors within meteorological observations. Years later, he would author the USDA's *First Report on the Relations Between Climates and Crops* (1905). Standard Time and crop and weather reporting were connected projects and their histories are inextricably linked, demonstrating yet again that organic timekeepers can be found wherever our human conceptions of time touch the material world.

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Where are They Now?

"Most people of my grandparent's generation had an intuitive sense of agricultural basics," author Barbara Kingsolver tells readers in her bestselling account of a year spent gardening, *Animal, Vegetable, Miracle (*2007). Older generations knew, Kingsolver assures her readers, "when various fruits and vegetables come into season…. On what day autumn's first frost will likely fall on their county, and when to expect the last one in spring."[1] Kingsolver frames her year in the garden as an attempt to reclaim environmental knowledge of this kind so that she can "realign" her lifestyle with a local food system and live a more sustainable life. To live more sustainably, Kingsolver suggested she needed to radically change her temporality. She moved her family from urban Arizona to rural North Carolina. Only there, she thought, could they escape the artificial tempos set by clocks and calendars, and put themselves in a position to recover an instinctive sense of natural time.

Moving her family across the country in search of a new temporality, Kingsolver was taking a radical leap to apply in her own life the perspectives temporal scholars had developed about the history of Western time. Scholars have framed the clock as the *sine quo non* of capitalism, the master machine of modernity, and the hegemonic metronome maintaining the tempo of industrial time-discipline. Scholars argued that the imposition of the clock "polluted" natural time perception, often to the point where it secreted into worker's psyches a kind of false consciousness in which individuals did not even recognize the extent to which their lives were

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[1] Barbara Kingsolver, Steven L. Hopp, and Camille Kingsolver, *Animal, Vegetable, Miracle: A Year of Food Life* (New York: Harper Perennial, 2007).

governed by the regular beats of a clock.[2] If our present climate catastrophe is a direct result of global capitalism, it can be no wonder popular responses to climate change like Kingsolver's involve a direct rejection of the clock. "The only way to escape the tyranny of the clock," E.P. Thompson concluded in 1967, "is to 're-learn some of the arts of living lost in the industrial revolution.'"[3] Forty years later, anthropologist Anna Tsing would echo Thompson's call, explaining in *The Mushroom at the End of the World,* that in a world destroyed by capitalism, where "progress stopped making sense," our hope lies in recovering the "arts of noticing" lost to capitalism. "To notice […] patterns means watching the interplay of temporal rhythms and scales," she explains.[4] As climate change loomed larger in our consciousness, the stakes of timekeeping, according to scholars, likewise grew. In the mid 1990s, Henri LeFebvre framed the politics of the everyday as the stakes of temporal debates. By the early 2000s, Harrison, Pile, and Thrift argued that the stakes of temporal debates were "the multi-layered structure of reality."[5] Tsing, writing ten years later, has expanded the necessity of a shift away from a capitalist temporality further still: "Indeed, life on earth seems at stake."[6]

Because it carries into the real world ideas scholars may not have fully considered in practice, Kingsolver's book also illustrates the gaps in this construction of the history of time. The literature on the imposition of clock time takes for granted the supposed death of "natural

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2 "Civilization […] need not be in the advanced stages of industrial capitalism for a natural time-sensitivity to be polluted or mutated. Whether through subjective, insidious inculcation or uncompromising, objective force, and whether managed by slave-owning plantation capitalists or by mature factory-owning moderns, clock-time has the ability to make both workers and it instigators obey its relentless orders." Mark Smith, "Old South Time in Comparative Perspective," In *The American Historical Review* 101, no. 5 (December 1996), 1432-1469, 1467.

3 E. P. Thompson, "Time, Work-Discipline and Industrial Capitalism," *Past &* Present 38 (December 1967), 56-97, 95.

4 Anna Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (Princeton: Princeton University Press, 2017), 24.

5 Stephen Harrison, Steve Pile, and Nigel Thrift, *Patterned Ground: Entanglements of Nature and Culture* (Reaktion Books, 2004), 28.

6 Tsing, *The Mushroom at the End of the World,* 25.

time" and its replacement by abstract homogenous time kept by machines. Even Tsing suggests that the "arts of noticing" temporal patterns in the natural world has been destroyed by capitalist clock time. Though they vary somewhat in the degree to which they imply this, all of these arguments rely on the idea that there is something called "natural" time and something called "abstract" or "mechanical" time, that the two categories are obviously separate, and that natural time is somehow *a priori.* Strip away the clock and the calendar, and Kingsolver expects she will be able to fall back into the non-clock tempos her grandparents knew through intuition. I'm pretty sure that Bernard M'Mahon, Nathaniel Bowditch, Henry David Thoreau, and Isaac Newton (the agriculturalist) would not have agreed that there is nothing intuitive or *a priori* about their knowledge of "natural" time.

Time perception, whether based on regular units or periodic phenomena, is always also cultivated. And focusing on the history of the imposition and expansion of clock-time has tempted us to overlook other ways that American time-sense was cultivated and applied across the nineteenth century. By refocusing on the history of organic timekeeping, we can begin to see some of the breadth and continuity obscured in clock-centered histories of changes in timekeeping. Most importantly, what we begin to see is the way in which histories of temporal (and spatial) abstraction like Standard Time cannot be considered in isolation, but instead are deeply linked to the history of organic timekeeping. The modern world is built on the foundations of modern organic time—a statement that holds true in urban settings as much as rural.

This dissertation chronicled nearly one hundred and fifty years of modern organic timekeeping. So, in the end what happened? Clearly, we don't live in Thoreau's vision of an instinctually-compelled agrarian countryside. Moreover, like Kingsolver, we often *feel* we live in a world largely determined by the ticking of a clock— and to a large degree we do. And yet, I would argue that this perception is only surface-deep. We still live in a world deeply influenced by modern organic timekeepers, but they now go by different names. To make that case, and to bring the previous chapters' stories to a close, let's revisit the four modern organic timekeepers profiled in this dissertation: the early melon, the ship's logbook, the cotton factory building, and the USDA crop report.

Old Sol Shelved

Because of the limited range of conditions under which it would grow and bear fruit, the early melon in its bed of dung could be used as a modern organic timekeeper. Careful gardeners could use the melon to synchronize their labor to the conditions of the local environment. At the end of the nineteenth century, melons remained the most prized and hardest to cultivate fruit of the forcing house.[7] Liberty Hyde Bailey, a renowned plant scientist at Cornell University's Experiment Station, listed all the conditions that could effect early melons in his 1914 work *The Forcing-book,* and finished by noting, "all these requirements seem to be easy enough of attainment as one reads them, but it has taken us six years to learn them."[8]

Bailey argued that melons remained the hardest fruit to grow out of season, despite myriad technological changes that elsewhere seemed to smooth the agricultural year. In 1890, for example, Bailey turned on an electric light over one of his green houses. A year later he reported on his findings in a USDA circular that, in turn, was widely reprinted in the popular press. Bailey confirmed that under the influence of electric light, some plants did germinate and grow faster—

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[7] L.H. Bailey, *The Forcing-Book, A Manual of the Cultivation of Vegetables in Glass Houses* (New York, 1914), 204-219.

[8] Bailey, *The Forcing-Book,* 205.

though not all plants had the same response. He concluded that electricity could be used to coax plants to not only grow out of season—as greenhouses and hot houses had been doing for centuries—but also at rates substantially faster than normal. Through electricity, Bailey explained, “we have telescoped the day far into the night, and morning is becoming obsolete.”[9]

Bailey’s experiments with electricity might seem to be an example of the ways that at the turn of the century some of the fundamental links between place and time that had been so impossible to overcome for horticulture and agriculture were loosening. And yet, despite many technologies that seemed to give him additional control over the effects of place and time in the forcing bed, it still took Bailey more than six years to master the early melon. As much as there was a story of change growing in Bailey’s greenhouse, we can also read in his experiments a narrative of continuity. Both stories are vital, but narratives of the death of natural time tempt us to overlook continuities and focus instead on the ways technologies like electric lights had begun to smooth some aspects of seasons and growing schedules. Despite the expansion of season-extending technologies or indoor agriculture (like hydroponics or vertical farming), the majority of the world’s crops still grow according to schedules that are unavoidably connected to local time and place, and human cultivation of those crops remains tied to organic timekeeping technologies. Some of those technologies, like the early melon, may operate on very small scales, while others, like crop zones, are used to make sense of much larger geographic patterns.

Held Fast to the Rock of Gibraltar

When Isaac Newton defined his concepts of absolute rest, time, and space, he used the example of a sailor in the hold of a ship. “Relative rest, is the continuance of the Body in the

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[9] L.H. Bailey, *The Outlook to Nature* (New York: Macmillan, 1905), 43-4.

same part of the Ship, or of its cavity," Newton explained, "But Real, absolute rest, is the continuance of the Body in the same part of that Immoveable space, in which the Ship itself, its cavity, and all that it contains, is moved."[10] Because the ship and all its contents were constantly in motion, often in ways that eluded or confounded the perceptions of a mariner, eighteenth- and nineteenth-century navigators looked for points outside of the ship to which they could anchor their calculations of space and time. Because they traveled around the world, navigators sought a fully universal anchor point, and in chapter two of this dissertation I traced the rise and fall of a technology intended to mediate between two imperfectly universal methods for telling time, astronomical navigation and the chronometer. This method was the logbook in the hands of a scientific sailor, a system of standardized organic timekeeping promoted by Nathaniel Bowditch in the pages of his *New American Practical Navigator*. After his death in 1838, Bowditch's son took over the editorship of the *Navigator*, and eventually signed the copyright over to the Coast Survey. The Coast Survey continued to publish the *Navigator* almost unchanged through 1880. In the first decade of the twentieth century, however, a major change in navigation forced a series of revisions to the *Navigator*, reflecting the ways that a new method for anchoring the ship's position in space and time reshaped the techniques of navigation. This new technology, the gyrostabilizer, effectively created a fixed point within the ship that could be used to establish the ship's position in time and space.

In 1898 one of the early inventors of the electric arc lightbulb, Elmer Sperry, suffered through his first cruise to Europe. The seas were "fresh" and the Cunard line ship rolled and plunged so much that Sperry found himself unable to leave his room. ("Didn't throw up hardly

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[10] Isaac Newton, *Mathematical Principles of Natural Philosophy, and His System of the World; Translated into English by Andrew Mottee in 1729,* trans. by Florian Cajori (Berkeley: University of California Press, 1934), 10.

any, acted on me the other way," he wrote to his children.)[11] Hoping to acclimate to ocean travel, Sperry resorted to a folk remedy for seasickness and requested a salt water bath. Unfortunately, "the solid marble tub never got warmer so I had to float free from the bottom all the time I was bathing." Floating in his tub of lukewarm water, in a windowless room inside the hull of a plunging and rolling ship seemed to help with the seasickness.[12] When the ship only made small rolls, the water in the bath stayed level, and because he floated free in the water, so did Sperry. The motion reminded Sperry of the movement of a gyroscope, a mathematical toy in which a rotating disc connected to gimbals is able to maintain its orientation and angular velocity as it is moved around.

From that formative experience of extreme seasickness on the ship, plus his extensive investigations of electrical engineering, Sperry incorporated a company dedicated to building gyrostabilizer for ships by 1910, and by 1912 he was pitching his new gyrostabilizer to the US Navy. The gyrostabilizer Sperry invented was built around a gyroscope.[13] As the ship pitched, the gyroscope spinning in its housing—in a box in the bridge—kept a fixed position. The gyroscope responded in real time to the continuously changing environment surrounding the ship, and registering the ways the ship bobbed in the water, sent a continuous signal to chambers of water ballast so that the ship could adjust its orientation relative to the horizon. Across the previous three centuries, Bowditch and his fellow nautical authors debated how to best locate a fixed point *outside* the ship. The more universal the better for navigation. Sperry's gyrostablizer brought that fixed point *inside* the hold of the ship.

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[11] Letter from October, 1898, Tuesday 4pm, Box 1, Elmer Sperry Papers, Soda House

[12] Bathing is not typically listed among the solutions to seasickness today, but hanging in a hammock as the ship pitches is.

[13] Sperry is credited as a co-founder of the gyrostabilizer along with Hermann Anschütz-Kaempfe.

"I told Mussolini that his Excellency was absolutely right. You cannot hold a ship in a heavy sea without reaching out and laying hold of something as solid as the rock of Gibraltar," Sperry wrote to a wealthy customer in the early 1920s, explaining how his invention worked and also bragging about his military contracts with the newly elected Italian Prime Minister.[14] To prove his point, Sperry wrote the he reached into his pocket and pulled out a toy gyroscope on a string and proceeded to show the leader of the fascist party how a gyroscope could become a fixed point inside a ship.

Organic timekeepers can be found wherever human temporal (and spatial) abstractions touch the world. Sperry's gyrostabilizer touched the world in useful as well as deadly ways. When American and Japanese warships hunted each other across the Pacific, the ships of both navies were held steady by Sperry's invention, the torpedoes of both navies found their marks by Sperry's invention, their airplanes found their way through the fog with Sperry's invention, and the submarines of both navies navigated in the abyss by Sperry's invention. When Sperry died in 1930, the YMCA in Tokyo held a memorial attended by over two hundred people, two admirals, several barons, and the Foreign Minister as well as Toyko's business and scientific elite. Fifteen years later, the Enola Gay would drop an atomic bomb on Hiroshima through bomb sights made possible through Sperry's invention. This is not to argue that these events would or would not have occurred without the gyrostabilizer, only to clarify that while some organic timekeepers, like the early melon, may seem benign or neutral in their affects, many other organic timekeeping technologies were far from neutral and there were (and remain) moral questions attached to their invention and use.

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[14] Copy of Correspondence by Elmer Sperry, undated, Elmer Sperry Papers, Box 4, Accession 1893, Soda House, Hagley Museum and Library.

It is easy to imagine that the gyrostabilizer is a different type of technology altogether from a logbook or a chronometer, but it actually operates in analogous ways to all of the modern organic timekeepers I've introduced thus far. The gyrostabilizer is a kind of modern organic timekeeper that transforms changes in position – caused by waves or wind or the curvature of the earth—into angular motion that is communicated in fluctuations in electrical signals. The mill did much the same thing, but communicated fluctuations in the external environment into different velocities for different machines and variations in the twist of the thread. Despite their ubiquitous presence in the digital world— in driverless cars, satellites, and cell phones—gyrostabilizers are analog technologies.

The Profitable Millman

Modern organic timekeeping may have been rapidly changing for agriculture and maritime navigation, but in 1905 the role and mentality of modern organic timekeeping for cotton manufacturing remained rather similar to the situation fifty years before. By that era most factories had converted to steam or electricity, and faced less energy loss across the system than had been the case with water-powered factories. However, the core challenge of the cotton mill remained its inability to disentangle its operations from local environmental conditions. Because they could not extricate themselves from their local environments, in 1905, cotton mill managers and designers continued to embrace modern organic timekeeping and ecological thinking as the key to efficient and consistent thread production.

"But alas!" *Progress and Profit for Mill Men* cautioned in 1909 "The conditions not only change, but the [thread] tensions required are not always the same for like conditions."[15] Even if

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[15] Henry D. Martin, *Progress and Profit for Mill Men* (Clinton, MA, 1909), 46.

all conditions external to the mill were as optimal as possible, environments still fluctuated both within and without the mill, and if they no longer as noticeably affected the rate at which the machines turned, they still could be read in the tension and twist of the thread. Place and time remained inextricably linked in the process of cotton thread production at the of the century. "The tensions are affected by the weather—extreme heat or cold, and too dry or too damp, size, speed, and gearing of machines; size and grade of goods, electricity…" *Profit for Mill Men* explained in a long entry about the numerous potential environmental causes for errors in thread tension.[16] To address these issue, the author, Henry D. Martin, insisted there were three things that a modern millman must know: "He knows that the weather and other environments which surround manufacturing are not always the same; that it is impossible to make exact a certain number of yarn without the count varying some; and that there is no such thing as perfect [thread] tension."[17] Like navigation, cotton mill manufacturers had embraced their work as a science of approximations in which consistent goods were produced by creating a dynamic production process that responded quickly and constantly to fluctuations in external and internal environmental conditions. The gyrostabilizer constantly twisted on its gimbals in order to maintain its orientation in the waves; a cotton mill constantly ran at variable speeds and twist ratios in order to produce consistent thread.

Because the mill could not be hermetically sealed against external conditions without making production entirely impossible, mill managers and designers had to lean the opposite direction and try to picture a future cotton mill that operated in even closer alignment with local environments. In 1905 Henry D. Martin used his decades of experience as a foreman and mill

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[16] Martin, *Progress and Profit for Mill Men*, 47.

[17] Martin, *Progress and Profit for Mill Men*, 47.

superintendent to sketch what he imagined to be "the mill of the future." This mill would have no belts, but motors attached to each machine. This would give the mill operatives a greater ability to calibrate the tension, speed, and rotation of each machine dynamically, without affecting the rest of the system.[18] The mill would have electric heating and some kind of water misting system that could keep the rooms at more a consistent temperature and humidity, and in the summer the misting system could cool overheated rooms. A coordinated network of electric windows could open and close around the building in the summer to optimize cooling across the day. And in this future mill, the mill clock geared off the mainshaft would be replaced by individual clocks attached to each machine and reporting to a central managers' office and rotating based on the individual speed of each machine. All this, the author imagined, would result in shorter work hours, faster speeds, and higher production.[19]

At a time when the *New York Times* imagined the farm of the future would operate in darkness and grow multiple crops a year in soil fertilized by nitrogen-fixing electric currents, it may seem strange that a major branch of American industry would imagine the cotton mill of the future as one more closely integrated and aligned with local environments.[20] Organic timekeeping happens when and where place and time remain inextricably linked, in which case it follows that the cotton industry would continue to incorporate organic timekeeping practices well into the twentieth century. The cotton industry embraced the idea of alignment with local environments because in 1915 it seemed that the environmental entanglements at the core of their production process could not be avoided.

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[18] Henry D. Martin, *The Economical and Successful Management of Cotton Mills* (Middleton, 1905), 132-135.

[19] Martin, *Economical and Successful Management,* 133-135.

[20] For instance, in 1904 the *New York Times* announced, "The Modern Farmer Hitches His Plow to the Lightning, He Fertilizes His Fields, Harrows Them, Kills the Pestiferous Bug, all with Electricity." "The Modern Farmer Hitches His Plow," *The New York Times,* April 10, 1904, ProQuest Historical Newspapers.

This entanglement would not be overcome until air conditioning and motors on each machine became commonplace in their industry. Until that point, timekeeping technologies like modern organic timekeepers and ecological thinking pointed the way forward for the cotton manufacturing industry. The mere presence of what we might now call ecological thinking did not prevent mill managers or owners from exploiting or despoiling the environments surrounding their mills. The mill manager's ecology illustrates the ways that modern organic timekeeping was not an inherently better way to keep time than other methods. Modern organic timekeeping was fully consistent with capitalism and industrialization even as it remained rooted in inescapable periodicities of local environments and regional climates.

A 35 Bushel Field

Unable to meet the demand for accuracy and timeliness, the USDA discontinued its monthly crop report in 1877. Across the 1880s and 90s, state agricultural societies produced monthly crop reports based on the network of crop reporters Dodge had assembled, but with a new President and expanded budget, the USDA returned to publishing the crop report in 1899. By that point, the scale of the crop reporting system began to approach the model envisioned by Newton and Dodge in the 1860s. At the turn of the century, the USDA statistical office received reports from 2,400 volunteer county correspondents and 6,800 assistants as well as 40,000 local correspondents.[21] By 1913, the New York Times boasted that the 130,000 reporters in the crop reporting network produced roughly 2.5 million reports a year.[22] At the same time, Congress

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[21] Jamie L. Pietruska, *Looking Forward: Prediction and Uncertainty in Modern America* (Chicago: University of Chicago Press, 2017), 50

[22] Pietruska, *Looking Forward,* 50

consolidated the disparate weather reporting services within the USDA as the Weather Bureau, responsible for issuing daily telegraphed weather “probabilities.”

These crop reports, market reports, and weather reports, interpreted by an office that had expanded to include forty statisticians, made it possible for the Statistical Office to begin publishing the kind of isochrone maps Dodge and Newton had imagined in the 1860s but been unable to generate. Around 1890, several agricultural scientists approached Cleveland Abbe asking if he could help them understand “the specific influence of climate in agriculture and its relation to… the resulting harvest.”[23] Abbe took the idea to the Chief Signal Officer, who authorized him to compile a report synthesizing meteorological, climate, phenological, and agricultural to provide better context for understanding harvest yields and climate. After roughly fifteen years, Abbe published his preliminary findings. By the 1920s, the weekly *Weather, Crops, and Market* report published by the USDA confidently issued announcements assigning causal relationships between weather, crops and market prices—associations that had been assumed but uncertain during Dodge’s tenure. Pronouncements like, “Corn Crop one of Main Factors in Hog Prices,” made in the April 22, 1922 edition of the *Weather, Crop, and Market* report could be combined with collections of maps like the USDA’s collection of *Seedtime and Harvest* from the same year. Maps of seedtime or harvest by region reflected established practice, but also had the effect of shaping it, standardizing practices while also encouraging farmers to perceive – and literally *see*— their local activities in relation to larger regional and national patterns. Not all activities were simultaneous, but they clearly took place in relation to each other. Meanwhile, textbooks like those in Liberty Hyde Bailey’s Rural Science Series applied the new stream of statistical information on crops and markets to standardize

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[23] Cleveland Abbe, *First Report on the Relations Between Climates and Crops* (1905), 5

environmental perception didactically. The image on the previous page, for example, is part of a chapter instructing young farmers on who to read fields for yield, teaching them to look at a field and *read* how that very local landscape related to a national market and interconnected national schedules.

Fig. 1. **Thirty-five-bushel wheat field (Cornell University).**

Figure 28: A photo from a series Bailey edited on the education of young farmers, here instructing readers on how to interpret a landscape for yield.

I.P. Roberts, The Farmstead: The Making of the Rural Home and the Lay-out of the Farm *(New York: The Macmillan Company, 1914)*, 28.

Figure 29: An isochrone map from Seedtime and Harvest *collection showing the average date of corn cutting and shocking by region and by date.*

Oliver Edwin Baker, Seedtime and Harvest: a Graphic Summary of Seasonal Work on Farm Crops *(Washington, D.C: U.S. Department of Agriculture, 1922), image from Wikimedia Commons.*

Analog Time

However divergent in form, each of the timekeeping technologies examined in this dissertation, interpreted and correlated processes in the natural environment (inputs), monitored them continuously based on predetermined, standardized, and universal processes (programs), and produced place-specific temporal information (output).[24] Armed with this information, farmers, sailors, and mill operatives and managers could more closely align their labor with the patterns of the natural world, and through synchronicity with those processes increase efficiency and productivity. In case after case and with general success, by rejecting the clock members of

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[24] Along the way, they often also produced spatial information—since knowing when you are is necessary to knowing where you are, and vice versa.

these industries imagined and created a series of what we could now identify as analog computers for use as organic timekeepers.

Across the twentieth century a vast array of authors have argued that natural time slowly ceded ground to the clock, first to the analog clock ticking away its regular units and then later to digital time recorded in 1's and 0's. In the new digital age, the internet seems to push us even farther towards a unified, universalized, homogenized *digital* time, an absolute but artificial ticker living somewhere in the ether. And yet, as ubiquitous as digital technology and digital time seem to be, they form only a thin veneer over a much deeper substrate of analog technologies essential to the maintenance of "modern" life. "The natural world is, in engineering terms, a thoroughly analog realm of endlessly variable waves of sound and light, temperature and pressure fluctuations, and shifting magnetic fields," *New York Times* technology reporter Barnaby J. Feder explained in a recent article.[25] As a consequence, the digital revolution actually requires an associated expansion of analog technologies. Behind national credit cycles, the daily weather report, my mother's pension fund, your Fitbit, or Exxon's most recent oil exploration, lurks analog technologies with roots in the organic timekeepers explored in this dissertation.

Climate change is ushering in a new reality that will require new approaches to time perception, environmental perception, and timekeeping technology. The future of life on this planet depends on our collective ability to imagine, choose, and follow new temporal orders. But our efforts to create and follow more resilient schedules on any scale, individual to global, will founder unless we learn to see the analog substrate living beneath our digital world—a realm filled with modern organic timekeepers that actively shape our temporal and environmental

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[25] Barnaby J. Feder, "Technology; A Digital World with Analog as its Workhorse," *The New York Times,* Aug. 9, 2004. https://www.nytimes.com/2004/08/09/business/technology-a-digital-world-with-analog-as-its-workhorse.html

perceptions in fundamental ways. Between the calendar and the clock and the unfolding phenomenal universe organic timekeepers are at work.

Without knowing what it looked like for people in the past to imagine a new temporal order, seek it out, cultivate their perceptions through it, and develop technologies to support it, Americans are left with few useful reference points when we want to change our own temporalities in the present. It isn't that we've lost the "arts of living" within or the "arts of noticing" other temporalities. What we've forgotten is what actively cultivating a new non-clock temporal order *looks* like on any scale larger than the household. Awash in literature that frames time as either instinctive or imposed, we've forgotten that we have choices to make. Worse yet, having forgotten to think of them as timekeepers, when we do look to reform, we overlook the vast majority of the timekeeping technologies that surround us. If addressing climate change requires a sweeping reconsideration of temporalities, than any reform movement needs to dig much deeper than the clock or the calendar. Temporal reform must begin with the enormous substrate of organic timekeepers that form the foundation of modern American life. Though we may quibble over whether it's the politics of the everyday, the construction of reality, or the fate of life on earth, we can't deny that a great deal is at stake in our choice.

Bibliography

"The Modern Farmer Hitches His Plow," *The New York Times,* April 10, 1904, ProQuest Historical Newspapers.

Abbe, Cleveland (anon.). "Standard Time in America." *Science* 22 (1905): 316.

Abbe, Cleveland. *First Report on the Relations Between Climates and Crops*. Washington, 1905. https://doi.org/10.5962/bhl.title.14839.

Abercrombie, John. *Everyman His Own Gardener. Being a new, and much more complete gardener's kalendar than any one hitherto published*. London, 1791.

Abercrombie, John. *The complete kitchen gardener, and hot-bed forcer; with the thorough practical management of hot-houses, fire-walls, and forcing-houses*. London, 1789.

Abercrombie, John. *The garden vade mecum*. London, 1789.

Abercrombie, John. *The Gardener's pocket journal, and daily assistant in the modern practice of English gardening. In a concise monthly display of all the practical works of general gardening throughout the year*. London, 1808.

Ahmed, Sara. *Queer Phenomenology: Orientations, Objects, Others*. Durham: Duke University Press, 2006.

Alexander, Amir R.. "Tragic Mathematics: Romantic Narratives and the Refounding of Mathematics in the Early Nineteenth Century." *Isis* 97, no. 4 (2006): 714-726.

Allen, A.B., ed.. *The American Horticulturalist: Designed to Improve the Planter, the Farmer, the Stock-Breeder, and the Horticulturalist (*New York, 1845).

Allen, A.B., ed.. *The American Horticulturalist: Designed to Improve the Planter, the Farmer, the Stock-Breeder, and the Horticulturalist (*New York, 1846).

Allen, John. "On Georg Simmel: Proximity, Distance, and Movement." In *Thinking Space*. Edited by Nigel Thrift and Mike Crang. London: Routledge, 2000. Kindle.

Allen, Thomas. "Clockwork Nation: Modern Time, Moral Perfectionism and American Identity in Catherine Beecher and Henry Thoreau," *Journal of American Studies* 39, no. 1 (April 2005): 65-86.

Allen, Thomas. *A Republic in Time: Temporality & Social Imagination in Nineteenth-Century America*. Chapel Hill: University of North Carolina Press, 2008.

Anderson, Benedict. *Imagined Communities: Reflections on the Origins and Spread of Nationalism*. New York: Verso, 1983.

Anon.. "Sketch of Sears Cook Walker," *Popular Science Monthly* 46 (November, 1894):116-121.

Appleby, Joyce Oldham. "The Vexed Story of Capitalism Told by American Historians." *Journal of the Early Republic* 21 (Spring 2001): 1-18.

Arnold, Thomas. *The American Practical Lunarian and Seaman's Guide*. Philadelphia, 1822.

Bailey, L.H.. *The Forcing-Book, A Manual of the Cultivation of Vegetables in Glass Houses*. New York, 1914.

Bailey, L.H.. *The Outlook to Nature*. New York: Macmillan, 1905.

Baird, Robert. *The American Cotton Spinner and Managers' and Carders' Guide: A Practical Treatise on Cotton Spinning*. Boston, 1854.

Baker, Benjamin. "March 28." *Franklin Journal* (Philadelphia, 1826):189.

Baker, Oliver Edwin. *Seedtime and Harvest: a Graphic Summary of Seasonal Work on Farm Crops*. Washington: U.S. Department of Agriculture, 1922. https://doi.org/10.5962/bhl.title.35400.

Barrows, Adam. *Time, Literature, and Cartography after the Spatial Turn: The Chronometric Imaginary*. New York: Palgrave MacMillan, 2016.

Bartky, Ian. *One Time Fits all: The Campaign for Global Uniformity*. Stanford, Stanford University Press, 2007.

Bartky, Ian. *Selling the Time True: Nineteenth Century Timekeeping in America*. Redwood City: Stanford University Press, 2000.

Beach, Mark. "Was there a Scientific Lazzaroni?" *Nineteenth Century American Science: A Reappraisal* (Evenston: Illinois Northwestern University Press, 1972): 115-132.

Bender, John and Wellbery, David, eds. *Chronotopes: The Construction of Time*. Redwood City: Stanford University Press, 1991.

Bender, Thomas. *Toward an Urban Vision: Ideas and Institutions in Nineteenth-Century America*. Baltimore: Johns Hopkins University Press, 1982.

Bennett, Jim. "The Travels and Trials of Mr. Harrison's Timekeeper," in *Instruments, Travel and Science: Itineraries of Precision from the Seventeenth to the Twentieth Century*. Edited by Marie Noelle Bourguet, Christian Licoppe, and H. Otto Sibum. New York: Routledge, 2002.

Bessen, James E.. 'More Machines, Better Machines… or Better Workers?" *The Journal of Economic History* 72, no. 1 (March 2012): 44-74.

Bessen, James E.. "Technology and Learning by Factory Workers: The Stretch-out at Lowell." *The Journal of Economic History* 63, no. 1 (March 2003): 33-64.

Biggs, Lindy. "The Engineered Factory." *Technology and Culture* 36, no. 2 Supplement: Snapshots of a Discipline: Selected Proceedings from the Conference on Critical Problems and Research Frontiers in the History of Technology, Madison, Wisconsin, October 30-Nov. 3, 1991 (April 1995): S174-188.

Biggs, Lindy. *The Rational Factory: Architecture, Technology, and Work in America's Age of Mass Production*. Baltimore: The Johns Hopkins University Press, 1996.

Blunt, Edmund M.. *Seamanship, both in Theory and Practice*. New York, 1813.

Blunt, Edmund M.. *The American Coast Pilot*. Newburyport, 1806.

Blunt, Joseph. *The Shipmaster's Assistant and Commercial Digest*. New York, 1853.

Bolster, Jeffrey W.. "'To Feel Like a Man': Black Seamen in the Northern States, 1800-1860." *The Journal of American History* 76, no. 4 (1990): 1173-1199.

Bowditch, Nathaniel. *The American Practical Navigator*. New York, 1802.

Bowditch, Nathaniel. *The New American Practical Navigator*. Newburyport, 1807.

Bowditch, Nathaniel. *The New American Practical Navigator*. New York, 1826.

Breen, T.H.. "The Non-Existent Controversy: Puritan and Anglican Attitudes on Work and Wealth, 1600-1640." *Church History* 35, no. 3 (September 1966): <pages>.

Breugel, Martin. " 'Time that can be Relied Upon.' The Evolution of Time Consciousness in the Mid-Hudson Valley, 1790-1860." In *Journal of Social History* 28, no. 3 (1995): <pages>.

Buchanan, Robinson. *Practical Essays on Mill Work and Machinery,* vol. 1 3rd ed.. London, 1841. Open Library: OL205310W.

Campbell, John F.. *History and Bibliography of* The New American Practical Navigator *and* The American Coast Pilot. Salem: Peabody Museum, 1964.

Capp, Bernard. *English Almanacs 1500-1800; Astrology and the Popular Press*. Ithaca: Cornell University Press, 1979.

Chandler, Alfred. *The Visible Hand: The Managerial Revolution in American Business*. Cambridge: Belknap Press, 1977.

Chapelle, Howard I.. *The History of American Sailing Ships*. New York:

Churchman, John. *An Explanation of the Magnetic Atlas or Variation Chart, Hereunto Annexed, Projected on a Plan entirely new*. Philadelphia, 1790.

Clark, Christopher, Vickers, Daniel, Aron, Stephen, Grey, Nancy Osterud, and Merrill, Michael. "The Transition to Capitalism in America: A Panel Discussion." *The History Teacher* 27, no. 3 (May 1994): 263-288.

Clark, Christopher. "Economics and Culture: Opening up the Rural History of the Early American Northeast," *American Quarterly* 43 (June 1991): 279-301.

Clark, Christopher. *The Roots of Rural Capitalism: Western Massachusetts, 1780-1860*. Ithaca: Cornell University Press, 1990.

Coen, Deborah R.. *Climate in Motion: Science, empire, and the Problem of Scale*. Chicago, The University of Chicago Press, 2018.

Cohen, Patricia Cline. *A Calculating People: The Spread of Numeracy in Early America*. New York, Routledge, 1999.

Colson, Nathaniel. *The Mariner's New Kalendar*. London, 1745.

Cotton, from the pod to the factory: a popular view of the Natural and Domestic History of the Plant, the adaptation and improvement of the raw material, with the rise and progress of the Cotton Factory, to its present state of perfection, and a brief history of bleaching and dyeing. New York: Homans & Ellis, 1844.

Curry, Helen Anne. *Evolution Made to Order: Plant Breeding and Technological Innovation in Twentieth-Century America*. Chicago: The University of Chicago Press, 2016.

Dalzell, Robert F. Jr.. *Enterprising Elite: The Boston Associates and the World They Made*. New York: W.W. Norton & Co., 1993.

Dana, Richard Henry Jr., *Two Years Before the Mast: A Personal Narrative of Life at Sea*. 1840. New York: Barnes and Nobles Classics, 2007.

Daston, Lorraine and Galison, Peter. *Objectivity*. Cambridge: Zone Books, 2010.

Delbourgo, James and Dew, Nicholas, eds.. *Science and Empire in the Atlantic World*. Routledge: New York, 2008.

Dew, Nicholas. "The Hive and the Pendulum: Universal Metrology and Baroque Science," in *Science in the Age of Baroque*. Edited by Ofer Gal and Raz Chen-Morris, 239-255. New York: Springer, 2012.

Dobson, James E.. "Lucy Larcom and the Time of the Temporal Collapse." *Legacy* 33, no. 1 (2016): 82-102.

Dobson, Thomas. *A System of Seamenship and Navel Tactics, Extracted from the Encyclopedia*. Philadelphia, 1799.

Dohrn-van Rossum, Gerhard. *The History of the Hour: Clocks and Modern Temporal Hours*. Edited by Thomas Dunlap. Chicago: The University of Chicago Press, 1996.

Donahue, Brian. *The Great Meadow: Farmers and the Land in Colonial Concord*. New Haven: Yale University Press, 2007.

Drayton, Richard. *Nature's Government: Science, Imperial Britain, and the 'Improvement' of the World*. New Haven: Yale University Press, 2000.

Dublin, Thomas. *Women at Work: The Transformation of Work and Community in Lowell Massachusetts, 1826-1860*. New York; Columbia University Press, 1981.

Dunn, Richard and Higgitt, Rebekeh. *Ships, Clocks, and Stars: The Quest for Longitude*. New York: Harper Designs, 2014.

Dunn, Richard, and Higgitt, Rebekeh. *Finding Longitude*. Royal Museums Greenwich: Collins, 2014.

Edwards, Clinton R.. "The Impact of European Overseas Discoveries on Ship Design and Construction during the Sixteenth Century." *GeoJournal* 26, no. 4 Quincentenary of the Discovery of the Americas (April 1992): 443-452.

Edwards, Steve. "Factory and Fantasy in Andrew Ure." *Journal of Design History* 14, no. 1 (2001): 17-33.

Elias, Amy and Burges, Joel, eds. *Time, A Vocabulary of the Present*. New York: NYU Press, 2016.

Ellis, Thomas. *The Gardener's Pocket-Calendar, Containing the Most Approved Methods of Cultivating the Useful and Ornamental Plants for the Kitchen-Garden, Flower-Garden, and flowering-in Shrubs; Arranged in Alphabetical Order, to Which are added, Directions of What is Necessary to be Done in Every Month of the Year*. London, 1776.

Essays, Mathematical and Physical: Containing New Theories and Illustrations of Some Very Important and Difficult Subjects of the Sciences. New Haven, 1800.

Evelyn, John. *Kalendarium Hortense: or, The gard'ner's almanac, directing what he is to do monthly through-out the year; and what fruits and flowers are in prime*. The 10th edition, with many useful additions. London, 1699.

Evenden, Matthew. "Beyond the Organic Machine? New Approaches in River Historiography." *Environmental History* 23, no. 4 (2018): 698-720.

Feder, Barnaby J.., “Technology; A Digital World with Analog as its Workhorse,” *The New York Times,* Aug. 9, 2004. https://www.nytimes.com/2004/08/09/business/technology-a-digital-world-with-analog-as-its-workhorse.html

Fischer, David Hackett. *Albion’s Seed; Four British Folkways in America*. Oxford: Oxford University Press, 1989.

Fitzgerald, Deborah. *Every Farm a Factory: the Industrial Ideal in American Agriculture*. New Haven: Yale University Press, 2003.

Fleming, James Rodger. *Meteorology in America, 1800-1870.* Baltimore: The Johns Hopkins University Press, 1990.

Foucault, Michael. *Discipline and Punish: The Birth of the Prison*. Translated by Alan Sheridan. New York: Vintage Books, 1979.

Galison, Peter. “Einstein’s Clocks: The Place of Time.” *Critical Inquiry* 26, no. 2 (2000): 355-389.

Ganguly, Keya. “Temporality and Postcolonial Critique.” In *The Cambridge Companion to Postcolonial Literary Studies*, edited by Neil Lazarus. <pages> Cambridge: Cambridge University Press, 2004.

Gardin, Michael, Tilley, Helen, and Prakash, Gyan. “Utopia and Dystopia beyond Space and Time.” *Utopia/Dystopia: Conditions of Historical Possibility*. Princeton University Press, 2010.

Gigerenzer, Gerd, Swijtink, Zeno, Porter, Theodore, Daston, Lorraine, Beatty, John, and Krüger, Lorenz. *Empire of Chance: How Probability Changed Science and Everyday Life*. Cambridge: Cambridge University Press, 1989.

Glasco, Jeffrey D.. “The Seaman Feels Himself a Man.” *International Labor and Working-Class History,* no. 66, New Approaches to Global Labor History (2004): <pages>.

Glennie, Paul and Thrift, Nigel. “Reworking E.P. Thompson’s ‘Time, Work-discipline and Industrial Capitalism.’” *Time & Society* 5, no. 3 (1996): 275-299.

Gould, Benjamin Apthorp. *An Address in Commemoration of Alexander Dallas Bache, delivered August 6, 1868 before the American Association for the Advancement of Science*. Salem: Essex Institute Press, 1868.

Gould, Stephen Jay. *Time’s Arrow, Time’s Cycle: Myth and Metaphor in the Discovery of Geological Time*. Cambridge: Harvard University Press, 1988.

Grier, David Alan. *When Computers were Human*. Princeton: Princeton University Press, 2005.

Gronim, Sara. *Everyday Nature: Knowledge of the Natural World in Colonial New York*. New Jersey: Rutgers University Press, 2009.

Guest, Richard. *Compendious History of the Cotton Manufacture: with a Disproval of the Claim of Sir Richard Arkwright to the Invention of its Ingenious Machinery*. Manchester, 1823. Open Library: OL16741934W.

Hahn, Steven, and Prude, Jonathan, eds. *The Countryside in the Age of Capitalist Transformation: Essay in the Social History of Rural America*. Chapel Hill: The University of North Carolina Press, 1988.

Hanchard, Michael. "Afro-Modernity: Temporality, Politics, and the African Diaspora." *Public Culture* 11, no. 1 (December 1999): 245-268.

Harrison, Stephen, Pile, Steve, and Thrift, Nigel. *Patterned Ground: Entanglements of Nature and Culture*. London: Reaktion Books, 2004.

Harvey, David. *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change*. New York: Wiley-Blackwell, 1991.

Hatton, Thomas. *An Introduction to the Mechanical Part of Clock and Watch Work. In Two Parts. Containing all the Arithmetic and Geometry Necessary, with their Particular Application in the said Branches, a Work very useful for the Working Mechanic or Gentleman Mechanically Inclined*. London, 1773.

Hays, Samuel. *Response to Industrialism*. Chicago: The University of Chicago Press, 1957.

Hedrick, U.P.. *History of Horticulture in America to 1860: With an Addendum of Books Published from 1861-1920*. New York: Timber Press, 1988.

Henretta, James A.. "Families and Farms: Mentalite in Pre-Industrial America." *The William and Mary Quarterly* 35, no. 1 (1978): 3-32.

Henrey, Blanche. *British Botanical and Horticultural Literature before 1800: Compiling a History and Bibliography of Botanical and Horticultural Books Printed in England, Scotland, and Ireland from the Earliest Times until 1800*. London: Oxford University Press, 1975.

Henry D. Martin, *The Economical and Successful Management of Cotton Mills*. Middleton, 1905.

Hensley, Paul. "Time, Work, and Social Context in New England." *The New England Quarterly* 65, no.4 (December 1992): 533-537.

Howe, Daniel Walker. *What Hath God Wrought: The Transformation of America, 1815-1848*. Oxford: Oxford University Press, 2009.

Ingold, Tim. *The Perception of the Environment; Essays on Livelihood, Dwelling, and Skill*. New York: Routledge, 2000.

Jankovic, Vladimir. *Reading the Skies: a Cultural History of English Weather, 1650-1820*. Chicago: University of Chicago Press, 2000.

Jasonoff, Sheila and Sang-Hyun Kim. *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*. Chicago: The University of Chicago Press, 2015.

Jasonoff, Sheila. *States of Knowledge: The Co-Production of Science and Social Order*. New York: Routledge, 2004.

Jenkovik, Vladimir. *Reading the Skies: A Cultural History of English Weather, 1650-1850*. Chicago: The University of Chicago Press, 2000.

Jeremy, David J.. *Technology and Power in the Early American Cotton Industry: James Montgomery, the Second Edition of His "Cotton Manufacture" (1840), and the "Justitia" Controversy about Relative Power Costs*. Philadelphia: American Philosophical Society, 1990.

Johnson, Andrew K., Conner, Roger D., Stephens, Carlene E., and Ceruzzi, Paul E.. *Time and Navigation: The Untold Story of Getting from Here to There*. Washington, DC: Smithsonian Books, 2015.

Johnson, George W.. *A History of English Gardening, Chronological, Biographical, Literary, and Critical Tracing the Progress of the Art in this Country from the Invasion of the Romans to the Present Time*. London, 1829. Open Library: OL5734577W.

Jones, Thomas P., ed. *Franklin Journal and American Mechanic's Magazine*, vol. 1. Philadelphia, 1826.

Juach, J. M.. *Are Quanta Real? A Galilean Dialogue*. Bloomington: Indiana University Press, 1989.

Justice, James. *The British Gardener's New Director, Chiefly Adapted to the Climate of the Northern Countries*. Dublin, 1771. https://doi.org/10.5962/bhl.title.26951

Kenchington, Trevor. "The Structures of English Wooden Ships: William Southerland's Ship, *Circa* 1710." *The Northern Mariner/Le Marin du nord* III, no. 1 (January 1993): 1-43.

Kingsolver, Barbara, Hopp, Steven L., and Kingsolver, Camille. *Animal, Vegetable, Miracle: A Year of Food Life*. New York: Harper Perennial, 2007.

Kulikoff, Allan. "The Transition to Capitalism." *The William and Mary Quarterly,* third series, 46, no. 1 (1989): 120-144.

Kulikoff, Allan. *The Agrarian Origins of American Capitalism*. University Press of Virginia, 1992.

Lamoreau, Naomi R.. "Rethinking the Transition to Capitalism in the Early American Northeast." *Journal of American History* 90, no. 2 (September 2003): 437-461.

Landes, David. *Revolution in Time*. Cambridge: Harvard Belknap Press of Harvard University Press, 1983.

Larcom, Lucy. *A New England Girlhood, outlined from memory*. Boston, 1889.

Larimer, Charles. *Letters to a Young Master Mariner, on some Subjects Connected with his Calling*, 3rd ed. London, 1843.

le Goff, Jacques. *Time, Work & Culture in the Middle Ages*. Translated by Arthur Goldhammer. Chicago: The University of Chicago Press, 1980.

Lears, T.J. Jackson. *No Place of Grace: Antimodernism and the Transformation of American Culture, 1880-1920*. Chicago: University of Chicago Press, 1981.

LeFebvre, Henri. *Rhythmanalysis: Space, Time, and Everyday Life*. New York: Bloomsbury Academic, 2013.

Leonard, Charles Elbredge. *The Mechanical Principe; Containing all the Various Calculations on Water and Steam Power, and on the different kinds of machinery used in manufacturing; with tables showing the cost of manufacturing different styles of cotton goods*. New York, 1848. Open Library: OL23272388M.

Lockard, Joe. "Lucy Larcom and the Poetics of Child Labour." *ESC* 38.3-4 (September/December 2012): 139-160.

Loeffelholz, Mary. "'A Strange Medley-Book': Lucy Larcom's an Idyl of Work." *The New England Quarterly* 80, no. 1 (March 2007): 5-34.

Louden, J.C.. *An Encyclopedia of Gardening; Comprising the Theory and Practice of Horticulture, Floriculture, Arboriculture, and Landscape-Gardening, Including All the Latest Improvements; A General History of Gardening in All Countries, and a Statistical View of Its Present State, With Suggestions for Its Future Progress in the British Isles*. 2nd edition. London, 1824. https://doi.org/10.5962/bhl.title.32681.

Lucier, Paul. "The Professional and the Scientist in Nineteenth-Century America." *Isis* 100, no. 4 (2009): 699-732.

Lyons, John. "Powerloom Profitability and Steam Power Costs: Britain in the 1830s." *Explorations in Economic History* 24, no. 4 (1987): 392-408.

M'Mahon, Bernard. *American Gardener's Calendar; Adapted to the Climates and Seasons of the United States*. Philadelphia, 1806.

Macey, Samuel L.. *Patriarchs of Time: Dualism in Saturn-Cronus, Father Time, the Watchmaker God, and Father Christmas*. Athens: The University of Georgia Press, 2010.

Mackey, Andrew. *The Theory and Practice of Finding the Longitude at Sea or Land: To which Are Added Various Methods of Determining the Latitude of a Place and Variations of the Compass with New Tables* Vol. 1, 3rd edition. London, 1810.

Malone, Patrick. *Waterpower in Lowell: Engineering and Industry in Nineteenth-Century America*. Baltimore: Johns Hopkins University Press, 2009.

Marche, Jordan D. II. "Restoring a 'Public Standard' to Accuracy: Authority Social Class, and Utility in the American Almanac Controversy, 1814-1818," *Journal of the Early Republic* 18, no. 4 (1998): 693-710.

Marshall, Charles. *An Introduction to the Knowledge and Practice of Gardening, First American from the Second London Edition, Considerably Enlarged and Improved to which is added An Essay on Quick-Lime as a Cement and as a Manure*. Boston, 1799. Open Library: OL7211082M.

Marshall, Henry. *Navigation Made Easy, or the Mariner's Daily Assistant and Self-instructor*. Milwaukee, 1877.

Martin, Henry D.. *Progress and Profit for Mill Men*. Clinton, MA, 1909.

Marx, Karl. *The Marx-Engels Reader*. Edited by Robert C. Tucker. New York: W.W. Norton & Company, Inc., 1978.

Massey, Doreen. "Traveling Thoughts." In *Without Guarantees: In Honor of Stuart Hall*. Edited by Paul Gilroy, Lawrence Grossberg, and Angela McRobbie. <pages> New York: Verso, 2000.

Massey, Doreen. *Space, Place and Gender*. Minneapolis: University of Minnesota Press, 1994.

McCarthy, Molly. *The Accidental Diarist: A History of the Daily Planner in America*. Chicago: University of Chicago Press, 2013.

McCrossen, Alexis. "The 'Very Delicate Construction' Of Pocket Watches and Time Consciousness in the Nineteenth-Century United States." *Winterthur Portfolio* 44, no. 1 (Spring 2010): 1-30.

McCrossen, Alexis. "The Sound and Look of Time." *Common-Place.org* 13, no. 1 (October, 2012). Accessed July 25, 2019. http://www.common-place-archives.org/vol-13/no-01/mccrossen/.

McCrossen, Alexis. *Marking Modern Times: A History of Clocks, Watches, and Other Timekeepers in American Life*. Chicago: The University of Chicago Press, 2013.

McPhee, John. *Founding Fish*. New York: Farrar, Straus, and Giroux, 2002.

McWilliams, James E.. "'To Forward Well-Flavored Productions': The Kitchen Garden in Early New England." *The New England Quarterly* 77, no. 1 (March 2004): 25-50.

Merleau-Ponty, Maurice. *Phenomenology of Perception*. New York: Routeledge, 1962.

Merriam, C. Hart. *Life Zones and Crop Zones of the United States*. Washington: U.S. Department of Agriculture, 1898. https://doi.org/10.5962/bhl.title.35423

Miller, Deagan. *This Radial Land: A Natural History of American Dissent*. Chicago: The University of Chicago Press, 2018.

Miller, Lillian B.. *The Lazzaroni: Science and Scientists in Mid-Nineteenth-Century America*. Washington: Smithsonian Institution Press, 1972.

Miller, Philip. *The Gardener's Dictionary*. London, 1754.

Miller, Philip. *The Gardener's Kalendar*. London, 1769.

Miller, Philip. *The Gardeners and florists dictionary, or a complete system of agriculture*. London, 1724.

Mohun, Arwen. *Risk, Negotiating Safety in American Society*. Baltimore: The John's Hopkins Press, 2013.

Montgomery, James. *The Cotton Manufacture of the United States Contrast and Compared with that of Great Britain*. Glasgow, post 1839.

Montgomery, James. *The Cotton Manufacture of the United States*; Justitia [pseud.] "Strictures on Montgomery on the Cotton manufactures of Great Britain and America." Newburyport, 1841.

Montrie, Chad. "I think Less of the Factory Than of my Native Dell," Labor, Nature, and the Lowell 'Mill Girls.'" *Environmental History* 9, no. 2 (2004): 275-295.

Moore, John Hamilton. *The New Practical Navigator*. London, 1800.

Morris, Christopher. *The Big Muddy: An Environmental History of the Mississippi and Its Peoples from Hernando De Soto to Hurricane Katrina*. New York: Oxford University Press, 2012.

Mortimer, John. *Cotton Spinning: The Story of the Spindle*. Manchester, 1895.

Mumford, Lewis. *Technics and Civilization*. Chicago: The University of Chicago Press, 1943.

Murphy, James McLeod. *Nautical Routine and Stowage, with Short Rules in Navigation*. New York, 1849.

Nanni, Giodanao. *The Colonisation of Time; Ritual, Routine, and Resistance in the British Empire*. Manchester: Manchester University Press, 2012.

Nash, Linda. "The Agency of Nature, or the Nature of Agency." *Environmental History* 10, no, 1 (2005): 67-69.

Newton, Isaac. *Sir Isaac Newton's Mathematical Principles of Natural Philosophy and His System of the World; Translated into English by Andrew Mottee in 1729*. Translated by Florian Cajori. Berkeley: University of California Press, 1934.

Nicol, Walter. *The Gardener's Kalendar, or, Monthly directory of operations in every branch of horticulture*. Edinburgh, 1812. https://doi.org/10.5962/bhl.title.33388.

Nye, David. *American Technological Sublime*. Cambridge: The MIT Press, 1996.

O'Malley, Michael. "Time Work, and Task Orientation: A Critique of American Historiography." In *Time & Society* 1, no. 3 (1992): 341-358.

O'Malley, Michael. *Keeping Watch: A History of American Time*. New York: Viking Penguin, 1990.

Oelschlaeger, Max. *The Idea of Wilderness, From Prehistory to the Age of Ecology*. New Haven: Yale University Press, 1991.

Ogle, Vanessa. "Whose Time Is It? The Pluralization of Time and the Global Condition, 1870s-1940s." *American Historical Review* 120, no. 5 (December 2013): 1376-1402.

Ogle, Vanessa. *The Global Transformation of Time: 1870–1950*. Cambridge: Harvard University Press, October 2015.

Orzolek, Michael, Bogash, Steven M., Kime, Lynn F., and Harper, Jayson K.. "Agricultural Alternatives: Cantaloupe Production." Publication Distribution Center: The Pennsylvania State University, 2006. Available online: agalternatives.aers.psu.edu

Pauly, Philip J.. "Is Environmental History a Subfield of Garden History?" *Environmental History* 10, no. 1 (January 2005): 70-71.

Pauly, Philip J.. *Fruits and Plains, The Horticultural Transformation of America*. Cambridge: Harvard University Press, 2008.

Paxson, Margaret. *Solovyovo: The Story of Memory in a Russian Village*. Bloomington: Indiana University Press, 2008.

Pietruska, Jamie L.. *Looking Forward: Prediction and Uncertainty in Modern America*. Chicago: University of Chicago Press, 2017.

Poole, Robert. " 'Give us Our Eleven Days!': Calendar Reform in Eighteenth-Century England." *Past & Present,* no. 149 (1995): 95-139.

Pratt, Lloyd. *Archives of American Time: Literature and Modernity in the Nineteenth Century*. Philadelphia: University of Pennsylvania Press, 2010.

Pritchard, Sara B.. *Confluence: the Nature of Technology and the Remaking of the Rhône*. Cambridge: Harvard University Press, 2011.

Rediker, Marcus. *Between the Devil and the Deep Blue Sea: Merchant Seamen, Pirates, and the Anglo-American Maritime World, 1700-1750*. Cambridge: Cambridge University Press, 1987.

Rifkin, Mark. *Beyond Settler Time: Temporal Sovereignty and Indigenous Self-Determination*. Durham: Duke University Press, 2017.

Riskin, Jessica. *The Restless Clock: A History of the Centuries-Long Argument about What Makes Living Things Tick*. Chicago: The University of Chicago Press, 2016.

Roberts, I.P.. *The Farmstead: The Making of the Rural Home and the Lay-out of the Farm*. New York: The Macmillan Company, 1914.

Sachs, Aaron. *Arcadian America: The Death and Life of an Environmental Tradition*. New Haven: Yale University Press, 2013.

Sachs, Aaron. *The Humboldt Current: Nineteenth-Century Exploration and the Roots of American Environmentalism*. Oxford: Oxford University Press, 2007.

Sauter, Michael J.. "Clockwatchers and Stargazers: Time Discipline in Early Modern Berlin." *The American Historical Review* 112, no. 3 (2007): 685-709.

Schaffer, Simon. "Babbage's Intelligence: Calculating Engines and the Factory System," *Critical Inquiry* 21, no. 1 (1994): 203-227.

Schivelbusch, Wolfgang. *The Railway Journey: The Industrialization of Time and Space in the 19th Century*. Oakland: University of California Press, 1986.

Schmidt, Eric Leigh. *Hearing Things: Religion, Illusion, and the American Enlightenment*. Cambridge: Harvard University Press, 2002.

Schotte, Margaret. "Expert Records: Nautical Logbooks from Columbus to Cook." *Information & Culture* 48, no. 3 (2013): 281-322.

Scott, James. *Seeing like a State*. New Haven: Yale University Press, 1998.

Scott, R.. *The Practical Cotton Spinner, and Manufacturer: the Manager's Overlooker's and Mechanics Companion*. Corrected and enlarged by Oliver Byrne. Philadelphia, 1851. Open Library: OL15744710W.

Scott, Robert. *Scott's Practical Cotton Spinner and Manufacturer: or Manager's Overlookers' & Mechanics' Companion*. Manchester, 1840.

Shepherd, Charles. *On the Application of Electro-Magnetism as a Motor for Clocks*. London, 1851.

Simmel, Georg. "The Metropolis and Mental Life." In *The Sociology of Georg Simmel*. Translated by Kurt Wolff, 409-424. New York: Free Press, 1950.

Smith, Jason W.. *To Master the Boundless Sea: The U.S. Navy, the Marine Environment, and the Cartography of Empire*. Chapel Hill, The University of North Caroline Press, 2018.

Smith, Mark M.. "Coming to 'Our' Senses: an Introduction." *The Journal of American History* 95, no. 2 (September 2008): 378-380.

Smith, Mark M.. "Old South Time in Comparative Perspective." *The American Historical Review* 101, no. 5 (December 1996): 1432-1469.

Smith, Mark M.. *Mastered by the Clock; Time, Slavery, and Freedom in the American South*. The University of North Carolina Press, 1997.

Smith, Mark M.. *Sensing the Past: Seeing, Hearing, Smelling, Tasting and Touching in History*. Berkeley: University of California Press, 2008.

Smith, Mark M.. *The Smell of Battle, the Taste of Siege*. Oxford: Oxford University Press, 2014.

Smith, Thomas C.. "Peasant Time and Factory Time in Japan." *Past & Present* 111, issue 1 (1986): 165-197.

Snell, Daniel W.. *The Manager's Assistant: Being a Condensed Treatise on the Cotton Manufacture, with suitable explanations, &c.: to which is added, various calculations, tables, comparisons, &c. of service to the manufacturer and general reader*. Hartford, 1850.

Sobel, Dava. *Longitude: The True Story of a Lone Genius who Solved the Greatest Scientific Problem of his Time*. New York, 2007.

Steinberg, Ted. *Nature Incorporated: Industrialization and the Waters of New England*. Amherst: University of Massachusetts Press, 1991.

Stephens, Carlene. "'The Most Reliable Time': William Bond, the New England Railroads, and Time Awareness in 19th-Century America." *Technology and Culture* 30, no. 1 (January 1989): 1-24.

Switzer, Stephen. *The Practical Kitchen Gardener: or, A new and entire system of direction for his employment in the melonry, kitchen-garden, and potagery, in the several seasons of the year*. London, 1727. https://doi.org/10.5962/bhl.title.69656

Tadier, Neferti. "Life-Times of Dispossability within Global Neoliberalism," *Social Text 115* 31, no. 2 (Summer 2013): 19-48.

The House of Commons. "Mills and Factories," *Reports from Committees: Six Volumes,* vol. IX. January - June, 1841.

The Statistical Reporting Service, Appendix B, "Statistical Reporting Service of the U.S. Department of Agriculture, Scope & Methods," Misc. Publications No. 967. Washington, 1964.

Thompson, E. P.. “Time, Work-Discipline, and Industrial Capitalism.” In *Past & Present* 38 (December 1967): 56-97.

Thoreau, Henry David. *First and Last Journeys of Thoreau; Lately Discovered Among His Unpublished Journals and Manuscripts, vol. 1.,* ed. Franklin Benjamin Sanborn. Boston, 1901. Open Library: https://openlibrary.org/works/OL55706W.

Thornton, Tamara Plakins. *Nathaniel Bowditch and the Power of Numbers: How a Nineteenth-Century Man of Business, Science and the Sea Changed American Life*. Chapel Hill: The University of North Carolina Press, 2016.

Thorson, Robert M.. *The Boatman: Henry David Thoreau’s River Years*. Cambridge: Harvard University Press, 2017.

Thorson, Robert M.. *Walden’s Shore: Henry David Thoreau and Nineteenth-Century Science*. Cambridge: Harvard University Press, 2015.

Thrift, Nigel and May, Jon eds.. *TimeSpace: Geographies of Temporality*. London: Routledge, 2001.

Tsing, Anna. *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton: Princeton University Press, 2017.

United Stated Patent Office. “Report of the Commissioner of Patents.” *Patent Office Annual Report*. Washington, 1861.

United Stated Patent Office. *Report of the Commissioner of Patents for 1860*. Washington, 1861.

United States Department of Agriculture Statistical Reporting Service, *The Story of U.S. Agricultural Estimates*. Washington: United State Department of Agriculture, 1999.

United States Department of Agriculture. *Department of Agriculture Monthly Reports*. Washington, 1863-64.

United States Department of Agriculture. *Department of Agriculture Monthly Reports*. Washington, 1866.

United States Department of Agriculture. *U.S. Commissioner of Agriculture Report*. Washington, 1887.

United States Patent Office. *Report of the Commissioner of the Patent Office*. Washington, 1855.

Vickers, Daniel and Walsh, Vince. “Young men and the sea: the sociology of seafaring in eighteenth-century Salem, Massachusetts.” *Social History* 24, no. 1 (1999): 17-38.

Vickers, Daniel and Walsh, Vince. *Young Men and the Sea: Yankee Seafarers in the Age of Sail*. New Haven: Yale University Press, 2007.

Vickers, Daniel. *Farmers & Fishermen: Two Centuries of Work in Essex County, Massachusetts, 1630-1850*. Chapel Hill: The University of North Carolina Press, 1994.

Walls, Laura Dassow. *Seeing New Worlds: Henry David Thoreau and Nineteenth-Century Natural Science*. Madison: University of Wisconsin Press, 1996.

Walls, Laura Dassow. *The Passage to Cosmos*. Chicago, The University of Chicago Press, 2009.

Walls, Laura Dassow. *Thoreau: A Life*. Chicago: The University of Chicago Press, 2017.

Walsh, James P.. "Holy Time and Sacred Space in Puritan New England." *American Quarterly* 32, no. 1 (Spring, 1980): 7-83.

Weber, Max. *The Protestant Ethic and the Spirit of Capitalism*. Translated by Talcott Parsons. New York: Routledge, 1930 (1992).

Weston, Richard. *Gardener's Pocket-Calendar: on a new plan in regular alphabetical order. With the necessary directions for keeping a garden, in proper order, & for raising flowers, in every month of the year*. Nottingham, 1787.

Whitrow, G.L.. *Time in History: Views of Time from Prehistory to the Present Day*. Oxford: Oxford University Press, 1988.

Wiles, Margaret. *The Gardens of the British Working Class*. New Haven: Yale University Press, 2014.

Winchester, Simon. *The Perfectionists: How Precision Engineers Created the Modern World*. New York, 2018.

Withers, Charles W. J.. *Zero Degrees*: *Geographies of the Prime Meridian*. Cambridge: Harvard University Press, 2017.

Worster, Donald. *Nature's Economy: a History of Ecological Ideas*. Second Edition. Cambridge: Cambridge University Press, 1977.

Wulf, Andrea. *The Brother Gardeners: A Generation of Gentlemen Naturalists and the Birth of an Obsession*. New York: Vintage, 2008.

Zerubavel, Eviatar. *Hidden Rhythms: Schedules and Calendars in Social Life*. London: University of California Press, 1981.