HISTORY HAS OFTEN NOTED THE IMPORTANCE OF NAVAL TIMBER
to empire building, especially to the growing rivalries of the early modern
period. Starting around 1500, gunpowder weapons, new shipbuilding tech-
niques, and overseas colonization fed a naval race among the Mediterra-
nean and Atlantic powers. Within the next two centuries, navies transformed
from glorified troop transports into specialized forces for fighting at sea. As
Robert Greenhalgh Albion shows in his classic study of the British navy,
timber became a key constraint in the construction of a specialized fleet. It
should be no surprise that the supply of naval timber was a constant focus of
early modern European statecraft. While the literature on Asia is in a more nascent stage, it is clear that similar considerations affected empires from
the Red Sea to the Yellow. Shipbuilding timber was a baseline cost of
empire, but it was also a strategic good, key to both the circulation of neces-
sities and the projection of power.

In some ways, naval developments in China between about 1100 and
1430 are a striking preview of the European fleet races of later centuries. In
the 1100s and 1200s, intense warfare between the Song, Jurchen Jin, and
Mongol Yuan states spurred rapid innovation, including the use of gun-
powder weapons, large-scale construction of specialized warships, and the
development of an independent naval administration. Following the Yuan unification of China, Mongol fleets looked further abroad to take territory, secure loyalty, and monopolize trade from Japan to Java. The breakup of the Yuan empire in the 1350s and 1360s brought another wave of naval competition, including the battle of Poyang Lake, one of the largest inland naval conflicts in history. After the Ming dynasty reunified China, it, too, launched fleets abroad. Between 1405 and 1433, the famous Ming armadas under Zheng He sailed as far as India and East Africa. Technologies like the mariner’s compass and gunpowder weapons developed during the Song maritime expansion and spread to Europe, influencing the naval race on the Atlantic. When Europeans challenged China for maritime dominance in the nineteenth century, they used cannons and navigational tools that ultimately derived from Chinese inventions.\(^4\) Yet in other ways, the European and Chinese experiences are not comparable, as the Chinese faced very different resource geographies, strategic considerations, and political constraints than their European contemporaries. For example, it is positively misleading to compare the Zheng He expeditions—often the only mention of Ming China in world history textbooks—to the European “age of discovery.”

Instead of abstract comparison, this chapter seeks to build a more grounded understanding of Chinese maritime exploits by embedding them in their material and institutional constraints. While ships could be abstracted as pawns in a grand strategy or lines on a bureaucrat’s ledger, they ultimately began their life as timber. The structural characteristics of woody plants indelibly shaped the ships built from their materials. Shipwrights selected different types of lumber for underwater hulls than for masts or deck planks, and Yangzi fir performed differently than Korean pine or Fujianese camphor, let alone European oak. Ships were also built to serve different ends on different waters. Purpose-built “sea hawks” handled very differently than grain barges or fishing sampans. Finally, ship construction depended on the large-scale dynamics of the timber supply. Emperors could issue orders for as many ships as they wanted, but shipyards could only fulfill them if they had enough supplies. In China, these three constraints—on wood, water, and institutions—largely overlapped, reinforcing a division of the maritime realm into three main regions.

Of China’s three naval fronts, the Yangzi River was by far the most important. Without command of the great river, a southern state could not secure itself from attack, and a northern state could not hope to dominate the south.\(^5\) For centuries, the Yangzi was the site of major naval battles and
developed a distinct military culture around fast, oared warships, a tradition that continues to the present as the Dragon Boat Festival (Duanwu Jie). Yangzi River fleets also employed paddle ships (*chechuan*) to sail against the current and tower ships (*louchuan*) to lay siege to riverside fortresses. Working in the fir heartland, Yangzi River shipwrights used this single, fast-growing, durable, and straight timber for almost every component, from masts to planking. The Yangzi was also the epicenter of the timber trade, boasting substantial revenues from the timber tariff and thousands of log rafts for purchase. This made it an ideal place to build ships for comparatively little expense. It was on the Yangzi that the Song built East Asia’s first substantial navy, the Mongols built much of the fleet for the invasion of Japan, and the Ming built the treasure ships that sailed to the Indian Ocean.

The second major area of fleet operations was the South China Sea, which, while less strategically important than the Yangzi, was at least as significant commercially. The South China Sea linked China into the great monsoon trading networks extending as far west as Arabia and East Africa. Until the eleventh century, these long-distance routes were dominated by sojourning Arabs, Persians, and Indians. But following a major liberalization of trading restrictions in 1070, merchants from Fujian and Guangdong began to supersede foreigners in the South Seas trade. For the next several centuries, Chinese states worked to dominate the South China Sea to control this trade. South Sea ships were built for different purposes than Yangzi River ships, generally with V-shaped hulls for blue-ocean stability rather than the U-shaped hulls needed to traverse sandy shoals. Due to the distinct environmental endowments of the southeast coast and its connections to Southeast Asia, Fujianese shipwrights built with camphor and teak as well as fir, incorporating techniques from the Indian Ocean and the Malay world. The relationship between shipyards and the state was also quite different on the southeast coast, where officials were as apt to press merchant ships into service as they were to build their own.

The third distinct naval region was the Yellow Sea, between Korea and North China. Maritime routes from the Yangzi River to Beijing and Liaodong ran through the Yellow Sea, as did the sea routes to Korea. This was frequently a zone of naval conflict during periods when the north and south were controlled by different states and a key transport route when the Grand Canal was inoperable. Compared to the South China Sea, tides and winds in the Yellow Sea were very unpredictable. To staff their Yellow Sea navies, both China and Korea recruited “pirate” navies from the fishing and
smuggling communities of the islands and peninsulas. Yellow Sea ships were also of different design than either the Yangzi River ships or the great trading junks of the South Seas. In Korea and Liaodong, they were built principally of pine. Unlike in South China, Yellow Sea shipyards in both China and Korea tended to draft corvée loggers to supply their timber rather than taxing it from merchants.

To unify China, an aspiring empire had to unify these three maritime realms and dominate the zone where they overlapped in the East China Sea. This entailed strategic mastery of distinct patterns of wind and tide; it also required domination of the multiple forest ecologies and institutions that brought wood to the water. In the early stages of empire building, the Song, Jin, Yuan, and Ming dynasties each assembled irregular flotillas of fishing boats, merchant vessels, and hastily built craft of questionable seaworthiness; when possible, they also seized warships from their predecessors and rivals. This smash-and-grab approach to naval construction sometimes worked in the short run, but it was not the basis for long-term maritime power. More mature empires faced a very different challenge: how to make their navies sustainable. The forests of the southern interior were already afloat. In theory, naval officials merely had to transform flotillas of fir logs into fleets of fir-beamed warships. Yet in practice, the material and institutional transformation of trees into timber into ships was anything but straightforward.

THE JIN WARS AND THE TRANSFORMATION OF THE SONG NAVY

In its founding decades, the Song developed a powerful fleet during its wars to conquer the south from 960 to 979. In doing so, it built on a wave of developments in shipbuilding, harbor construction, and canal dredging over the previous two centuries. But once the conquest was complete, the Song greatly reduced the fleet. For the most part, naval units were little more than small detachments attached to provincial garrisons. These small fleets served important purposes in patrol, bandit suppression, and naval training. Nonetheless, the Song navy lost much of its importance after the conquest of the south. Through much of the eleventh century, the only specialized military fleets were the elite “tiger wings” (huyi) of the imperial guard and the southeast sea patrol fleet in Guangdong. While each of these was responsible for early innovations, including the development of rockets,
bombs, and new types of seagoing warships, naval development was not a Northern Song priority.14

For the next century and more, the Song built ships in places where it could command labor or where there were extensive woodlands, or ideally both. Yangzi River garrisons built warships for the rivers, while seagoing ships were built at Guangzhou.15 Military units in heavily wooded Zhejiang logged (caikan) and operated lumberyards (shanchang) to supply the shipyards.16 Circuit-level transport bureaus built their own barges to transport the grain tax.17 Their shipyards were concentrated along the Yangzi River and the Grand Canal, especially in tree-rich Jiangxi and Hunan.18 For the first century of the Northern Song, shipbuilding was largely treated as a corollary to the command of any large pool of labor.19

Starting in the early twelfth century, policies began to shift toward more judicious use of timber. In 1114, the state ordered the Ningbo shipyards to stop cutting living timber unless they received specific written permission and to use tariff materials instead.20 New deadlines and budgetary limits were also imposed on the shipyards.21 To save on materials, the court even ordered reductions in the size of transport ships, from 300 to 250 units of grain.22 With growing fleets, and perhaps growing pressures on the forest resources, we see the first attempts to economize.

This all changed in 1127, when Jurchen armies invaded North China and the Song court fled southward across the Yangzi River. After a short-lived attempt to regroup in the north, the court settled in Hangzhou, finding itself defending a northern frontier largely defined by the Huai and Yangzi Rivers.23 Almost immediately, the Song officiate began an unprecedented naval buildup to defend this great moat. During the retreat, Li Gang, a vice president in the Department of State Affairs, reactivated all naval units and reorganized them into two main navies, one for the Yangzi River and one for the seacoast.24 These nascent fleets included a confusing array of ships assembled from dozens of different garrisons, including paddle wheelers, galleys, scout ships, and flat-bottomed “sand ships” (shachuan).25 To create a more unified fleet, Li Gang ordered shipyards to focus on building a single style of ship, the high-capacity, low-cost “mullet ships” (daoyu chuan) used by Jiangnan merchants.26 The court also ordered the Suzhou (Pingjiang) shipyards to construct two additional types of ships: eight-oared galleys and smaller four-oared “sea hawks” (haigu chuan).27 To cover this substantial expense, the state levied a tax on all seagoing vessels (haichuan shui) to use for military finance. Between central and local officials and transport costs,
this tariff drew off seven parts in fifteen (46.67 percent) of merchants’ trade goods, an astoundingly high rate that led to a correspondingly high rate of tax evasion.28

In late 1129 and early 1130, Jin armies gave the Song fleets their first real test, crossing the Yangzi, capturing Nanjing (Jiankang) and Hangzhou (Lin’an), and pursuing the Song emperor to sea. A much larger Song navy soon arrived to defeat the Jin fleet, forcing the Jin army to retreat across the Yangzi.29 Nonetheless, the danger of a second Jin invasion led the Song to a second wave of naval buildup. In 1131, Zhejiang shipyards disassembled ferries to repurpose as large warships.30 In 1132, the court ordered another 980 warships built across five circuits.31 The fleet buildup culminated in the 1132 establishment of the Office of Coastal Control (Yanhai Zhizhi Shisi), which brought the coastal defense fleet under the imperial guard. Specialized naval officials were now given ranks equivalent to their counterparts in the Fiscal Commission.32 While the Song-Jin war continued for another decade, this powerful Song navy prevented any further invasions across the Yangzi.33

Following its retreat, the Song court also faced banditry throughout much of the south.34 In 1130, a local sectarian leader on Dongting Lake established the breakaway kingdom of Chu. While the leader was soon captured and executed, his lieutenant Yang Yao continued the resistance on Dongting, the large lake that feeds into the Yangzi in Hunan. Leading perhaps four hundred thousand rebels, Yang seized warships from the Song fleet and logged the region to build their own paddle-wheeled tower ships (che lou dachuan).35 To counter the Chu threat, the Song built hundreds of its own river warships. In 1133, the four river circuits constructed a total of 480 warships, most of which were probably small sampans.36 Between 1132 and 1135, when Yang was finally defeated, officials submitted multiple paddle-wheel designs to the court, including small four-wheeled interceptors and ships with five, nine, and even thirteen wheels.37 The emperor ordered shipyards in the region to build a total of fifty-six paddle wheelers.38 Much of the expense of shipbuilding was underwritten by the timber tariff.39 Just as the Jin invasion led to the buildup of the coastal fleet, the Chu rebellion forced the Song to expand its presence on the middle Yangzi.

After two decades of relative peace, warfare returned to the Song in the late 1150s with the rise of the Jin Prince of Hailing. In 1150, conspirators assassinated the Jin emperor and placed Hailing on the throne. He soon raised taxes and labor service to extreme levels to fund his imperial
ambitions, including a greatly expanded fleet. In 1159, Hailing recruited shipwrights from South China, set up shipyards in Tongzhou, and impressed thirty thousand sailors. The Tongzhou shipyards relied heavily on corvée labor, sending four hundred thousand conscripts to log nearby and thousands more to dredge a canal to float warships to the sea. With word of the invasion plans, the Song’s long-dormant shipbuilding program also returned in force. The Song court ordered Fujian to build ten mullet ships and six larger oceangoing vessels and Jiangnan shipyards to build two hundred warships and one hundred transports. As Li Gang had done in 1127, officials sought to establish a uniform standard for their warships to ensure that fleets could sail together as units.

If the Song navy played a key role in defending the Yangzi in 1131, it was even more critical during the Song-Jin war of 1161. In November, a Song fleet defeated the main Jin force of six hundred ships off the coast of Shandong. In addition to a better-constructed and better-sailed fleet, the Song ships also used new military technologies, including catapult-hurled gunpowder bombs and incendiaries. While the Jin army was able to seize Hezhou, on the Yangzi’s north bank the defeat of the main Jin navy left it using grain barges as troop transports and building ships with timbers torn from houses. Outnumbered Song defenders held off the invasion long enough for a large fleet of paddle wheelers and seagoing “whales” (haiyu) to arrive, defeating repeated Jin attempts to cross the river. Ultimately, the second Song-Jin war was not decided on the battlefield. In 1161, the Prince of Hailing was murdered in his tent by members of his own entourage. Nonetheless, the Song victories off Shandong and on the Yangzi demonstrated clear naval superiority based on a larger, better-built, and better-sailed fleet of specialized warships.

While the Song court briefly canceled ship construction in 1164, fleet construction soon resumed and reached new levels. Between 1165 and 1189, the Song expanded its five existing naval squadrons and established ten new ones. Figures are incomplete, but by conservative estimate the Song navy in 1190 was three to five times larger than it had been in 1160. It continued to expand in the early 1200s, establishing another five squadrons and further expanding existing ones. The largest squadron guarding the mouth of the Yangzi reached 11,500 men. Estimating from troop sizes, it probably maintained at least fifty large warships and hundreds of smaller craft. Most other squadrons were about one-third to one-half this size. Meanwhile, innovations continued, with warships growing ever larger, including galleys
with forty-two oars and “sea hawks” (haigu) up to four times the size of earlier vessels.\textsuperscript{51} 

In addition to the ships built at naval shipyards, the Southern Song relied on merchant vessels bought, borrowed, or commissioned for government use. Immediately following the southward retreat of the Song court in 1127, it commandeered more than six hundred ships from merchants in Fujian and Guangdong and divided them into three six-month terms of service.\textsuperscript{52} In 1132, all ships over 1.2 \textit{zhang} in the beam (approximately 4 meters wide) were registered for patrol duty.\textsuperscript{53} In the lead-up to the war of 1161, overseas merchants contributed a total of 436 vessels to the Song navy.\textsuperscript{54} Both merchant patrols and contributions to the navy continued through the end of the Song.\textsuperscript{55} Given the extent of private trade, this was an efficient way to staff the navy. By 1259, nearly 4,000 ships larger than 1 \textit{zhang} (3 meters) in the beam were registered in the three ports of Ningbo, Wenzhou, and Taizhou alone.\textsuperscript{56} The Song also relied on private shipyards to construct official naval vessels. Quanzhou, which lacked an official shipyard, received commissions to construct naval vessels throughout the twelfth century.\textsuperscript{57} State commissions probably also went to both state and private shipyards in Ningbo, another shipbuilding hub.\textsuperscript{58} Taking advantage of the flourishing trade from Ningbo to Guangzhou, the Song outsourced much of its coastal defense to private merchants and contracted much of its shipbuilding to private shipyards.

Throughout the buildup of the Southern Song navy from 1127 through the end of the twelfth century, its superiority rested on the strength of trade. In contrast to Northern Song shipyards, which relied on military loggers to supply lumber, the Southern Song made almost no use of forced labor. In official sources, there is only one clear mention of corvée, an edict from 1164 when the Song court specifically canceled an emergency measure from the war of 1161.\textsuperscript{59} Prior to the 1160s, the court simply disbursed money to buy timber, assuming it was available on local markets. After 1161, as naval bases were built in strategic locations that lacked timber, the court sent officials with specific instructions on where and how to buy supplies.\textsuperscript{60} Along the Yangzi, shipbuilding was largely financed and supplied through timber tariffs. Along the seacoast, fleets were a mixture of merchant ships pressed into service and warships financed by tariffs on overseas trade. But throughout the Southern Song, the power of the navy was an extension of commercial wealth, and of timber markets in particular.
The Mongol empire is generally thought of as a land empire, deriving its military superiority from its highly mobile cavalry and effective use of siege weapons. Yet at its peak in the mid-1280s, the Mongol-ruled Yuan dynasty also boasted the largest navy East Asia had seen to that point in its history. Like most of the empire, the Yuan navy was built by grafting its conquests—the Jin, Koryŏ, and Song fleets—onto the trunk of the Mongol imperial project. The thirty-year peak of naval expansion under Kublai Khan (r. 1260–94) revealed the capacities of a large and diverse empire to deploy multiple labor forces and draw on a continent’s worth of forests to build a large fleet quickly, but it also showed the limitations of a roughly grafted assemblage of regional timber economies without a coherent or sustainable system to integrate them.

During the Mongols’ initial conquests, they had little need for a navy. They only began to build significant waterborne forces in 1259, following an unsuccessful attack on the Song dynasty’s Yangzi River fortress city of Xiangyang. Realizing he would need a navy to cross the Yangzi and defeat the Song, Kublai Khan began extensive preparations for an amphibious assault. In 1265, he ordered ships built at the Mongol capital of Dadu (Beijing), at Kaifeng, at Dengzhou on the Shandong Peninsula, and at Guanghua just upriver of Xiangyang. He appointed Zhang Xi, a longtime naval officer from coastal Shandong, as director of the navy (shuijun zongguan). While it failed in its initial assault on Xiangyang, this small Mongol fleet repulsed two attempts by the Song navy to break the siege in 1269 and 1270. This was enough to convince the khan of its importance, and he gave orders to expand the fleet by an astounding five thousand warships and seventy thousand men. Xiangyang held out for another three years, until March 1273, before finally falling to Yuan forces. In the meantime, the Yuan navy had grown to nearly four times its previous size.61

After capturing Xiangyang, the Yuan continued to build up their navy to further press its advantage. In 1273, they built another two thousand warships, half at newly captured Xiangyang and half at Kaifeng. The following year, Kaifeng built another eight hundred ships, probably bringing the fleet to around six thousand craft.62 Over the winter of 1274–75, the expanded Yuan navy proceeded down the Han River, twice outflanking Song fleets, burning more than three thousand ships, and gaining the south bank of the
Yangzi near Wuhan. In March 1275, they defeated another force of five thousand vessels near the point where the Grand Canal crosses the Yangzi, capturing two thousand Song ships and rendezvousing with the Kaifeng-built wings of the fleet. In July, the combined Yuan navy faced the Song’s coastal defense fleet, defeating several larger warships of the “yellow goose” (huanggu) and “white falcon” (baiyao) classes. These engagements broke the back of the Song’s river defense fleets. By the end of the summer, the Yuan fleet advanced to the delta and was in full command of the Yangzi.

Having defeated the Song’s riverine navy by copying its ship designs, the Yuan proceeded to build a blue-ocean navy using the same model. They took control of nearly eight hundred sea ships from the Song coastal defense fleet and used an undamaged white falcon-class warship as a model for building a hundred more, staffed with a combination of North Chinese and former Song sailors. Yuan envoys also recruited the pirate chiefs Zhu Qing and Zhang Xuan, who brought five hundred large ships and thousands of experienced sailors. When the fleet set sail at the end of 1275, it boasted forty-one wings, perhaps ten times the size of the Mongol navy in 1268. The Song officially capitulated in 1276, while the Yuan fleet continued to pursue the rump of the court down the southeast coast, finally defeating it in Guangdong in 1279.

Even as Kublai’s first fleet was fighting on the Yangzi, he forced the king of Koryŏ to build him a second fleet in Korea. In 1258, Kublai’s brother Möngke had subdued Korea, taking members of the ruling family hostage to ensure their loyalty. Following the deaths of both Möngke and the Koryŏ king in 1259, Kublai sent one of these former hostages to rule Korea as King Wŏnjong. Almost immediately upon assuming the throne, Wŏnjong began building ships to support the invasion of the Southern Song. While these efforts were initially delayed by an attempted coup, shipbuilding eventually continued. In 1266, the khan instructed the king to build one thousand ships for the invasions of the Song and Japan. Once again, Korean compliance was delayed by anti-Mongol resistance, this time by holdouts on Cheju Island, off the southwest coast of the peninsula. Yet preparations for the invasion of Japan commenced elsewhere in Korea. In the winter of 1273–74, loggers cleared the hills in the southwestern province of Chŏlla, supplying timber to a force of more than thirty thousand shipwrights commanded by the Korean general Kim Panggyong. The khan’s leading shipwright, Ji Gongzhi, traveled between Shandong, Chŏlla, and Xiangyang to oversee the construction of multiple fleets. After a delay caused by the death of King
Wŏnjong, the invasion of Japan launched in November 1274 with twenty thousand to thirty thousand Mongol, North Chinese, and Korean soldiers; seven thousand Korean sailors; and seven hundred to nine hundred ships. After successful forays onto the islands of Tsushima and southwestern Kyushu, the invasion fleet was forced back to sea by inclement weather in late November.

Despite the limited success of the first invasion, Kublai Khan was enthusiastic about a second foray into Japan. He granted a temporary respite from shipbuilding while completing the conquests of South China and Cheju Island. But as soon as the final Song holdouts were defeated in 1279, Kublai ordered the shipyards to resume preparation. He ordered six hundred ships built in the former Song prefectures of Yangzhou, Changsha, and Quanzhou; transferred riverine units to the coast to allow coastal detachments to deploy to Japan; assigned the last Song holdouts to oversee coastal shipbuilding; and transferred the remnants of the Song fleet for repair and redeployment. Kublai also sent a Mongol officer to the Korean court to oversee the construction of nine hundred ships, plus another three thousand built in Koryŏ shipyards with timber from recently subdued Cheju Island. Logging was probably overseen by the region's newly established myriarchies (Mongolian: *tumen*, Korean: *manhobu*, Chinese: *wanhufu*).

By the end of the year, the southern fleet had one hundred thousand soldiers ready for invasion—largely former Song subjects, deserters, and pirates. The Koryŏ king personally led the eastern fleet. The two fleets combined to number around four thousand ships.

The eastern fleet departed for Japan in May 1281, engaging Japanese forces but finding them better prepared than in 1274. The southern fleet did not arrive until early July, when it was also attacked by Japanese forces. The two fleets joined only in mid-August, whereupon they were almost immediately beset by a typhoon—the famous “wind of the gods” (*kamikaze*) credited with saving Japan. Many ships sank, especially from the southern fleet, whose ships and sailors handled poorly outside their home waters. By contrast, most of the eastern fleet managed to retreat to Korea.

This was far from the end of Yuan shipbuilding. In 1282, Kublai ordered 4,000 ships built in Liaodong, Hebei, Cheju, Chŏlla, Yangzhou, Nanchang, and Quanzhou. The Koryŏ king promised another 150 ships, while 3,000 typhoon-damaged ships recovered were sent for repair. In 1283, the khan dispatched master shipwright Ji Gongzhi to South China with orders for 1,000 more ships. Meanwhile, forests near the Yellow Sea shipyards were
under heavy pressure to provide adequate timber. The Pingluan yards in Hebei sent two detachments of nine thousand soldiers to log the Tushan and Qianshan ranges and another eight thousand soldiers and civilians to float logs to the shipyards. In one season of lumbering, they reportedly cut 186,000 logs. Elsewhere, Kublai’s soldiers seized private timber stocks and even tore down houses, while coastal and riverine populations were pressed with massive labor service duties. Revolts broke out across South China, leading Kublai to furlough the soldier-lumberjacks and suspend shipbuilding. But soon the detention of the khan’s ambassadors in Champa (now central Vietnam) provoked a further change of plans. Rather than sending the fleets east to Japan, he sent them south. As in Japan, the Yuan navy floundered. In 1285, Kublai again made concrete plans for the invasion of Japan, but once again sent his forces south rather than east, this time to Annam (northern Vietnam). It was only in 1286 that Kublai formally ended planning for the invasions of Japan, whereupon the people of Zhejiang were reportedly “so glad that their cheers sounded like thunder.” Yet naval expeditions continued. In 1293, Kublai sent fleets south to Java, and he continued to entertain plans for a third invasion of Japan until his death in 1294.

Kublai’s navy was not simply one great mass of ships, but rather the gradual accretion of boats captured or converted from different fleets, with thousands of others purpose-built in shipyards from Cholla to Quanzhou. The Yuan naval buildup showed its military-industrial machine at peak capacity, even as the processes of building the fleet changed over its thirty-year history. For its first decade, the fleet was essentially a wing of the Yuan’s North China army (Hanjun). The khan’s major shipwrights were almost all military officers with prior service to the Jin. In the 1260s, the Koryŏ king also began to contribute ships and men from his own household budget. Starting in the 1270s, the Yuan built thousands of ships in southern ports captured from the Song and hundreds more in southwestern Korea. Throughout Korea and North China, Mongol myriarchs oversaw massive deployments of forced labor. By contrast, while South Chinese shipyards were heavily taxed, there are no reports of logging corvée south of the Yangzi. Instead, the southern fleet was presumably built with timber purchased or requisitioned on the market. Despite its rapid successes, the irregular nature of this fleet revealed itself during the invasions of Japan and Southeast Asia, as hastily built ships and impressed sailors performed poorly outside of their home waters.
By the mid-1300s, the Yuan navy was a shadow of its former self. Due to sedimentation of the Grand Canal, the Yuan were forced to ship grain to Beijing by sea, where they were repeatedly defeated by the pirate commander Fang Guozhen. With little other recourse, the Yuan offered Fang favorable terms for “surrendering” to the court in 1349, and again in 1353 and 1356. During Fang’s final “capitulation,” the Yuan navy revealed its full weakness by granting Fang command of a sea transport battalion (qianhu). By 1356, it was Fang’s thousand-ship fleet—not the regular Yuan navy—that controlled most of coastal Zhejiang.81 The rot in the Yuan navy soon spread to the rest of the state. In 1351, the court sent an army to deal with scattered rebels in northern and central China; in response, the rebels merged into two main armies, known as the Red Turbans (Hongjin) for the colored head scarves and banners they used to identify themselves. In 1352, the Red Turbans seized control of much of the Yangzi River valley and large parts of North China, before being driven back by Yuan forces in 1353. As on the seas, the court empowered a motley array of local bandits, self-defense forces, and breakaway commanders to push back the millenarian rebels.82 Through several further years of warfare, these acephalous armies further coalesced into several self-declared states, including Zhang Shicheng’s “Wu kingdom” in Jiangnan; the “Great Han” state of Chen Youliang in the middle Yangzi; and Han Lin’er’s “Song dynasty” in southern Anhui, effectively controlled by his nominal subordinate Zhu Yuanzhang.83

As these rival regimes sought to extend their control, the Yangzi River became a major axis of naval conflict. Zhang, Chen, and Zhu each built up fleets from a motley array of fishing vessels, merchant ships, and purpose-built warships, for which they presumably logged the surrounding regions.84 In 1363, the buildup of the previous decade culminated in the battle of Poyang Lake in Jiangxi, where the navies of Chen Youliang and Zhu Yuanzhang each sought to gain control of the key outlet to the Yangzi River. At the height of the battle, Zhu’s fleet was said to number one thousand ships and at least one hundred thousand men, facing Chen’s force of perhaps twice the size and including large tower ships.85 After a lengthy siege at the riverside fortress at Nanchang, the battle broke when Zhu loaded dozens of vessels with gunpowder and used them to break Chen’s line of battle. Fearing further fire attacks, Chen’s remaining captains divided their fleets, allowing Zhu’s more maneuverable navy to defeat them one at a time. The
battle ended when Chen Youliang was shot in the eye during a last-ditch attempt to break out of the lake. As Hok-lam Chan reveals, the records of this battle are full of unbelievable occurrences, including the intercession of Daoist immortals to warn Zhu of sea demons and foretell Chen’s death. Nonetheless, the battle of Poyang Lake was inarguably one of the largest inland naval conflicts in history and perhaps the first time that cannons were used from the decks of ships. Once Zhu defeated Chen’s navy, he was able to dominate the Yangzi River and easily defeated Zhang Shicheng, his last major rival in the region. In 1367, Fang Guozhen surrendered to Zhu on favorable terms, bringing with him the oceangoing fleet that enabled Zhu’s conquest of the southeast coast.

Having defeated his rivals through naval might, Zhu Yuanzhang recognized the importance of shipbuilding, but faced the new challenge of making it sustainable. Shortly after the declaration of the Ming dynasty, he established a shipyard at Longjiang in Nanjing to build both military and transport ships. Each of the capital battalions (jing suo) was also assigned responsibility for building its own ships. In 1391, Nanjing officials planted over five hundred thousand tung, lacquer, and palm trees to supply auxiliary materials to these shipyards. Starting with the establishment of the Longjiang customs in 1393, much of the shipbuilding previously done in the provinces was moved to the Longjiang shipyards to take advantage of tariff materials. Regulations required that these shipyards use materials from the timber tariff whenever possible. These regulations set an enduring precedent, although perhaps not the one the Ming founder intended.

Following Zhu Yuanzhang’s death and a brief succession struggle, the Yongle emperor took command and reoriented shipbuilding toward his northern capital at Beijing and expanded the overall scale of the Ming navy. To ship supplies north, Yongle built two new shipyards, one on the Yangzi at Qingjiang to build river transports and another at Weihe in Shandong to build sea transports. Provincial tariff stations forwarded materials to provision these shipyards: timber from Jiangxi, Huguang, and Sichuan; cash from Zhejiang and the Southern Metropolitan Region; and iron and tung oil from Fujian. Labor was provided by a levy on nearby populations, 70 percent borne by commoners and 30 percent by military households. But Yongle’s greater legacy was a massive buildup in seagoing vessels for his various expeditions, including the famous Indian Ocean armada and a fleet used for the invasion of Annam. In 1403, his first year on the throne, Yongle issued orders for a total of 561 ships, almost all of them built on the Yangzi
River or the southeast coast. In 1404, the capital garrisons in Nanjing built another 50 ships, and Fujian constructed the first 5 ships built specifically for the expedition to the Indian Ocean. In 1405, a single edict commissioned an astounding 1,180 ships, again principally from South China. In total, the Veritable Records contain orders for 2,339 ships issued by the end of 1407 and 2,868 ships by the end of the Yongle reign in 1424. During these three decades, the Ming’s oceangoing navy may have exceeded 3,000 ships.

To build all the ships demanded by the emperor, the Longjiang shipyards doubled in size, largely through the addition of specialized yards to build the “treasure ships” (baochuan) for the expeditions to South and Southeast Asia and East Africa led by Zheng He. According to the official biography of Zheng He, these treasure ships measured 44 zhang in length and 18 zhang in the beam. There is some controversy over how to interpret these measures, but some scholars argue that they may have been between 385 and 440 feet long (117–34 meters), which would make them the largest wooden ships ever built. For comparison, Christopher Columbus’s flagship was 86 feet long, and European ships only reached lengths of 200 feet during the Napoleonic Wars. Zheng He’s armada ultimately made six expeditions under Yongle, and a seventh under the Xuande emperor, each with a complement of around 250 ships, 40 of which were the massive treasure ships. At least 150 orders for treasure ship construction are attested in the historical record.

The Yongle boom in shipbuilding, especially the construction of the Zheng He fleets, is often treated as fundamentally unprecedented. A widely circulated image shows a treasure ship towering over Columbus’s flagship the Santa Maria. Jack A. Goldstone’s influential metaphor compares the scale of the Zheng He expeditions to the Apollo moon missions. Yet there are several controversies associated with these interpretations. On the one hand, there are serious questions regarding the size and number of ships used on the missions. Details on the number and size of ships derive from rather dubious sources, including a fantasy novel and histories written centuries after the expeditions. Stelae from the 1430s missions suggest that both the number and the size of the ships may have been substantially smaller. Scholars have also used naval architectural analysis and archeology of the treasure shipyards to question the plausibility of building ships over 400 feet long. On the other hand, there was a clear precedent for very large armadas of massive ships. As we saw above, Kublai’s fleets had as many
as 4,000 ships, and the biggest ships of his era reached 20 zhang (200 feet). The treasure ships followed the trajectory of naval developments over the previous three centuries toward ever-larger fleets of ever-larger ships.

Regardless of the exact size of Zheng He’s fleets, they were clearly enormous projects. But did they pose economic or environmental ruin? Edward Dreyer argues that in absolute terms the costs of the expeditions were not too large to be borne by the Ming fisc. I would add that the demands of timber and labor did not greatly exceed the capacity of Jiangnan shipyards. As seen above, Yangzi River shipwrights had repeatedly fulfilled orders for hundreds and even thousands of ships per year in the twelfth and thirteenth centuries. While loggers were sent to the upper reaches of the Yangzi in Sichuan and the Min River in Fujian, probably to cut mast timber, contemporary accounts otherwise give no mention of logging expeditions.

This suggests that the demand for timber was a large but manageable burden. While the fleets were a significant expense, they probably did not significantly deplete forest resources. If anything, the main effect of the Yongle projects was probably to shift much of South China’s forest production from private construction to state projects.

While they may not have deforested the empire, the Yongle projects caused an acute fiscal and political crisis. The decade following the Yongle emperor’s death in 1424 saw widespread retrenchment across almost all state institutions; shipbuilding was no exception. The court substantially reduced quotas for the Longjiang shipyards in 1428. In 1435, the Nanjing garrisons and the Board of Works brokered a compromise attempted to stabilize the operations at Longjiang by splitting the cost of materials 40–60. To pay its end, the board rented out state-owned farmland near the Longjiang yards, collecting rents in goods like tung oil and hemp (huangma) that were used to make naval stores. The court made similar provisions to save costs at the Qingjiang shipyards as well. Between the Xuande reign (1426–35) and the 1460s, the Yangzi River provinces built their own transport ships to avoid the expense of forwarding materials to Nanjing. For three decades, the Qingjiang yards only built grain ships for the Southern Metropolitan Region. During the Zhengtong reign (1436–50), the court reduced the annual quota of seagoing transports at Weihe by 70 percent. Overall, the middle decades of the fifteenth century saw a massive drawdown in the size of the navy to half or less of its former strength. By the early sixteenth century, the Ming navy—like the Yuan navy before it—struggled even in engagements with pirate fleets.

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SHIPYARDS IN THE LONG SIXTEENTH CENTURY

While the post-Yongle decline of the Ming navy was pronounced, the Ming shipyards ultimately accomplished something that had not been done since the Southern Song—they made shipbuilding sustainable. The renaissance at the shipyards began in the 1460s, as an influx of silver began to revive the economy, allowing officials to expand production again. Customs stations began to reopen in the 1460s and 1470s, often for the express purpose of providing shipbuilding funds.123 Starting in 1462, the court once again designated the Qingjiang yards to build all the grain ships for the south. Instead of constructing their own transports, the southern provinces now forwarded silver tariff receipts to Qingjiang, which bought materials on the open market. The court also revived the Weihe yards as the principal shipyards for oceangoing transports.124 The availability of silver made it far easier to supply these shipyards with currency rather than going through the difficulty of shipping materials. Yet even as the growing money supply simplified logistics, it subjected the shipyards to a new problem: inflation, especially in the price of timber.

Inflation was a fundamentally new problem for the shipyards, one that the Ming fiscal system was especially ill equipped to address due to its reliance on fixed tax quotas. Between 1462 and the 1480s, the cost of each ship built at Qingjiang doubled, largely due to increases in timber prices. To make up the difference, the state diverted additional funds from the customs stations at Hangzhou, Wuhu, and Huai’an and pressed the military households of the Nanjing garrisons with tax surcharges. Officials even returned to collecting timber tariffs in kind in an attempt to stock the shipyards while avoiding the growing burden of timber price inflation.125 By the early sixteenth century, inflation was felt at the Longjiang yards as well. In 1503, Longjiang had to request additional funds from every prefecture in the Southern Metropolitan Region. By 1516, Longjiang’s fast warships (kuai-chuan), formerly built for 100 taels, now cost 130 taels each, although the shipyards brought the cost down by 10 taels by reusing materials stripped from decommissioned ships. By 1521, fast warships cost 150 taels apiece, and costs continued to increase. Throughout this period, worker salaries were held constant, so the rising expenses came entirely due to increases in timber prices.126

Account books submitted to Qingjiang by the merchant Chen Xu allow us to follow timber price inflation into the 1530s and 1540s. According to
Chen, the cost of materials for grain ships increased from 52.5 taels per ship in 1524 to 60 taels each in 1545. The smaller shipyards attached to each garrison also felt the rising cost of materials. By the 1540s, shipbuilding costs at the Nanjing garrisons were so unsustainable that the heads of supernumerary household groups (bangjia) were reduced to selling family members to raise the money they needed to pay their tax surcharges. Others committed suicide. While we cannot read too much into these sparse accounts, they suggest that timber price inflation averaged around 3.5 percent annually in the late 1400s and around 2.5 percent per year in the early 1500s, before falling below 1 percent in the 1530s and 1540s. While this would be fairly modest inflation by modern standards, even a small increase in the cost of timber wreaked havoc on Ming institutions with fixed budgets.

Despite the problems caused by inflation, the conversion to silver budgets allowed shipyard officials to compile better records and standardize prices. In 1501, officials at Qingjiang compiled Treatise on Transport Ships (Caochuan zhi), containing an institutional history of the shipyards and a list of standard prices for materials. In 1503, the Longjiang shipyards posted a clear list of salaries for shipwrights. In 1518, Longjiang regulations took advantage of better market information to peg the price of materials to the going price of timber. In 1523, the Weihe shipyards were closed, concentrating transport shipbuilding entirely at Qingjiang, near the other main yards at Longjiang and the capital garrisons. Finally, in 1529, the state appointed specialized managers to the Longjiang shipyards, which had previously been managed by the same officials overseeing the Longjiang customs. The concentration of management at the Nanjing-area shipyards, and especially at Longjiang, soon allowed officials to consolidate the reforms of the previous two decades.

Starting in 1529, the new Longjiang managers developed regulations for reporting materials requisitions. The shipyards now submitted material requests in duplicate, sending one copy to the Nanjing Board of Works and one to the Longjiang customs. Shipyard and tariff officials worked together to assess timber stocks, set a date for construction, disburse materials from the tariff depots, and purchase any additional timber needed. When construction was completed, the shipyards produced reports in duplicate, one for the board and one for the construction office. The 1540s brought further reforms across all three shipyards. In 1541, the Nanjing Board of Works required that the Longjiang customs record exact length and circumference
for each pole of timber, rather than grading them according to rough sizes. Before forwarding materials to the shipyards, customs officials checked each item against their records to ensure that workers did not substitute inferior materials during transport. In 1542, officials at the Nanjing Board of War compiled price lists for ships constructed at Nanjing garrisons, explicitly based on the standard prices set for the Qingjiang yards. Both shipyards now paid the same fixed prices for nanmu (Phoebe nanmu) and fir logs based on their circumference in Chinese feet (chi). In 1543, officials established a standard dimension for timber planking as well, at one zhang by one chi by one cun (roughly ten feet by one foot by one inch).

In 1545 and 1546, negotiations between the shipyards and leading timber merchants led to a second raft of systematic reforms. The court established the Imperial Timber Pavilion (Huangmu Ting) to oversee the shipping routes along the Yangzi and prevent log rafts from blocking the rivers, either by accident or by merchants intentionally trying to monopolize (longduan) the timber market. The garrison shipyards also communicated with Longjiang to create standardized one-foot measures to use at the two regional tariff depots, all three shipyards, and the Board of Works office. Using these standard measures, officials at the tariff depots now branded each log to indicate its size, one character (zi) for each foot of circumference. The shipyards now referred to timber as four-, five-, and six-character poles. The military even negotiated an agreement with leading merchants to supply a package of the large timbers needed for each ship, including one six-character log, three five-character logs, and three four-character logs of fir or nanmu. Starting in 1546, the Longjiang shipyards used the same standard prices as the Board of War, which was itself based on the price lists first produced at Qingjiang around 1500. The shipyards also established standard discounts for subgrade timber, including hollow, rotten, bent, or warped logs. They enumerated punishments for shipyard workers or merchants who defrauded the state. Finally, they published diagrams depicting the components of each type of ship (figure 6.1) and a standard form for purchasing officials to list the size, grade, and production location of each timber; the name of the vendor, inspector, and accountant; and the price based on the standard lists, after accounting for any flaws (figure 6.2). They forwarded this form to the bureau responsible for finances and to the officials overseeing sawyers to ensure the timber purchases were received intact. Shipyard officials also produced several sets of records for future
Fig 6.1 Diagram of a flat-decked warship (*pingchuan*). Labels indicate names of individual components, sometimes their dimensions. Elsewhere, the text provides standard prices and other specifications for each part. Image from *Shipyard Administration* (Chuanzheng; 1546), reprinted in *Tianyige cang Mingdai zhengshu zhenben congkan*. Courtesy of the C. V. Starr East Asian Library, Columbia University.
Form for recording timber purchases. This page and the following page (not pictured) include four identical forms, which could be printed from a woodblock as needed. A note reads, “Consult the official registers for the number of boards to saw.” This form is for purchases of *nanmu* (*Phoebe nanmu*). A note later in the text indicates that the form should be modified for the purchase of fir or other types of wood. Image from *Shipyard Administration* (Chuanzheng; 1546), reprinted in *Tianyige cang Mingdai zhengshu zhenben congkan*. Courtesy of the C. V. Starr East Asian Library, Columbia University.
administrators, including a new edition of Treatise on Transport Ships (1545), Shipyard Administration (Chuanzheng; 1546), and Treatise on the Longjiang Shipyards (Longjiang chuanchang zhi; 1552).

Half a century after the reforms of the 1540s, another shipyard official, Ni Dong, recorded further improvements in shipyard operations in New Treatise on Shipyard Administration (Chuanzheng xin shu; c. 1590). The addition of fifty years of experience allowed further improvements to scheduling, budgeting, and oversight. Top officials now laid out schedules for new ship construction; large, medium, and small repairs; and teardowns of defunct vessels. They checked their timber stocks every fall to plan for timber purchases the following spring and estimated a budget while allowing actual prices to shift in accord with market conditions. To prevent theft or improper handling, lower-level officers now kept monthly records and marked each log with the names of the workers and overseers responsible for its storage and processing.144

After a century of erratic timber procurement in the 1400s, the Ming state gradually outsourced much of the labor to merchants. The shipyards commodified timber through forms that specified standards for size, type, and price but that also accounted for the subjective nature of individual logs by branding them with the names of those responsible for purchase, storage, and finishing. These same standards allowed board officials to budget for shipbuilding from a general-purpose treasury and shipwrights to build ships without worrying about how to requisition the materials. By the 1590s, the compilation of more than seventy years of records allowed officials to anticipate and track changes in the price of timber, avoiding the budgeting problems experienced in the early years of the century. This was arguably the peak of Ming timber management, a system built atop the markets, customs depots, and shipyards that processed logs into lumber and lumber into ships.

FORESTS AND CHINESE SEA POWER

Chinese sea power rested on different principles and faced different rivalries than those of the later European powers. The Song navy was mostly defensive and built for warfare on the lakes and rivers as much as on the sea. The Yuan invasions of Japan were amphibious assaults, not protracted naval warfare. Yuan and Ming expeditions to Southeast Asia were largely intended to open sea-lanes for commerce and diplomacy, not to explore and conquer.
Like the European navies in Robert Greenhalgh Albion’s seminal exploration in *Forests and Sea Power*, the Chinese fleets of the twelfth through sixteenth centuries demanded a large and high-quality supply of timber. But unlike in Europe, China’s fleets were built by a shipyard administration without an accompanying forest bureaucracy. Finance and labor were major concerns at the peaks of Song, Yuan, and Ming shipbuilding, but only rarely did bureaucrats worry about finding adequate sources of timber. While forced laborers supplied the fleets of the Northern Song, Jin, and Yuan, in the Southern Song and Ming the overwhelming majority of naval timber was supplied by private merchants, through either tariffs or licensed sales. Timber depots in Song Hangzhou and Ming Nanjing developed sophisticated lumber operations built around the standard sizing, grading, and pricing of timber; a paper trail to track materials from point of collection to point of use; and clear penalties for violations of market guidelines. With limited (but important) exceptions, Chinese states concentrated their timber oversight at the customs office, not in the forest.

The navy was, in turn, largely a reflection of the forests—and markets—that undergirded it. In the Northern Song, this meant a diffuse and varied array of ships built by provincial garrisons and transport commissions. Under the Southern Song, the navy resembled its two main timber sources: a Yangzi River fleet built in official shipyards with the fir timbers of Jiangnan and an oceangoing fleet built by the trading communities of the southeast coast. The navy yielded by the larger, more heterogeneous Yuan empire was a similar hodgepodge of pine ships from Korea, fir riverboats from Jiangnan, and a camphor-hulled fleet from Fujian. In the early Ming, the massive Zheng He fleets were largely constructed at Nanjing using fir timbers, reflecting the emerging dominance of Jiangnan’s tree plantations. The growing size of the fleet reflected the growing capacity of timber markets to supply the shipyards. Yet while officials at the shipyards recorded their reforms in specialized treatises, developments in merchant operations are harder to probe. We likewise know very little about the shipwrights and carpenters at the other end of the commodity chain. Nonetheless, it is clear from the cameo appearances of merchants and woodworkers that they provided extensive input into price dynamics and standard measures. Much like the development of forests as property, the emergence of timber as a commodity depended on the willing participation of a range of actors, not the exclusive fiat of the bureaucratic state.