Western Oregon University

Insatiable Shipyards:
The Impact of the Royal Navy on the World's Forests, 1200-1850

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HST 499
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June 11, 2012

I. Introduction

Shipbuilding has a long tradition in England, and likewise, it has long been a topic of discussion in British history. Famously captured in 1890 in Cpt. A.T. Mahan's *The influence of Sea Power upon History*, the importance of England's Royal Navy to the nation's history has been well recognized for many years. In 1926, Robert G. Albion added a new facet to the discussion, highlighting England's deep reliance on timber to keep its shipyards in operation. Based on contemporary correspondence, parliamentary papers, and naval and forestry reports from the seventeenth, eighteenth, and nineteenth centuries, Albion hypothesized that the demand for ship timber stripped the landscape of wooded resources. He argued that the procurement of good oak for the construction and maintenance of English hulls was so critical that its failure could reduce the strength of the Royal Navy as a whole and hamper the operations of the admiralty. Such was the case in the Dutch Wars, the American Revolution, and the Napoleonic Wars, where Albion supposed that difficulty in timber procurement hampered naval operations.[1] Deeming this loss of naval stores the "timber problem," Albion set a new standard for naval histories of England's wooden fleets. Based on his work, many historians treated eighteenth and nineteenth century English shipbuilding as a major source of deforestation in the British Isles for the next fifty years.[2]

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[1] Robert G. Albion, *Forests and Sea Power: The Problem of the Royal Navy, 1652-1862* (Cambridge: Harvard University Press, 1926), vii-ix.

[2] Albion's studies into the history of British woodlands were conducted in an effort to provide better understanding of the military history of the Empire. This remained the case for decades to follow. William R. Carlton, writing in the late 1930s, followed Albion's example, often resorting to restatements of Albion's arguments. As new schools of thought began influencing the field, historians began to add new dynamics to discussions of this topic. H.S.K. Kent added economic understanding of England's maritime policies through influence of the social sciences, and Ronald L. Pollitt brought in Annales influence in addressing the breadth of naval store imports, but no one diverged fully from Albion's arguments until the cultural turn of the 1970s.

More recently, however, the popular trend in the historiography of this topic has been to argue the opposite, claiming that even during its peak, shipbuilding was not a major contributor to deforestation. This new approach was first proposed by Oliver Rackham, who wrote in 1990 that "the 'tradition' that [shipbuilding] destroyed woods is implausible...The dockyard had a wide, but by no means universal, impact on woodland."[3] Rackham argued instead, that the regenerative nature of trees and the meticulous manner in which British woodlands were managed allowed the woodlands to fully cope with all demands placed on them by humans.[4] Since Rackham, the argument has been taken beyond the claim that cutting for ship timber did not cause deforestation, to the claim that shipbuilding had little or no effect on the landscape whatsoever.

Nonetheless, Rackham's claims have been taken too far. When combating the timber shortage theory, Rackham approached the topic from a concept of total forest clearing leading to a general wood shortage, as had Albion and other early proponents of the theory. Admittedly, shipbuilding removed only specific species of trees from the landscape. Furthermore, only a very small number of trees among those species were removed in any one location at a time. These practices would have prevented the clearing of full forests for the sole purpose of shipbuilding. When examined in this light, it is easy to dismiss the concept of timber shortages. Woods continued to exist through to the nineteenth century and continued to produce new growth.[5]

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[3] Oliver Rackham, *Trees and Woodland in the British Landscape:The Complete History of Britain's Trees, Woods & Hedgegrows, 2nd ed.* (New York: Phoenix Press, 1990), 96.
[4] Oliver Rackham, *Ancient Woodland: Its History, Vegetation and Uses in England*. (London: Edward Arnold, 1980), ix.
[5] For more on Rackham's approach to pre-industrial woodland clearing and continued woodland productivity, see Rackham, *Trees and Woodland*, 59-97.

However, when the topic is approached solely from the standpoint of timber availability, or even more specifically ship timber, dismissal of the "timber problem" is not so easy. There was neither a sudden wood shortage brought on by shipbuilding demand, nor was the regenerative nature of trees able to cope entirely with the demands placed on woodlands by the Royal Navy. Instead, the rate of usage likely outpaced that of regeneration. There may not have been a universal wood shortage as Albion suggested, but consistent removal of great oaks for shipbuilding very likely stripped suitable oaks from the landscape more quickly than they could reproduce, causing a gradual, dispersed reduction in the quality and quantity of available timber.[6] If this is indeed the case, then Albion's arguments for instances in which timber shortages reduced the strength of the Royal Navy gain renewed validity. Complete dismissal of the "timber problem" may hide this key influence upon the effectiveness of English fleets, rendering naval histories incomplete.

Furthermore, total acceptance of Rackham's regeneration theory would have us ignore the ecological cost of pre-industrial naval buildup. Shipbuilding contributed to a long tradition of woodland exploitation which has affected domestic woodland biodiversity and soil quality.[7] Additionally, a great quantity of wood resources used in the construction of the Royal Navy came from outside of the British Isles, spreading its

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[6] While, to my knowledge, this paper is the first to take up this specific line of argument, a similar claim has been made by James A. Galloway, Derek Keene, and Margaret Murphy. They take issue with what they see as an overcorrection of the notion that traditional accounts of wood scarcity were fictitious, though rightly attributing the majority of what wood scarcity may have existed to the demand for firewood. Basing their arguments on price increases for firewood while wheat and coal remained more constant, and an increase in import of sea coal and peat, the authors suggest that a wood shortage may have indeed occurred. James A. Galloway, et al. "Fueling the City: Production and Distribution of Firewood and Fuel in London's Region, 1290-1400," *Economic History Review* 49 (1996): 455-496.

[7] For more on the history of English woodland management and exploitation, see Rackham's *Ancient Woodlands*. Rackham does not delve deeply into the ecological impacts of wood use in Britain, but he offers the most complete examination of the many relationships between human activity and the British landscape available today.

impact through Europe and North America. The scale of the Royal Navy's ecological impact was immense and can only be barely touched on here. While woodland regeneration indeed took place throughout England's period of wooden vessels, domestic and foreign timber supplies were habitually taxed at a rate which surpassed the landscape's ability to cope, causing both a reduction in available ship timber as well as a gradual but extensive ecological impact on Britain's and the world's forests.

II. Naval Timber and British Life

The importance of ships and ship timber to the British way of life in the eighteenth and early nineteenth centuries is well recognized and borne out in sources from the time. Written accounts demonstrating a clear concern for the maintenance of woodland trees turn up in increasing abundance from the 1600s through the 1850s. In 1792, the *Eleventh Report of the Commissioners Appointed to Enquire into the State and Condition of the Woods, Forests and Land Revenues of the Crown* warned of a decline in Britain's ability to supply oak timber and an ever increasing need to rely on imports to supply the Royal Navy.[8] Similarly, an eighteenth century illustration connecting British power as a maritime nation to timber oaks (Figure 1) promoted the notion that perpetuation of the nation's woodlands was the "key to England's future."[9]

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[8] James Davey, "Securing the Sinews of Sea Power: British Intervention in the Baltic 1780-1815," *The International History Review* 33 (2011): 169.
[9] John Perlin, *A Forest Journey: The Role of Wood in the Development of Civilization* (Cambridge: Harvard University Press, 1989), 30.

Even so, the relative rates of usage for ship timber tell the story more clearly. By the late eighteenth century, the Royal Navy demanded 50,000 loads of oak per year to keep its shipyards in operation, while the entirety of the country required only 218,000 loads.[10] In the case of masts (which were almost always imported due to a lack of domestic timber long and straight enough for the purpose), 1801 saw the import of 1,186 masts from the Baltic region with an additional 198 coming from North America.[11] At the same time, a single ship-of-the-line required the wood from roughly 4,000 mature oaks for construction.[12]

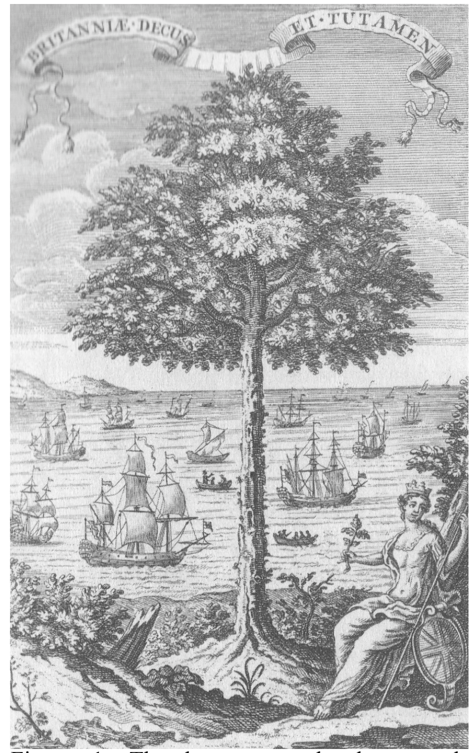

Figure 1: The banner translated to read, "Britain's Glory and Protection," the central character to this eighteenth century illustration is a mature oak tree, standing before a backdrop of naval ships and other vessels, the hulls of which required many such oaks to construct. At the tree's base sits *Britannia,* a symbol of Great Britain, holding an oak seedling. The illustration was perhaps a propaganda piece promoting the re-planting of oaks to assure the perpetuation of British strength as a maritime nation. From Perlin, *A Forest Journey*, 30.

While such oaks were produced domestically for the most part, the necessary importation of other naval stores like pitch, tar, hemp, and masts dramatically shaped England's foreign policy. By the eighteenth century, it was common practice for the Crown to send diplomats to the timber-rich Baltic countries for the purpose of securing such stores. Insuring the availability of naval stores for England at all costs while

[10] One load is defined as fifty cubic feet of timber. H.S.K. Kent, "The Anglo-Norwegean Timber Trade in the Eighteenth Century." *The Economic History Review* 8 (1955): 63. The above figures reflect only annual wood sales. The total amount of wood used by the shipyards depended both upon the quality of the wood purchased and the practices of individual shipwrights, but actual wood usage was doubtlessly far less than the total 50,000 loads consumed by the Royal Navy.
[11] Davey, "Securing the Sinews," 161-162.
[12] J. R. McNeill, "Woods and Warfare in World History," *Environmental History* July 2004 <http://www.historycooperative.org/journals/eh/9.3/McNeill.html> (6 Mar. 2011), 30.

simultaneously denying them to her maritime enemies such as France became a key facet to England's foreign policy. Not infrequently, this effort resulted in conflict and was the direct cause of the League of Armed Neutrality of 1780, an international agreement designed to protect neutral shipping against England's wartime search policies.[13] In the midst of the Napoleonic Wars, three armed conflicts erupted between 1800 and 1815 over concerns of naval stores, demonstrating the nation's self-conscious dependency on maintaining a strong navy.[14]

Moreover, this relationship between maritime prowess and the English way of life stretches far back beyond the golden age of the wooden Royal Navy in the eighteenth and nineteenth centuries. Concerns over a timber shortage which might inhibit the shipyards appeared as early as the sixteenth century. Admiral Sir William Monson wrote that woods in England were then "utterly decayed," and began to be so too in Ireland.[15] As early as 1612, land lease documents show that lessee requirements could include the planting of new timber trees and the protection of seedlings from cattle grazing, demonstrating foresight in the protection of naval stores.[16]

Even before the necessity of maintaining resources for shipbuilding was well recognized, the English way of life was tied to the sea and its navy. Henry VII formed the base of the first true Royal Navy when he embarked on a program of protective

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[13] Albion, *Forests and Sea Power*, x.

[14] Davey, "Securing the Sinews," 161. More than a identifying a simple relationship between naval stores and foreign policy, Davey argues that the relationship was so extreme that it is impossible to understand the motivations behind any British foreign policy between the late eighteenth and early nineteenth century without first recognizing the importance of her standing as a maritime nation for her protective and commercial interests.

[15] Albion, *Forests and Sea Power*, 95.

[16] Rackham, *Ancient Woodland*, 159. Rackham provides annotated text from a fourteen year lease agreement for the twenty four acre Hawe Wood in Norfolk. Though this source stretches practices of systematic replanting back to the early seventeenth century, it should be noted that this document appears roughly a century earlier than any other with similar stipulations that Rackham could uncover.

shipbuilding, ordering the construction of a fleet for a means of defense against those who might seek power through conquest as he himself had done. In so doing, he fundamentally changed the English attitude toward the sea, transforming the nation's "moat" into a realm of British power, an attitude which was perpetuated and intensified by Henry VIII, Elizabeth I, and others.[17]

Carrying the relationship back still further, among the earliest known references to a naval buildup occurred in 897 when King Alfred of Wessex ordered the construction of a number of large galleys. Though physical evidence of the building of these or earlier ships has yet to be uncovered, details of naval construction become increasingly clear into the thirteenth century. In 1204, King John's loss of Normandy transformed the English Channel from a convenient transit route to a dangerous frontier. In response, he constructed fifty galleys and posted them at ports across England and Ireland, initiating one of the first periods of naval buildup. Between 1209 and 1212, a total of twenty additional galleys and thirty-four other vessels were built under order of the Crown.[18] Although notably more punctuated than the period after Henry VII, naval construction occurred repeatedly throughout England's early history. England, by virtue of its island residence, was inexorably linked to the sea, and so too were her military interests.[19]

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[17] Ronald L. Pollitt, "Wooden Walls, English Sea Power and the World's Forests," *Forest History* 15 (1971): 8.
[18] Friel, *The Good Ship*, 146.
[19] Delineating between strictly military vessels and those built for other purposes can be difficult before Henry VII. Prior to the establishment of a permanent Royal Navy, fleets tended to be smaller and built in response to specific threats or interests. After those threats receded, many such ships were allowed to fall into disrepair as these early fleets dwindled. To cope with more urgent naval demands, merchant vessels were often requisitioned for use in combat. Though these vessels were not constructed with military exploits in mind, their use as a makeshift navy when the need arose represents a continuation of the connection between English naval interests and her woods during periods in which a standing fleet was not maintained. Ian Friel, *The Good Ship: Ships, Shipbuilding and Technology in England 1200-1520* (Baltimore: Johns Hopkins University Press, 1995), 29.

Just as the importance of a wooden navy existed before the eighteenth century, so too did its connection to the landscape. England's condition as a maritime nation required that she maintain shipyards along her coast, and also, that she keep them stocked with ample naval stores. Though the scale at which this practice took place increased dramatically in the eighteenth century, the Crown's reliance on resources from her wooded landscape existed much earlier than even the period that is the focus of this paper. In an effort to extend the recognized impact of naval cutting back before the traditional focus of the late eighteenth to mid nineteenth centuries, this paper does not propose to find the initiation of that relationship, but rather adjusts its scope to Rackham's time-scale of woodland stability for the six hundred years beginning in 1250.

From 1250 to 1850, England grew increasingly reliant on its Royal Navy, and thus grew ever more dependent on the exploitation of its woodland resources. Even early theories of a timber shortage limited their scope to the last two centuries of wooden fleets based on the assumption that only at its peak did the Royal Navy overtax its woodlands; a time period which Rackham deems too short lived to have any real impact.[20] Both Albion and Rackham assume woodlands remained roughly stable between the thirteenth and eighteenth centuries. However, as we shall see, this period was better defined by chronic woodland stress. Eighteenth and nineteenth century increases in the size of the Royal Navy represent not the start, but an intensification of demands on a habitually taxed system.

III. Timber Decline

Ever since Rackham first denied the concept of pre-industrial timber shortages in the 1970s, historians like James Galloway and Margaret Murphy (noted above) have

[20] Rackham, *Ancient Woodland*, 154.

eagerly debated the scale to which such exploitation may have impacted the landscape before 1850. One of Rackham's most important sources of evidence for a supposed uniformity of the wooded landscape comes from simple woodland acreage correlations. As an example, he claims that the acreage of select woods in Suffolk "agree to a surprising extent over 740 years," starting in 1251. Giving only three data points per location (likely due to a limitation of available records spanning this timeframe), Rackham shows that what is today England's Park Wood covered 9.0 acres in 1251, 14.0 in 1639, and 13.9 in 1988. Titley Hill varied from 5.0 acres, to 4.0 acres, and 4.7 at the same dates. Prestley Wood measured in at 30.0 acres in 1251, and then remained a consistent 43.5 in 1639 and 1988. Similarly, Swingen's Wood showed a 7.0, 13.0, then 14.2 acre coverage at the same times.[21] Far from showing a steady decline, Rackham's data points remain mostly consistent or even demonstrate growth over time.

Unfortunately, Rackham's data is far from conclusive. To start, little can be said for the accuracy of thirteenth and seventeenth century woodland surveys. Rackham himself contends that the coverage of thirteenth century woods was likely underestimated due to systematic errors in surveying methods.[22] If this is indeed the case, then conclusions drawn from such data can only be very weak. Correlations showing stability could be obscuring actual decay. Growth relationships may very well be nullified. Furthermore, by Rackham's own numbers, Bonny Wood lost at least 54 acres between

[21] Rackham, *Trees and Woodland*, 61.
[22] Rackham correlates woodland surveys from 1279 to their condition in 1968 to find that extant woodlands show a surprisingly consistent discrepancy of 45 percent growth by the later date. The consistency of this discrepancy suggests that the growth has not actually occurred. Rather, surveying practices from the thirteenth century likely resulted in smaller acreage estimates due to the difficulties of measuring irregular landscapes without the benefits of trigonometry or modern techniques. Oliver Rackham, "Medieval Woodland Areas," *Nature in Cambridgeshire* 11 (1968): 24.

1251 and 1988, dropping from 180 to 126 acres.[23] This substantial decline would only be compounded by underestimates in the thirteenth century. If nothing else, this potential underestimation suggests that Rackham's findings based on this information may be faulty. When compounded with the relative inconsistency even within the data that he provides, Rackham's claims of medieval forest stability are notably weakened.

To further complicate this concept of continuity, Rackham's acreage data makes no mention of quality or density of wooded areas. Throughout the period in question, woods could be cut for timber, coppiced (the rapid turnover of undergrowth harvesting for building materials and use as fuel), or left uncut. They could be used as grazing areas for sheep and cattle, reserved for deer, or left to rabbits and other small mammals. They could be actively replanted, or left to regenerate naturally. With the management methods of woodlands nearly as numerous as the woodlands themselves, their relative density could vary dramatically over time. Where woodland borders remain roughly the same over time, the total tree count could be far lower at the opening of the twentieth century than in the thirteenth century. At the same time, differing management practices and wildlife conditions can have a major impact on the quality of wood grown.[24] While not perhaps affecting tree count, a declining forest quality could complicate the task of finding suitable timber for shipbuilding. In either case, acreage correlations cannot prove woodland stability.

With Rackham's "woodland stability" theory thus in question, the first step to re-envisioning the impact of naval ship building on the landscape is to examine the rate at

[23] Rackham, *Trees and Woodland*, 61. Bonny Wood coverage records for 1639 are absent but estimated at no less than 100 acres.
[24] K. Mellanby, "The Effects of some Birds and Mammals on Regeneration of Oak," *Journal of Applied Ecology* 5 (1968): 364.

which wood could be replaced. Though figures for strictly timber wood are lacking, several scholars have estimated the rate at which wood could be produced with coppice management. Assuming rapid cutting of thin branches and trunks does not greatly impact overall growth rates, these figures can be used to extrapolate a rough rate of timber production. Based on an account book of Beaulieu in Essex, Rackham concludes that woodlands could produce approximately two tons of wood per acre per year, equating to roughly 7.0 cubic meters of solid wood per hectare.[25]

Contemporary estimates tended to be far more conservative. In 1612, Rock Church estimated a growth rate of 3.5 cubic meters per hectare. Over a century later, Houghton estimated production of a maximum of just over 3.0 cubic meters per hectare per year. Both estimates fall within the range of a late seventeenth century survey of the Forest of Dean, which showed 2.6 to 4.0 cubic meters of solid wood growth per hectare. To lend further credence to these early estimates (which could have been just as easily miscalculated as woodland coverage above) the most current research places the high end of growth rates at 3.3 cubic meters per hectare, based on current growth rates of oak standards in Western Europe.[26]

Herein lies a potential fallacy of Rackham's findings. This method of determining growth rate may not be the best suited for the argument of this paper, but Rackham's estimates of 7.0 cubic meters of solid wood growth per hectare nearly double

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[25] Numerous estimates for woodland productivity, including the above estimate by Rackham, have been compiled by Paul Warde, "Wood and Wood Products in the English Economy, c.1550-1750" (personal communication from author and unpublished article manuscript, March 8, 2012): 3. Warde made the praiseworthy gesture of permitting me to use his unpublished research for the purposes of this paper. Though he too discredits the notion that shipbuilding had a notable impact on British oaks, Warde takes issue with Rackham's claims against wood shortages, showing a steady decrease in wooded area in England and Wales due primarily to coppicing of firewood.

[26] Paul Warde, "Wood and Wood Products," 3.

those of any other research.[27] This suggests that his belief that woodlands were capable of regenerating fully from the demand placed on them may be skewed. If woodlands produced only half what Rackham claims, then twice the area must be cleared for each of Rackham's estimates on wood use. The reasons for Rackham's acceptance of such an inflated estimate are unclear. Nonetheless, if more current estimates are to be believed, demands for wood must have been spread over twice the area suggested by Rackham's estimates. With this adjustment effectively doubling the impact envisioned by Rackham, cutting may very well have overtaken the regenerative potential of British woodlands.

Through examining the time-span required for a single tree to reach maturity, another method for estimating timber production can be achieved. By reducing the focus to individual trees rather than area coverage, this method eliminates many potential complications. Coppiced woodlands likely produce a very different overall volume of yield than those designated for timber. If these two management methods indeed promote different overall yields, then the above production estimates would likely prove too general to hold much value for an examination of ship timber. Additionally, many woodlands contained both coppice trees and oak standards. Though this was a common practice, shade from large standards inhibits the growth of coppice, further complicating estimates of growth volume. Furthermore, estimates of total wood production, while likely very useful for studies of fuel wood usage, do little to account for wasted wood volume when correlated with shipbuilding. Eliminating the focus on wood volume in favor of a tree-by-tree examination of cutting and re-growth helps to avoid these difficulties, proving this method to be the superior option for the purposes of this paper.

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[27] Paul Warde, "Wood and Wood Products," 3.

Moreover, various estimates of the time required for an oak to reach a suitable age for shipbuilding agree more than volume estimates. Contemporary observers concerned with the need for replanting realized that the life-span of an oak from seedling to maturity far exceeded the life-span of those who would plant them. Admiral Sir William Monson estimated the time between planting and harvesting at three to four generations.[28] Fortunately, modern researchers have come up with more concise, numerical estimates. In the 1920s, Robert Albion concluded that the minimum profitable age at which to cut an oak for shipbuilding was between 80 and 150 years.[29] Before that age, oaks would not have reached a usable thickness, and trees younger than this age decay at a far more rapid rate, making them unsuited for the rigors of seafaring. Furthermore, many of the timbers used in shipbuilding were required to be at least 20 inches in diameter, a thickness not reached until an age of at least 150 years.[30] Even Rackham places the age of a commercially harvestable oak at up to 150 years.[31]

The impact of this rather lengthy term of maturation can be better put into perspective when compared to the rate of use as ship timber. A great deal of effort went into trying to preserve the wooden hulls of ships. Constant submersion in sea water and exposure to harsh weather hardly provide ideal conditions for wood preservation. Hulls were caulked with pitch and tar as waterproofing, the production of which caused its own impact on woodlands (discussed below), and trees were even harvested during different seasons in hopes that the conditions would provide greater longevity. The *Hawke*, built at Deptford in 1795, was constructed using half winter-felled and half summer-felled oak

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[28] Albion, *Forests and Sea Power*, 95.
[29] Albion, *Forests and Sea Power*, 99.
[30] Albion, *Forests and Sea Power*, 99.
[31] Rackham, *Ancient Woodland*, 301.

as an experiment to test their relative longevity; both halves were badly decayed after only ten years. The *Montegue* and the *Achilles* of 1774 lasted about twice as long, lasting over 20 years.[32] These numbers seem to represent the mid-range of life-spans of wooden ships. Although some reached greater ages of 40 to 50 years, those that did were the outliers and were considered very old ships.[33]

In the fourteenth and fifteenth centuries, many ships seemed to require extensive repairs or retirement after only 5 to 15 years. In the 1580s, a group of 37 docked ships were precisely dated in documents of the High Court of the Admiralty in an effort to assess their longevity. Twelve of these ships were 10 years of age or less. Twenty-two were between 11 and 20 years. Only three were said to be older, with an eldest of 50 years.[34] Such numbers suggest an estimated life expectancy of perhaps fifteen to twenty years would be an acceptable average for wooden ships. However, these figures are not restricted to naval vessels. Although merchant vessels also faced the dangers of piracy, privateers, severe weather, and other seafaring hazards, the intentional engagement in naval battle and training would naturally reduce the life expectancy of a ship. With all such concerns in mind, current research has settled on an average life expectancy of only 12 years for wooden naval vessels.[35]

To further compound the demand for wood needed to build such vessels, many that survived their first decade soon required extensive refitting. The *Mary Rose*, for example, well exceeded the average life-span, sinking in 1545 after nearly 35 years of service. Though the final sinking of the vessel was accidental and likely the result of a

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[32] Albion, *Forests and Sea Power*, 101.
[33] Friel, *The Good Ship*, 188.
[34] Friel, *The Good Ship*, 188.
[35] Warde, “Wood and Wood Products,” 9.

design flaw after a refit, the ship had already been extensively repaired twice in its lifetime. Discovered in 1971 and raised in 1982, dendrochronological analysis of the ship's timbers show that substantial portions of its stern were cut no earlier than the 1520s and at least one main deck beam dated to 1535, supporting contemporary records stating that the ship was refit in 1528 and 1536.[36] As such repairs were common among wooden vessels, estimates on the total number of trees cut for a single ship can be compounded repeatedly as the ship grows in age. Unfortunately, although the timber used for the refitting of a single vessel was recorded at as much as 140 loads,[37] data on wood use for this purpose remains too sparse during much of the period in question to draw strong generalizations.

Into the eighteenth century, however, practices became more controlled and formalized. Naval policy required each ship to make port for inspection at least once every three years in a preemptive effort to avoid major repairs. Small repairs could be made relatively quickly and at minimal cost; but left untreated, a little rot or a few cracks could quickly grow into a major problem, requiring several years and great expense to remedy. Of course, major repairs were still necessary from time to time, and even minor repairs represented a constant drain on wooded resources, making repair one of the major contributors to Albion's argument for the shipyard-driven "timber problem."[38] At the very least, we can assume that the use of wood for repair work offsets the extended life span of outliers like the *Mary Rose*. A very few ships lasted as long as 50 years, thus not needing replacement for four times the average life-span of military vessels. Still, the

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[36] Eugene Samuel, "There's something about Mary," *New Scientist* 167 (2000): 38.
[37] Friel, *The Good Ship*, 188.
[38] Albion, *Forests and Sea Power*, 82-84.

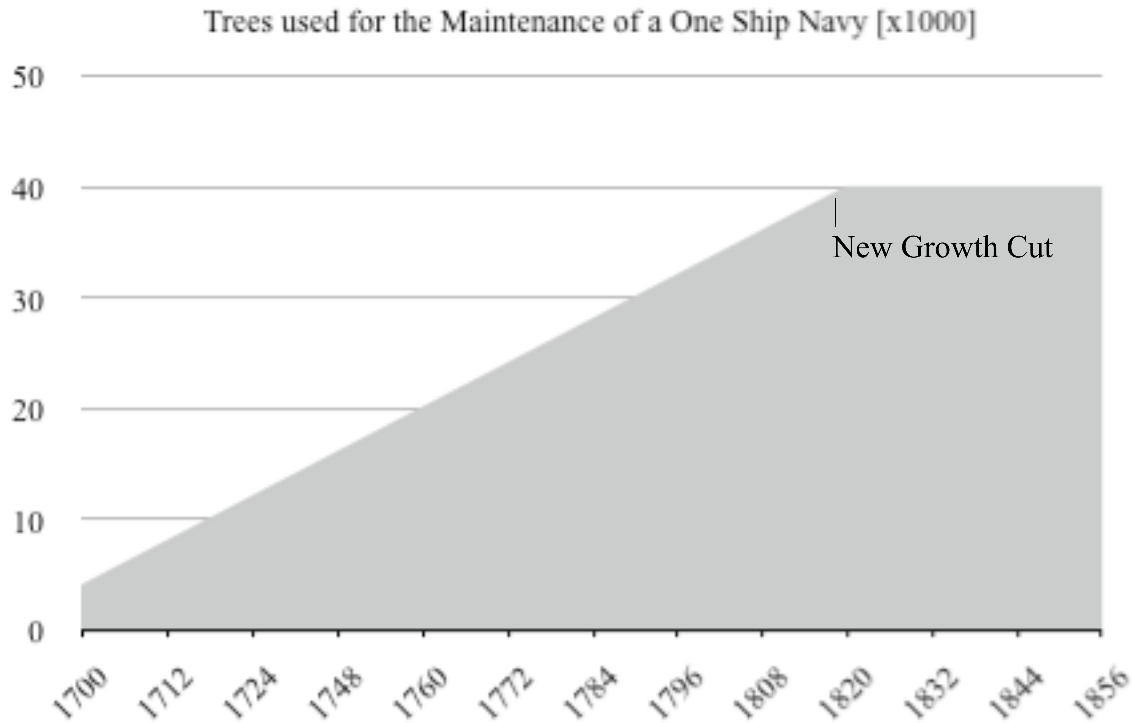

Figure 2: This graph shows the impact of oak procurement for the maintenance of even a single ship fleet over a period of a century and a half. As the average life expectance of a military vessel is only twelve years, the original 4,000 trees is compounded by a factor of ten before the finally being replaced by new growth. Therefore, if only a single ship were maintained for use by the Crown at all times, as many as 40 thousand mature oaks would be missing continually from the landscape. This figure does not account for additional wood used in repair.

constant flow of wood used to maintain these ships and the whole of the fleet likely surpassed the amount of wood saved by not building replacement vessels.

Together, these numbers show a process of substantial decline throughout the production of wooden vessels. Treating the age of maturation as the replacement rate of wood and the average life expectancy of wooden ships as the standard rate of use, the average life span of a ship would have to equal the maturation time of replacement trees in order for woodlands to be able to cope fully with the demand placed on them by shipbuilders. The real situation, of course, did not reflect such a relationship. If we assume a mid-range maturation age of 120 years, there is a ten-fold difference between the replacement rate of trees and the average life expectancy of naval ships, at which point the vessel would have to be replaced (Figure 2). Even if we give the benefit of the doubt to Rackham's replacement theory and place the rate of maturation at the minimum of eighty years and the rate of use at the maximum of fifty years (unreasonable as this may be), there would still be a thirty year lapse between the death of the ship and the replacement of the wood used in its construction. And of course, this ratio would then be further skewed by increased wood consumption due to repair. If even a single ship were continually maintained for service to the Crown, the rate of wood use would outpace that of regeneration, causing a continually escalating drain on wooded resources until new growth began to come of age 120 years later.

The overall effect of this drain is obscured from Rackham's research and that of other opponents to the timber shortage theory due to the highly dispersed manner in which trees were selected for shipbuilding. Even in the thirteenth century, wood for a single ship often came from many locations and rarely from territories adjacent to the shipyards. One explanation for this occurrence was the Crown's unwillingness to pay full value for timber, insuring that quantities sold to the Royal Navy by traders were kept small to preserve profits.[39] A second likely explanation is the required quality of naval timber. Ship hulls required oaks of ample size with a characteristic curved profile (Figure 3), very few of which could be found at any given location.

For the sake of modeling, if we transfer the demand of the Royal Navy onto an imaginary landscape comprised exclusively of mature, suitable oaks, the total level of forest clearing for naval shipbuilding can be better demonstrated. Estimates on the total number of trees that can exist in a given area vary. Albion claims that about 50 large oak

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[39] Friel, *The Good Ship*, 47.

standards could be raised on a single acre.[40] This number well exceeds Rackham's estimation that during the eighteenth century woodlands held an average of 22 timber trees per acre.[41] Nonetheless, the larger figure will be used for the purposes of this imaginary landscape, permitting the greatest production potential.

From the perspective of tree use, this model will likewise err on the side of conservatism. The construction of a single ship-of-the-line could require only a few thousand trees if each was of ample size and quality, but the same ship could demand up to tens of thousands of oaks if quality standards were hard to meet.[42] Nonetheless, this model will utilize William McNeill's estimate of an average use of 4,000 mature oaks for a single ship.[43] In such a case, the construction of a single ship-of-the-line would require the clearing of eighty full acres of this imaginary landscape. In the year 1790, the Royal Navy had about 300 ships in its ranks.[44] To build this navy, at least 1,200,000 good oaks

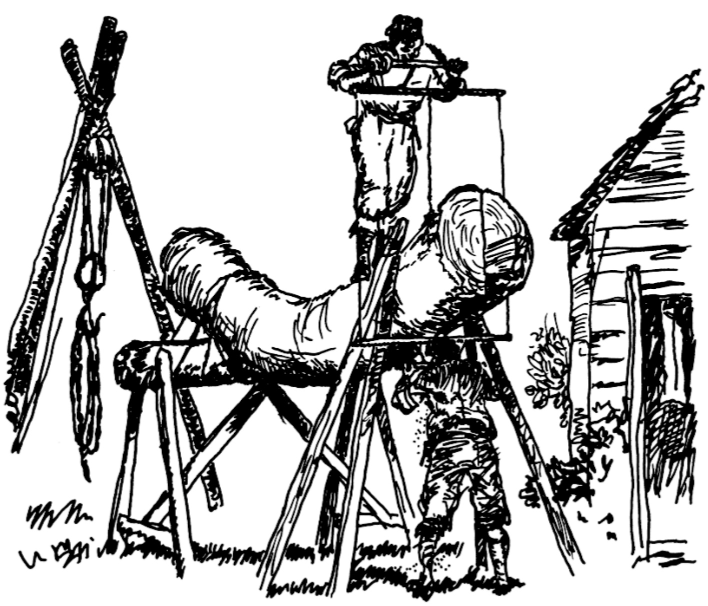

Figure 3: The hull framing of military vessels required precise curvatures. To maintain strength, the necessary curve must have been a natural characteristic of the wood used. If the ribbing of a ship were cut out of otherwise straight wood, the curves would cross the wood's natural grain, weakening the structure greatly. Trees were carefully selected so that their natural grain would follow the curved profile of the ship hulls for which they would be used. Image from Pollitt, "Wooden Walls," 12.

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[40] Albion, *Forests and Sea Power*, 99.
[41] Rackham, *Ancient Woodland*, 148.
[42] Warde, "Wood And Wood Products," 9.
[43] McNeill, "Woods and Warfare," 30.

must have been cut. Assuming that these ships fell into the same average life span determined above, then 24,000 full acres of this imaginary landscape would have been cleared for their twelve years of service. This area is equivalent to 37.5 square miles or 3,750 western U.S. city blocks of optimum density oak forest. To maintain or even increase the count of the naval fleet, as was the case for decades to follow, the number of total trees cut would be compounded again and again as replacement ships were built during the century or more it took to replace the trees used in even the initial 300 ships. If you cut only one tree from 4,000 different acres of woodland to meet the McNeill's demand estimates for a single ship, the overall impact is no less real.[45]

IV. Regeneration

Of course, this necessarily overly simplistic line of argument is not without its problems. Most notably, it relies on an assumed one-to-one ratio of use verses replacement; but who is to say that a single tree can only produce a single offspring? Every acorn has the potential to grow. Any one oak could potentially produce hundreds, even thousands of offspring before it was cut for timber. In such a case, arguments that demand for ship timber caused a gradual decrease in timber trees would be invalidated. If even a quarter of the acorns from each cut tree were allowed to germinate and mature into timber oaks, the woodlands could easily have handled any demand put on them by the Royal Navy. Far from being a simple one-to-one replacement rate, oaks could have the potential for exponential population growth.

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[44] Albion, *Forests and Sea Power*, 115.
[45] This is to say nothing of the non-military and merchant ships also constructed in England, which are placed at a count of roughly 15,000 in 1790. Albion, *Forests and Sea Power*, 115. Though the scope of this paper limits itself to naval wood use, a more comprehensive narrative of the impact of shipbuilding would have to take account of this much larger contribution to demand.

To settle this potential contradiction, we must look at other influences on the landscape which may have restricted regeneration and expansion of woodland. The first of these influences is natural wildlife. Oaks must survive up to ten years through the acorn and seedling stages before becoming durable enough to be likely to survive to adulthood.[46] Early botanical research into the difficulty of oak regeneration in the mid-twentieth century focused attention on the perils of the acorn. Acorn production can vary substantially from year to year, but in a good season, a single tree can produce thousands of acorns. High in nutrition, such acorns are readily consumed by small mammals and birds. However, this relationship is more symbiotic than detrimental to the health of oak woods, for the same animals responsible for the consumption of fallen acorns often carry off and drop the seeds again where they can take root. Acorns transported in this manner have been shown to produce as many as 2,000 seedlings per acre at a random distribution of up to 200 meters from their parent trees.[47]

More harmful to regeneration are the hazards faced at the seedling and sapling age. Most of these 2,000 seedlings do not survive to adulthood. Very early on, they become subject to grazing by rabbits, deer, and other mammals. Small mammals typically only attack very young trees, eating the leaves and buds and nibbling on the stems. However, oaks are hardy plants and most often survive this onslaught, though they may bear injury and deformity into adulthood. Sheep and cattle are far more

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[46] Rackham, *Ancient Woodland*, 1.

[47] Mellanby, "The Effects of some Birds and Mammals on Regeneration of Oak," 365. One further source of acorn destruction that was likely far less of a factor in the twentieth century than in the eighteenth was human beings. Rackham makes reference to a 1792 report pertaining to the difficulty of maintaining oaks in coppice-woods of Whittlewood which alludes to a circumstance in which poor people have been known to gather up acorns to sell. Humans motivated by economic necessity could doubtlessly be more thorough and proficient at removing acorns from the landscape, further hampering regrowth, but lacking more detailed analysis of this practice, human-driven acorn removal will not be treated here. Rackham, *Ancient Woodland*,295.

destructive. Even in the twentieth century, infant oaks and herd animals have been juxtaposed onto the same landscape. These large grazers tend to eat young oaks down to their base, killing many outright and returning to eat the new growth from those that survive. Modern research shows that herd grazing and oak regeneration are more or less incompatible, as a grazed field which was barren of young oaks will often produce seedlings once grazing ceases.[48]

However, the raising of sheep or cattle in woodland was a very common practice between 1200 and 1850, and Rackham has aptly demonstrated that the two were not mutually exclusive. Two types of wood-pasture systems were implemented in British woods. The first Rackham deems *uncompartmented*, in which tree fields were grazed freely by sheep and cattle. In the second, *compartmented*, portions of field were restricted from grazers until new growth was established well enough to survive. In this second system, the complication of domesticated grazers is effectively neutralized, but Rackham argues that even uncompartmented fields were home to oak regeneration. To his credit, this point is indisputable. Though wood and grazing rights for a given piece of land were often not held by the same individual, owners of livestock would be unlikely to find permission to graze their herds on wooded land if the practice eliminated all regeneration. Furthermore, Rackham shows that even select grazed woods can be proven to have supplied a small turnover of timber.[49] The wood-pasture system likely slowed regeneration, but cannot, alone, account for the reduction in the rate of regeneration to even the above one-to-one ratio.

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[48] Mellanby, "The Effects of some Birds and Mammals on Regeneration of Oak," 365.
[49] Rackham, *Ancient Woodland*, 173-187.

Rather, the largest contribution to a reduction in regeneration was made by land use practices. Infinite growth requires infinite space, but even by the mid-1200s much of the British countryside was extensively cultivated. Rackham describes the landscape from the thirteenth century on as an, "essentially modern countryside, with islands of wood surrounded by farmland."[50] At the same time, modern botanical research has demonstrated that agricultural practices inhibit the establishment of new trees.[51] Therefore, woodlands were likely unable to spread into new territories. The logical outcome, then, is that woods regenerated only within their own boundaries. Be that as it may, modern botanical research has also shown that oaks will not regenerate beneath existing canopy.[52] Rackham himself provides a feasible explanation for this situation, arguing that the shade caused by an existing canopy inhibits the recuperative ability of young trees, making them more likely to succumb to damage caused by grazing.[53] Regardless of the cause, a limited ability to regenerate either in new territory or beneath an existing canopy leaves little room for new trees.

Therefore, circumstances required that new trees grow within the spaces left after the cutting of their forbearers. Given that there is a logical limit to woodland density before trees begin to inhibit each others' growth, the general assumption must be then that only a single tree could survive to maturity in the space left by another felled timber tree. This should not be considered a hard and fast rule. Doubtless, a few new trees established themselves on the outskirts of existing woodlands from time to time, and density variations might permit two or even three standards to grow in a space previously

[50] Rackham, *Trees and Woodland*, 61.
[51] Mellanby, "The Effects of some Birds and Mammals on Regeneration of Oak," 365.
[52] Mellanby, "The Effects of some Birds and Mammals on Regeneration of Oak," 365.
[53] Rackham, *Ancient Woodland*, 295.

occupied by only one, but land-use practices could well have restricted regeneration near to the one-to-one ratio mentioned above.

Moreover, the removal of one good timber tree did not always leave an open space for the growth of a replacement. Branches from existing hardwoods can rapidly grow into the void left by a felled tree, squeezing the canopy shut before a replacement tree could grow. Additionally, the site of a felled timber tree might be turned over to coppice management. From the thirteenth century to the nineteenth, the more profitable form of woodland management varied between firewood coppice and timber. Woods were often managed for one or the other, but also existed in unison as coppiced underwood with sparse standards.[54]

At times when coppicing proved more profitable, the stumps of felled timber oaks were often reutilized as the starts of new underwood. In fact, stool growth and other coppice methods were responsible for much of the growth that Rackham's regeneration theory allowed for.[55] While it may be possible for a stool-grown trunk to develop into a new standard suitable for shipbuilding, no coppiced tree could be utilized in this way. If the area of a felled timber tree were then turned over to coppicing, as was frequently the case, then that space was no longer available for production of a replacement timber tree.

With the understanding that trees cut for ship timber might not be replaced at all, their territory being otherwise utilized for coppice management, the potential for a long term trend towards the reduction of suitable timber oaks becomes apparent. Documents expressing concern for a lack of timber for shipbuilding in the sixteenth century and later were not alluding to a broader wood shortage. The royal Navy was concerned with

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[54] Rackham, *Ancient Woodland*, 145.
[55] Rackham, *Ancient Woodland*, 295

timber, not wood production. The documents rather suggest an ever-increasing scarcity of suitable timber trees for the construction and maintenance of the growing Royal Navy. Shipbuilding did not cause uniform deforestation, but the timber shortage was likely very real. With limited and potentially decreasing space available for the growth of timber trees, the presence of suitable ship timber on the landscape likely decreased throughout the period from 1200 to 1850.

V. Secondary Impact

Additionally, although this concept has received only minimal historical attention, Royal shipbuilding also stripped nutrients from woodland soils. This lack of attention likely results from the relatively young age of the field of environmental history.[56] Rackham was actually one of the first to approach this topic from an environmental perspective. Albion and his adherents gave focus to trees in hopes of better understanding the military history of the Empire. Rackham gave focus to woodlands in an effort to provide British trees with their own history. In that light, Rackham spent considerable time discussing the condition of soils beneath English woodlands. Before about 1800, fertilizers were not utilized to replenish or increase the nutrient load of soils. Soils were either fertile or not, and as Rackham discovered, those under British woodlands certainly were not. Rackham notes that produce removal (attributed primarily to underwood coppicing) likely contributed to this uniform infertility, but his treatment of this issue seems to assume that infertile soil was more a favorable habitat characteristic for British hardwoods than a result of human interaction. He suggests that oak and other hardwoods are well suited for extracting what they need from nutrient poor soils. Less

[56] For a detailed discussion of the historiographic setting and origins of environmental history, see J.R. McNeill, "Observations on the Nature and Culture of Environmental History," *History and Theory* 42 (2003): 5-43.

well adapted species having died off in low fertility areas long before, Rackham explains the existence of infertile soil under woodlands as a partially natural condition creating a proclivity towards the growth of hardwoods and the establishment of woodlands.[57]

While this explanation could be partially accurate, Rackham fails to give full weight to the impact of consistent, repetitive nutrient removal from woodlands over the many centuries of human interaction. From the mid sixteenth century to the 1720s, domestic wood use continued on an upward trend, climbing from 5,500,000 to 8,400,000 cubic meters per year. Throughout this period, the largest contribution to this consumption was, of course, firewood, comprising roughly half of each year's domestic wood use, followed by fuel wood for iron production. In fact, shipbuilding represented less than one percent of each year's domestically produced wood.[58] Still, while the cutting of ship timber may have been only a small part of this problem in any given area, every ship constructed represents a tremendous bulk of nutrient-laden wood which would inexorably end up burnt, sunk, or otherwise destroyed, permanently removing those nutrients from the natural systems of biologic recycling in woodlands.

Of course, if Rackham's assertions are to be believed, the consequences of this nutrient stripping would be negligible. If the trees of British woodlands are suited to survive on infertile soil, then any actions resulting in the creation of infertile soil would

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[57] Rackham, *Ancient Woodland*, 37-38.

[58] Warde, "Wood and Wood Products," 13. Perception of this number can be skewed somewhat by the fact that as little as ten and at most fifty percent of each tree felled for ship timber could actually be utilized for that purpose. Warde, "Wood and Wood Products," 9. Once at the shipyards, the wood which could not be used in shipbuilding did not go to waste. Chips, any piece below three feet of length, were considered property of the shipwrights which they used or sold for firewood or even other building purposes. Often it was complained that shipwrights intentionally splintered the planking of ships under repair or sawed up good wood into three foot lengths, abusing this policy. Albion, *Forests and Sea Power*, 87. With as much as ninety percent or more of felled ship timber being used for other purposes, the above figures could greatly underestimate the impact of the shipbuilding if based on total tonnage of constructed ships rather than the amount of wood consumed at the shipyards.

not inhibit their growth. And indeed, the profusion of woodlands still in existence in Britain today would well seem to support such a conclusion.

However, the total impact of nutrient stripping is only recently becoming known. British oak woods have all but ceased regeneration. Since the mid twentieth century, this apparent inability of oaks to regenerate effectively in Britain has been a common topic of botanical research. Oaks were apparently fully capable of regenerating as recently as the nineteenth century, but today, only about twenty percent of oak woods in England contain even a scattering of trees that were established within the last century. Furthermore, only about seven percent of modern English oak woods have maintained enough re-growth to reach replacement levels. Those that have managed to regenerate are mostly concentrated in mid Suffolk, such as Ken, Thundersley West, and Bradfield Woods.[59]

Rackham himself offers a rather convincing explanation for such a sudden drop in regeneration. In search of changes that occurred in the nineteenth century and which might have inhibited the establishment of new trees, he settled on an end to the wide spread practice of coppicing. The clearing of underwood for fuel and other purposes perpetuated a circumstance in which large, canopy forming trees were in the minority in most areas. As stated above, for the last half a century it has been understood that seedlings will not survive under the branches of adult trees,[60] and Rackham proposes that the restricted sunlight through a continuous canopy inhibits the ability of seedlings to survive injury, making them more likely to die due to the grazing of rabbits, sheep, and other mammals. When coppicing was common, the canopy was broken, allowing greater

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[59] Rackham, *Ancient Woodland*, 296.
[60] Mellanby, “The Effects of some Birds and Mammals on Regeneration of Oak,” 365.

sunlight to reach young oaks and enabling them to better survive damage until they grew large enough to survive to adulthood. In support of this conclusion, Rackham notes that in most woodlands which continue to regenerate, coppicing has continued to some degree past the nineteenth century.[61]

But here too, Rackham obscures the full picture. One of the very studies which Rackham cites found that no new oaks were present in a maple coppice and oak standard forest which had been coppiced only thirteen years earlier.[62] Although Rackham's arguments are convincing, this absence of saplings, even with ample time since underwood cutting to permit their establishment, suggests that coppicing was not the sole factor enabling wide regeneration of oak woods.

A comparable landscape across the Atlantic helps to identify a reduction in soil fertility as another possible contributor to this lack of regeneration. California's once abundant oak woods are in much the same condition today as those in Britain. Oaks in California have long been subject to grazing, human acorn removal, cutting for firewood and timber, and even burning to clear land. The one major difference in the condition of Californian and British oaks is that Californian woodlands are often far less dense. Many do not form the cohesive canopy which would choke off young trees from sunlight, but oak woods in California also have not regenerated its since approximately the same time as those in Britain. As coppicing was not a major factor in California's history, research into why regeneration has ceased has departed from the British model. Instead, research in California has shown that removal of oaks from the landscape does indeed remove soil nutrients, and that repetitive removal causes a steady climb in infertility. Moreover,

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[61] Rackham, *Ancient Woodland*, 297.
[62] Mellanby, "The Effects of some Birds and Mammals on Regeneration of Oak," 365.

studies in California have shown that reduced soil fertility may indeed inhibit regeneration.[63]

For the most part, is seems that this connection has been ignored in Britain. D.T. Streeter has pointed out that natural deaths have not been a part of British woodland history for a long time and that natural oak deaths might be necessary for woodland regeneration, but his reasoning follows the argument for shade relief. He claims that natural deaths are necessary to provide pockets of sunlight in which replacement trees can grow,[64] but the lack of natural deaths also prohibited the decomposition of fallen trees which would reintroduce their nutrients into the soil for future generations. Rather than settling blame on some new management change in the mid nineteenth century, such as the end of coppicing, the current state of non-regeneration may have been created as the long tradition of nutrient stripping crossed a threshold at which new trees could no longer find enough nutrients to survive to adulthood. Shipbuilding was only a small contributor to nutrient stripping, but a contributor nonetheless. By robbing woodland soils of nutrients necessary for the survival of new oaks, shipbuilding may have aided in a potentially sharp decline in forest coverage which could come as current mature trees begin to naturally die off.

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[63] Randy A. Dahlgren, et al., "Blue Oaks Enhance Soil Quality in California Oaklands," *California Agriculture* 57 (2003), 42. and M. Barbour, et al. *California's Changing Landscapes - Diversity and Conservation of California Vegetation* (Sacramento: California Native Plant Society, 1993), 87-89. So great is the potential nutrient loss due to tree removal that, despite rampant soil infertility, California Blue Oaks have actually been proven to increase soil fertility when allowed to live. If this attribute is common among British oak species as well (keeping in mind that I know of no research which would claim that it is) then Rackham's assertions about a natural infertility to woodland soils could be entirely backward.

[64] Rackham, *Ancient Woodland*, 295. Rackham uses Streerer's research to support his assertion that cessation of coppicing inhibited regrowth, but dismisses his arguments on the grounds that natural deaths have not been a part of the historical past of British woodlands. It should also be pointed out that timber harvesting would leave the same openings as natural deaths. Though many of the same trees which were present when regeneration slowed still live, timber harvesting actually increased into the twentieth century. This evidence would suggest that other influences are also contributing to the prevention of regeneration. Loss of soil fertility may be and likely is one of those influences.

VI. The Big Picture

Of course, much of the Royal Navy's woodland impact was not domestic at all. Oak, cloth, and iron were the only shipbuilding resources that the British Isles held in abundance; nearly all others needed to be imported. Naturally, historians do not deny England's reliance on imports to keep her shipyards stocked, and great quantities of scholarship exist that examine imports and import practices in detail. However, most fail to include that usage when envisioning the environmental impact of the Royal Navy, limiting their focus of forest degradation to the British Isles. Again, this failing likely stems from the young age of environmental history. Research connecting the building of the Royal Navy to its ecological impact on foreign landscapes simply has not yet been conducted. Still, in order to fully grasp the impact of the pre-industrial Royal Navy, its effects on forests beyond Britain's own borders must be taken into account.

Limited English trade of timber in the Baltic region has been recorded as early as the thirteenth century.[65] Later, new technologies adopted under Henry VII demanded larger masts than could be produced domestically, requiring an increase in Baltic timber trade which continued to grow until the nineteenth century.[66] Soon, Baltic timber was just one among many examples of trade in naval stores. By 1750, English ports annually accepted from Norway several thousands masts of varying sizes and from 1,900,000 to 2,700,000 deals (sawn boards of up to three and a quarter inches thick, seven to eleven inches wide, and eight to twenty feet in length) used in part for deck planking. Similar products also found their way into the British Isles from other northern countries like

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[65] Rackham, *Ancient Woodland*, 151.
[66] Ronald L. Pollitt, "Wooden Walls, English Sea Power and the World's Forests," *Forest History* 15 (1971): 7-9.

Sweden and Russia.[67] Towards the other side of the globe, the British colonies in America also grew to be important sources of timber imports.

Even after trade with the Baltic region and Norway started bringing in larger masts than could be found domestically, many were still insufficiently sized to carry the very large sails of naval vessels, and the difficulty of procuring such great masts only increased over time. For that reason, English shipwrights more frequently were forced to settle for the use of made masts (masts built by binding smaller pieces of wood together with iron bands) until the massive timbers from New England and Canada became available in the early seventeenth century.[68] Access to American white pine breathed new life into the shipbuilding industry. The size, quality, and abundance of masts to come out of New England and Canada surpassed that found anywhere else, and they were added to domestic oak hulls, and topmasts and planking from the Ukraine, Poland, Norway, and elsewhere to carry the Royal wooden fleet to its peak.[69]

Furthermore, imported naval stores by no means stopped at timber. Pitch and tar were used for caulking and waterproofing of ships. Such products are derived from the refining of softwoods and can cause a great deal of wood consumption for a relatively meager volume of production. Britain, however, lacked sufficient softwood resources for this purpose, so neither pitch nor tar could be produced domestically to any degree. By the opening of the seventeenth century, Sweden was the source of choice for suitable softwoods, and hundreds of thousands of cubic meters worth of wood were cut and

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[67] Kent, "The Anglo-Norwegian Timber Trade," 63-64. Masts were categorized as small, middle or great masts, great masts being the most sought for large sailing vessels. The above figures relate to the total number imported, not specifically to amounts used for ship construction.

[68] William R. Carlton, "New England Masts and the King's Navy," *The New England Quarterly* 12 (1939): 4. Made masts were composite masts fitted together from smaller pieces of wood and bound with iron. They could be used as a makeshift repair or when no suitable sticks of ample size were available when needed, but made masts were intrinsically weak and far less desirable.

[69] Pollitt, "Wooden Walls," 15.

refined for export to England. Little more than a decade later, Russian and North American imports surpassed those from Sweden, totaling approximately 1,500,000 cubic meters of softwood harvested each year. In total, the biggest volume of wood demand for shipbuilding each year was for tar and pitch, dwarfing that of oak or any other solid wood.[70] The sheer volume of softwoods consumed for refined ship stores represents an extensive impact on wooded landscapes, though it was felt solely outside of the British Isles.

Research into the English trade in naval stores has been studied extensively from economic, political, and foreign policy perspectives, but an environmental focus is far more rare. Those that do exist barely scratch the surface, supplying volume estimates like those above, but doing far less to trace the impact of that demand back to the landscapes from which the Royal Navy sapped its resources. The domestic environmental implications of England's wooden fleet cannot be examined in isolation. The reach of the dockyards spread much further than the nation's coasts. To fully understand the broader implications of the building and maintaining of England's wooden navy, a great deal more research must be done, and it is in this direction that the question should be taken. As best put by Ronald L. Pollitt, "the average ship-of-the-line in [the] period of England's greatest naval supremacy literally was a product of the world's forests."[71]

VII. Conclusion

The concept of the "timber problem" is far more complicated than Albion originally imagined, but it cannot be entirely dismissed. Domestically, approaching the question of a timber shortage from a tree-by-tree perspective reveals that demand

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[70] Warde, "Wood and Wood Products," 11-12.
[71] Pollitt, "Securing the Sinews," 15.

outpaced regeneration throughout this time period. The rapidity with which new ships were constructed and decayed or were destroyed consumed domestic oaks far more quickly than they could be replaced, stripping them from the landscape. As shipbuilding intensified, the resulting inaccessibility of timber would have grown more acute, likely impacting the Royal Navy's ability to function. Outright denial of the "timber problem" obscures this inhibiting influence upon naval operation from historical review.

Additionally, the simple assertion that oak regeneration allowed woodlands to fully cope with all demands placed upon them conceals the ecological repercussions of naval buildup. Today, the apparent inability for oaks to regenerate may, in part, be the result of nutrient stripping due to woodland harvesting, showing that over a century and a half later, the ecosystems of British woodlands have yet to recover from the impacts of sustained harvesting. Beyond Britain's borders, trade in masts, planking, oak, pitch, and tar demanded far more from woodland sources than were ever felt at home, and stretched the Royal Navy's reach to diverse ecosystems around the world. As research continues, the full extent to which the construction of the wooden Royal Navy consumed both domestic and foreign woodlands must be recognized. Shipbuilding has comprised only a small fraction of the total environmental impact generated by England from 1200 to 1850, but even that fraction represents a tremendous influence on the world's forests.

Rackham's arguments against the possibility of shipyard-driven wood shortages have been taken too far. General wood shortages never resulted due solely to shipbuilding, but escalating scarcity of ship timber was both possible and the likely outcome of pre-industrial naval buildup. Shipyard consumption outpaced the productive abilities of woodlands, contributing to a constant drain on natural systems already taxed by fuel wood production and other industries. Without understanding of the ecological implications of sustained naval buildup including the consistent stripping of mature oaks from the landscape, as well as the resulting operating difficulties faced by the Royal Navy, no study of this topic can be considered complete.

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