prestige to them: luxury goods for the wealthiest households, vestments and jewelry for the clergy, and bells and stained glass for the churches. Among the uses to which they allocated their few boats were the Nordrseta hunt, in order to acquire the luxury exports (such as ivory and polar bear hides) with which to pay for those imports. Chiefs had two motives for running large sheep herds that could damage the land by overgrazing: wool was Greenland's other principal export with which to pay for imports; and independent farmers on overgrazed land were more likely to be forced into tenancy, and thereby to become a chief's followers in his competition with other chiefs. There were many innovations that might have improved the material conditions of the Norse, such as importing more iron and fewer luxuries, allocating more boat time to Markland journeys for obtaining iron and timber, and copying (from the Inuit) or inventing different boats and different hunting techniques. But those innovations could have threatened the power, prestige, and narrow interests of the chiefs. In the tightly controlled, interdependent society of Norse Greenland, the chiefs were in a position to prevent others from trying out such innovations.

Thus, Norse society's structure created a conflict between the short-term interests of those in power, and the long-term interests of the society as a whole. Much of what the chiefs and clergy valued proved eventually harmful to the society. Yet the society's values were at the root of its strengths as well as of its weaknesses. The Greenland Norse did succeed in creating a unique form of European society, and in surviving for 450 years as Europe's most remote outpost. We modern Americans should not be too quick to brand them as failures, when their society survived in Greenland for longer than our English-speaking society has survived so far in North America. Ultimately, though, the chiefs found themselves without followers. The last right that they obtained for themselves was the privilege of being the last to starve.

CHAPTER 9

Opposite Paths to Success

Bottom up, top down ■ New Guinea highlands ■ Tikopia ■ Tokugawa problems ■ Tokugawa solutions ■ Why Japan succeeded ■ Other successes ■

The preceding chapters have described six past societies whose failure to solve the environmental problems that they created or encountered contributed to their eventual collapse: Easter Island, Pitcairn Island, Henderson Island, the Anasazi, the Classic Lowland Maya, and the Greenland Norse. I dwelt on their failures because they offer us many lessons. However, it's certainly not the case that all past societies were doomed to environmental disaster: the Icelanders have survived in a difficult environment for over 1,100 years, and many other societies have persisted for thousands of years. Those success stories also hold lessons for us, as well as hope and inspiration. They suggest that there are two contrasting types of approaches to solving environmental problems, which we may term the bottom-up and the top-down approach.

This recognition stems especially from the work of archaeologist Patrick Kirch on Pacific islands of different sizes, with different societal outcomes. The occupation of tiny Tikopia Island (1.8 square miles) was still sustainable after 3,000 years; medium-size Mangaia (27 square miles) underwent a deforestation-triggered collapse, similar to that of Easter Island; and the largest of the three islands, Tonga (288 square miles), has been operating more or less sustainably for 3,200 years. Why did the small island and the large island ultimately succeed in mastering their environmental problems, while the medium-sized island failed? Kirch argues that the small island and the large island adopted opposite approaches to success, and that neither approach was feasible on the medium-sized island.

Small societies occupying a small island or homeland can adopt a bottom-up approach to environmental management. Because the homeland is small, all of its inhabitants are familiar with the entire island, know that they are affected by developments throughout the island, and share a sense of identity and common interests with other inhabitants. Hence everybody

realizes that they will benefit from sound environmental measures that they and their neighbors adopt. That's bottom-up management, in which people work together to solve their own problems.

Most of us have experience of such bottom-up management in our neighborhoods where we live or work. For instance, all homeowners on the Los Angeles street where I live belong to a neighborhood homeowners' association, whose purpose is to keep the neighborhood safe, harmonious, and attractive for our own benefit. All of us elect the association's directors each year, discuss policy at an annual meeting, and provide the association's budget by means of an annual dues payment. With that money, the association maintains flower gardens at road intersections, requires homeowners not to cut down trees without good cause, reviews building plans to ensure that ugly or oversized houses aren't built, resolves disputes between neighbors, and lobbies city officials on matters affecting the whole neighborhood. As another example, I mentioned in Chapter 1 that landowners living near Hamilton in Montana's Bitterroot Valley have banded together to operate the Teller Wildlife Refuge, and have thereby contributed to improving their own land values, lifestyle, and fishing and hunting opportunities, even though that in itself does not solve the problems of the United States or of the world.

The opposite approach is the top-down approach suited to a large society with centralized political organization, like Polynesian Tonga. Tonga is much too large for any individual peasant farmer to be familiar with the whole archipelago or even just with any single one of its large islands. Some problem might be going on in a distant part of the archipelago that could ultimately prove fatal to the farmer's lifestyle, but of which he initially has no knowledge. Even if he did know about it, he might dismiss it with the standard ISEP excuse ("It's someone else's problem"), because he might think that it made no difference to him or else its effects would just lie far off in the future. Conversely, a farmer might be inclined to gloss over problems in his own area (e.g., deforestation) because he assumes that there are plenty of trees somewhere else, but in fact he doesn't know.

Yet Tonga is still large enough for a centralized government under a paramount chief or king to have arisen. That king does have an overview over the whole archipelago, unlike local farmers. Also unlike the farmers, the king may be motivated to attend to the long-term interests of the whole archipelago, because the king derives his wealth from the whole archipelago, he is the latest in a line of rulers that has been there for a long time, and he expects his descendants to rule Tonga forever. Thus, the king or central authority may practice top-down management of environmental resources, and may give all of his subjects orders that are good for them in the long run but that they don't know enough to have formulated themselves.

This top-down approach is as familiar to citizens of modern First World countries as is the bottom-up approach. We're accustomed to the fact that governmental entities, especially (in the U.S.) state and federal governments, pursue environmental and other policies affecting the whole state or country, supposedly because the government leaders can have an overview of the state or country beyond the capacity of most individual citizens. For example, while the citizens of Montana's Bitterroot Valley do have their own Teller Wildlife Refuge, half of the valley's acreage is owned or managed by the federal government, as national forest or under the Bureau of Land Management.

Traditional middle-sized societies, occupying medium-sized islands or homelands, may not be well suited for either of these two approaches. The island is too large for a local farmer to have an overview of, or stake in, all parts of the island. Hostility between chiefs in neighboring valleys prevents agreement or coordinated action, and even contributes to environmental destruction: each chief leads raids to cut down trees and wreak havoc on rivals' land. The island may be too small for a central government to have arisen, capable of controlling the entire island. That appears to have been the fate of Mangaia, and may have affected other middle-sized societies in the past. Today, when the whole world is organized into states, fewer middle-sized societies may be facing this dilemma, but it may still arise in countries where state control is weak.

To illustrate these contrasting approaches to success, I shall now relate briefly the story of two small-scale societies where bottom-up approaches worked (the New Guinea highlands and Tikopia Island), and one large-scale society where top-down measures worked (Japan of the Tokugawa era, now the eighth most populous country in the world). In all three cases the environmental problems addressed were deforestation, erosion, and soil fertility. However, many other past societies have adopted similar approaches for solving problems of water resources, fishing, and hunting. It should also be understood that bottom-up and top-down approaches can coexist within a large-scale society that is organized as a pyramidal hierarchy of units. For example, in the United States and other democracies we have bottom-up management by local neighborhood and citizens' groups coexisting with top-down management by many levels of government (city, county, state, and national).

Our other success story resembles Tikopia in that it too involves a densely populated island society isolated from the outside world, with few economically significant imports, and with a long history of a self-sufficient and sustainable lifestyle. But the resemblance ends there, because this island has a population 100,000 times larger than Tikopia's, a powerful central government, an industrial First World economy, a highly stratified society presided over by a rich powerful elite, and a big role of top-down initiatives in solving environmental problems. Our case study is of Japan before 1868.

Japan's long history of scientific forest management is not well known to Europeans and Americans. Instead, professional foresters think of the techniques of forest management widespread today as having begun to develop in German principalities in the 1500s, and having spread from there to much of the rest of Europe in the 1700s and 1800s. As a result, Europe's total area of forest, after declining steadily ever since the origins of European agriculture 9,000 years ago, has actually been increasing since around 1800. When I first visited Germany in 1959, I was astonished to discover the extent of neatly laid-out forest plantations covering much of the country, because I had thought of Germany as industrialized, populous, and urban.

But it turns out that Japan, independently of and simultaneously with Germany, also developed top-down forest management. That too is surprising, because Japan, like Germany, is industrialized, populous, and urban. It has the highest population density of any large First World country, with nearly 1,000 people per square mile of total area, or 5,000 people per square mile of farmland. Despite that high population, almost 80% of Japan's area consists of sparsely populated forested mountains (Plate 20), while most people and agriculture are crammed into the plains that make up only one-fifth of the country. Those forests are so well protected and managed that their extent is still increasing, even though they are being utilized as valuable sources of timber. Because of that forest mantle, the Japanese often refer to their island nation as "the green archipelago." While the mantle superficially resembles a primeval forest, in fact most of Japan's accessible original forests were cut by 300 years ago and became replaced with regrowth forest and plantations as tightly micromanaged as those of Germany and Tikopia.

Japanese forest policies arose as a response to an environmental and population crisis paradoxically brought on by peace and prosperity. For almost 150 years beginning in 1467, Japan was convulsed by civil wars as the ruling coalition of powerful houses that had emerged from the earlier disintegration of the emperor's power in turn collapsed, and as control passed instead to dozens of autonomous warrior barons (called *daimyo*), who

fought each other. The wars were finally ended by the military victories of a warrior named Toyotomi Hideyoshi and his successor Tokugawa Ieyasu. In 1615 Ieyasu's storming of the Toyotomi family stronghold at Osaka, and the deaths by suicide of the remaining Toyotomis, marked the wars' end.

Already in 1603, the emperor had invested Ieyasu with the hereditary title of *shogun*, the chief of the warrior estate. From then on, the shogun based at his capital city of Edo (modern Tokyo) exercised the real power, while the emperor at the old capital of Kyoto remained a figurehead. A quarter of Japan's area was directly administered by the shogun, the remaining three-quarters being administered by the 250 daimyo whom the shogun ruled with a firm hand. Military force became the shogun's monopoly. Daimyo could no longer fight each other, and they even needed the shogun's permission to marry, to modify their castles, or to pass on their property in inheritance to a son. The years from 1603 to 1867 in Japan are called the Tokugawa era, during which a series of Tokugawa shoguns kept Japan free of war and foreign influence.

Peace and prosperity allowed Japan's population and economy to explode. Within a century of the wars' end, population doubled because of a fortunate combination of factors: peaceful conditions, relative freedom from the disease epidemics afflicting Europe at the time (due to Japan's ban on foreign travel or visitors: see below), and increased agricultural productivity as the result of the arrival of two productive new crops (potatoes and sweet potatoes), marsh reclamation, improved flood control, and increased production of irrigated rice. While the population as a whole thus grew, cities grew even faster, to the point where Edo became the world's most populous city by 1720. Throughout Japan, peace and a strong centralized government brought a uniform currency and uniform system of weights and measures, the end of toll and customs barriers, road construction, and improved coastal shipping, all of which contributed to a trade boom within Japan.

But Japan's trade with the rest of the world was cut to almost nothing. Portuguese navigators bent on trade and conquest, having rounded Africa to reach India in 1498, advanced to the Moluccas in 1512, China in 1514, and Japan in 1543. Those first European visitors to Japan were just a pair of shipwrecked sailors, but they caused unsettling changes by introducing guns, and even bigger changes when they were followed by Catholic missionaries six years later. Hundreds of thousands of Japanese, including some daimyo, became converted to Christianity. Unfortunately, rival Jesuit and Franciscan missionaries began competing with each other, and stories

spread that friars were trying to Christianize Japan as a prelude to a European takeover.

In 1597 Toyotomi Hideyoshi crucified Japan's first group of 26 Christian martyrs. When Christian daimyo then tried to bribe or assassinate government officials, the shogun Tokugawa Ieyasu concluded that Europeans and Christianity posed a threat to the stability of the shogunate and Japan. (In retrospect, when one considers how European military intervention followed the arrival of apparently innocent traders and missionaries in China, India, and many other countries, the threat foreseen by Ieyasu was real.) In 1614 Ieyasu prohibited Christianity and began to torture and execute missionaries and those of their converts who refused to disavow their religion. In 1635 a later shogun went even further by forbidding Japanese to travel overseas and forbidding Japanese ships to leave Japan's coastal waters. Four years later, he expelled all the remaining Portuguese from Japan.

Japan thereupon entered a period, lasting over two centuries, in which it cordoned itself off from the rest of the world, for reasons reflecting even more its agendas related to China and Korea than to Europe. The sole foreign traders admitted were a few Dutch merchants (considered less dangerous than Portuguese because they were anti-Catholic), kept isolated like dangerous germs on an island in Nagasaki harbor, and a similar Chinese enclave. The only other foreign trade permitted was with Koreans on Tsushima Island lying between Korea and Japan, with the Ryukyu Islands (including Okinawa) to the south, and with the aboriginal Ainu population on Hokkaido Island to the north (then not yet part of Japan, as it is today). Apart from those contacts, Japan did not even maintain overseas diplomatic relations, not even with China. Nor did Japan attempt foreign conquests after Hideyoshi's two unsuccessful invasions of Korea in the 1590s.

During those centuries of relative isolation, Japan was able to meet most of its needs domestically, and in particular was virtually self-sufficient in food, timber, and most metals. Imports were largely restricted to sugar and spices, ginseng and medicines and mercury, 160 tons per year of luxury woods, Chinese silk, deer skin and other hides to make leather (because Japan maintained few cattle), and lead and saltpeter to make gunpowder. Even the amounts of some of those imports decreased with time as domestic silk and sugar production rose, and as guns became restricted and then virtually abolished. This remarkable state of self-sufficiency and self-imposed isolation lasted until an American fleet under Commodore Perry arrived in 1853 to demand that Japan open its ports to supply fuel and provisions to American whaling and merchant ships. When it then became

clear that the Tokugawa shogunate could no longer protect Japan from barbarians armed with guns, the shogunate collapsed in 1868, and Japan began its remarkably rapid transformation from an isolated semi-feudal society to a modern state.

Deforestation was a major factor in the environmental and population crisis brought on by the peace and prosperity of the 1600s, as Japan's timber consumption (almost entirely consisting of domestic timber) soared. Until the late 19th century, most Japanese buildings were made of wood, rather than of stone, brick, cement, mud, or tiles as in many other countries. That tradition of timber construction stemmed partly from a Japanese esthetic preference for wood, and partly from the ready availability of trees throughout Japan's early history. With the onset of peace, prosperity, and a population boom, timber use for construction took off to supply the needs of the growing rural and urban population. Beginning around 1570, Hideyoshi, his successor the shogun Ieyasu, and many of the daimyo led the way, indulging their egos and seeking to impress each other by constructing huge castles and temples. Just the three biggest castles built by Ieyasu required clear-cutting about 10 square miles of forests. About 200 castle towns and cities arose under Hideyoshi, Ieyasu, and the next shogun. After Ieyasu's death, urban construction outstripped elite monument construction in its demand for timber, especially because cities of thatch-roofed wooden buildings set closely together and with winter heating by fireplaces were prone to burn, so cities needed to be rebuilt repeatedly. The biggest of those urban fires was the Meireki fire that burned half of the capital at Edo and killed 100,000 people in 1657. Much of that timber was transported to cities by coastal ships, in turn built of wood and hence consuming more wood. Still more wooden ships were required to transport Hideyoshi's armies across the Korea Strait in his unsuccessful attempts to conquer Korea.

Timber for construction was not the only need driving deforestation. Wood was also the fuel used for heating houses, for cooking, and for industrial uses such as making salt, tiles, and ceramics. Wood was burned to charcoal to sustain the hotter fires required for smelting iron. Japan's expanding population needed more food, and hence more forested land cleared for agriculture. Peasants fertilized their fields with "green fertilizer" (i.e., leaves, bark, and twigs), and fed their oxen and horses with fodder (brush and grass), obtained from the forests. Each acre of cropland required 5 to 10 acres of forest to provide the necessary green fertilizer. Until the civil wars ended in 1615, the warring armies under daimyo and the shogun took fodder for their horses, and bamboo for their weapons and defensive palisades,

from the forests. Daimyo in forested areas fulfilled their annual obligation to the shogun in the form of timber.

The years from about 1570 to 1650 marked the peak of the construction boom and of deforestation, which slowed down as timber became scarce. At first, wood was cut either under the direct order of the shogun or daimyo, or else by peasants themselves for their local needs, but by 1660 logging by private entrepreneurs overtook government-ordered logging. For instance, when yet another fire broke out in Edo, one of the most famous of those private lumbermen, a merchant named Kinokuniya Bunzaemon, shrewdly recognized that the result would be more demand for timber. Even before the fire had been put out, he sailed off on a ship to buy up huge quantities of timber in the Kiso district, for resale at a big profit in Edo.

The first part of Japan to become deforested, already by A.D. 800, was the Kinai Basin on the largest Japanese island of Honshu, site of early Japan's main cities such as Osaka and Kyoto. By the year 1000, deforestation was spreading to the nearby smaller island of Shikoku. By 1550 about one-quarter of Japan's area (still mainly just central Honshu and eastern Shikoku) had been logged, but other parts of Japan still held much lowland forest and old-growth forest.

In 1582 Hideyoshi became the first ruler to demand timber from all over Japan, because timber needs for his lavish monumental construction exceeded the timber available on his own domains. He took control of some of Japan's most valuable forests and requisitioned a specified amount of timber each year from each daimyo. In addition to forests, which the shogun and daimyo claimed for themselves, they also claimed all valuable species of timber trees on village or private land. To transport all that timber from increasingly distant logging areas to the cities or castles where the timber was needed, the government cleared obstacles from rivers so that logs could be floated or rafted down them to the coast, whence they were then transported by ships to port cities. Logging spread over Japan's three main islands, from the southern end of the southernmost island of Kyushu through Shikoku to the northern end of Honshu. In 1678 loggers had to turn to the southern end of Hokkaido, the island north of Honshu and at that time not yet part of the Japanese state. By 1710, most accessible forest had been cut on the three main islands (Kyushu, Shikoku, and Honshu) and on southern Hokkaido, leaving old-growth forests just on steep slopes, in inaccessible areas, and at sites too difficult or costly to log with Tokugawa-era technology.

Deforestation hurt Tokugawa Japan in other ways besides the obvious one of wood shortages for timber, fuel, and fodder and the forced end to monumental construction. Disputes over timber and fuel became increasingly frequent between and within villages, and between villages and the daimyo or shogun, all of whom competed for Japan's forests. There were also disputes between those who wanted to use rivers for floating or rafting logs, and those who instead wanted to use them for fishing or for irrigating cropland. Just as we saw for Montana in Chapter 1, wildfires increased, because the second-growth woods springing up on logged land were more flammable than were old-growth forests. Once the forest cover protecting steep slopes had been removed, the rate of soil erosion increased as a consequence of Japan's heavy rainfall, snowmelt, and frequent earthquakes. Flooding in the lowlands due to increased water runoff from the denuded slopes, higher water levels in lowland irrigation systems due to soil erosion and river siltation, increased storm damage, and shortages of forest-derived fertilizer and fodder acted together to decrease crop yields at a time of increasing population, and thus to contribute to major famines that beset Tokugawa Japan from the late 1600s onwards.

The 1657 Meireki fire, and the resulting demand for timber to rebuild Japan's capital, served as a wake-up call exposing the country's growing scarcity of timber and other resources at a time when its population, especially its urban population, had been growing rapidly. That might have led to an Easter-Island–like catastrophe. Instead, over the course of the next two centuries Japan gradually achieved a stable population and much more nearly sustainable resource consumption rates. The shift was led from the top by successive shoguns, who invoked Confucian principles to promulgate an official ideology that encouraged limiting consumption and accumulating reserve supplies in order to protect the country against disaster.

Part of the shift involved increased reliance on seafood and on trade with the Ainu for food, in order to relieve the pressure on farming. Expanded fishing efforts incorporated new fishing techniques, such as very large nets and deepwater fishing. The territories claimed by individual daimyo and villages now included the sea adjacent to their land, in recognition of the sense that fish and shellfish stocks were limited and might become exhausted if anyone else could freely fish in one's territory. Pressure on forests as a source of green fertilizer for cropland was reduced by making much more use of fish meal fertilizers. Hunting of sea mammals (whales, seals, and sea otters) increased, and syndicates were formed to finance the

necessary boats, equipment, and large workforces. The greatly expanded trade with the Ainu on Hokkaido Island brought smoked salmon, dried sea cucumber, abalone, kelp, deer skins, and sea otter pelts to Japan, in exchange for rice, sake (rice wine), tobacco, and cotton delivered to the Ainu. Among the results were the depletion of salmon and deer on Hokkaido, the weaning of the Ainu away from self-sufficiency as hunters to dependence on Japanese imports, and eventually the destruction of the Ainu through economic disruption, disease epidemics, and military conquests. Thus, part of the Tokugawa solution for the problem of resource depletion in Japan itself was to conserve Japanese resources by causing resource depletion elsewhere, just as part of the solution of Japan and other First World countries to problems of resource depletion today is to cause resource depletion elsewhere. (Remember that Hokkaido was not incorporated politically into Japan until the 19th century.)

Another part of the shift consisted of the near-achievement of Zero Population Growth. Between 1721 and 1828, Japan's population barely increased at all, from 26,100,000 to only 27,200,000. Compared to earlier centuries, Japanese in the 18th and 19th century married later, nursed their babies for longer, and spaced their children at longer intervals through the resulting lactational amenorrhea as well as through contraception, abortion, and infanticide. Those decreased birth rates represented responses of individual couples to perceived shortages of food and other resources, as shown by rises and falls in Tokugawa Japanese birth rates in phase with falls and rises in rice prices.

Still other aspects of the shift served to reduce wood consumption. Beginning in the late 17th century, Japan's use of coal instead of wood as a fuel rose. Lighter construction replaced heavy-timbered houses, fuel-efficient cooking stoves replaced open-hearth fireplaces, small portable charcoal heaters replaced the practice of heating the whole house, and reliance on the sun to heat houses during the winter increased.

Many top-down measures were aimed at curing the imbalance between cutting trees and producing trees, initially mainly by negative measures (reducing the cutting), then increasingly by positive measures as well (producing more trees). One of the first signs of awareness at the top was a proclamation by the shogun in 1666, just nine years after the Meireki fire, warning of the dangers of erosion, stream siltation, and flooding caused by deforestation, and urging people to plant seedlings. Beginning in that same decade, Japan launched a nationwide effort at all levels of society to regulate

use of its forest, and by 1700 an elaborate system of woodland management was in place. In the words of historian Conrad Totman, the system focused on "specifying who could do what, where, when, how, how much, and at what price." That is, the first phase of the Tokugawa-era response to Japan's forest problem emphasized negative measures that didn't restore lumber production to previous levels, but that at least bought time, prevented the situation from getting worse until positive measures could take effect, and set ground rules for the competition within Japanese society over increasingly scarce forest products.

The negative responses aimed at three stages in the wood supply chain: woodland management, wood transport, and wood consumption in towns. At the first stage, the shogun, who directly controlled about a quarter of Japan's forests, designated a senior magistrate in the finance ministry to be responsible for his forests, and almost all of the 250 daimyo followed suit by each appointing his own forest magistrate for his land. Those magistrates closed off logged lands to permit forest regeneration, issued licenses specifying the peasants' rights to cut timber or graze animals on government forest land, and banned the practice of burning forests to clear land for shifting cultivation. In those forests controlled not by the shogun or daimyo but by villages, the village headman managed the forest as common property for the use of all villagers, developed rules about the harvesting of forest products, forbade "foreign" peasants of other villages to use his own village's forest, and hired armed guards to enforce all these rules.

Both the shogun and the daimyo paid for very detailed inventories of their forests. Just as one example of the managers' obsessiveness, an inventory of a forest near Karuizawa 80 miles northwest of Edo in 1773 recorded that the forest measured 2.986 square miles in area and contained 4,114 trees, of which 573 were crooked or knotty and 3,541 were good. Of those 4,114 trees, 78 were big conifers (66 of them good) with trunks 24–36 feet long and 6–7 feet in circumference, 293 were medium-sized conifers (253 of them good) 4–5 feet in circumference, 255 good small conifers 6–18 feet long and 1–3 feet in circumference to be harvested in the year 1778, and 1,474 small conifers (1,344 of them good) to harvest in later years. There were also 120 medium-sized ridgeline conifers (104 of them good) 15–18 feet long and 3–4 feet in circumference, 15 small ridgeline conifers 12–24 feet long and 8 inches to 1 foot in circumference to be harvested in 1778, and 320 small ridgeline conifers (241 of them good) to harvest in later years, not to mention 448 oaks (412 of them good) 12–24 feet long and

3–5-½ feet in circumference, and 1,126 other trees whose properties were similarly enumerated. Such counting represents an extreme of top-down management that left nothing to the judgment of individual peasants.

The second stage of negative responses involved the shogun and daimyo establishing guard posts on highways and rivers to inspect wood shipments and make sure that all those rules about woodland management were actually being obeyed. The last stage consisted of a host of government rules specifying, once a tree had been felled and had passed inspection at a guard post, who could use it for what purpose. Valuable cedars and oaks were reserved for government uses and were off limits to peasants. The amount of timber that you could use in building your house varied with your social status: 30 *ken* (one ken is a beam 6 feet long) for a headman presiding over several villages, 18 ken for such a headman's heir, 12 ken for a headman of a single village, 8 ken for a local chief, 6 ken for a taxable peasant, and a mere 4 ken for an ordinary peasant or fisherman. The shogun also issued rules about permissible wood use for objects smaller than houses. For instance, in 1663 an edict forbade any woodworker in Edo to fabricate a small box out of cypress or sugi wood, or household utensils out of sugi wood, but permitted large boxes to be made of either cypress or sugi. In 1668 the shogun went on to ban use of cypress, sugi, or any other good tree for public signboards, and 38 years later large pines were removed from the list of trees approved for making New Year decorations.

All of these negative measures aimed at solving Japan's forestry crisis by ensuring that wood be used only for purposes authorized by the shogun or daimyo. However, a big role in Japan's crisis had been played by wood use by the shogun and daimyo themselves. Hence a full solution to the crisis required positive measures to produce more trees, as well as to protect land from erosion. Those measures began already in the 1600s with Japan's development of a detailed body of scientific knowledge about silviculture. Foresters employed both by the government and by private merchants observed, experimented, and published their findings in an outpouring of silvicultural journals and manuals, exemplified by the first of Japan's great silvicultural treatises, the *Nōgyō zensho* of 1697 by Miyazaki Antei. There, you will find instructions for how best to gather, extract, dry, store, and prepare seeds; how to prepare a seedbed by cleaning, fertilizing, pulverizing, and stirring it; how to soak seeds before sowing them; how to protect sown seeds by spreading straw over them; how to weed the seedbed; how to transplant and space seedlings; how to replace failed seedlings over the next four years; how to thin out the resulting saplings; and how to trim branches

from the growing trunk in order that it yield a log of the desired shape. As an alternative to thus growing trees from seed, some tree species were instead grown by planting cuttings or shoots, and others by the technique known as coppicing (leaving live stumps or roots in the ground to sprout).

Gradually, Japan independently of Germany developed the idea of plantation forestry: that trees should be viewed as a slow-growing crop. Both governments and private entrepreneurs began planting forests on land that they either bought or leased, especially in areas where it would be economically favorable, such as near cities where wood was in demand. On the one hand, plantation forestry is expensive, risky, and demanding of capital. There are big costs up front to pay workers to plant the trees, then more labor costs for several decades to tend the plantation, and no recovery of all that investment until the trees are big enough to harvest. At any time during those decades, one may lose one's tree crop to disease or a fire, and the price that the lumber will eventually fetch is subject to market fluctuations unpredictable decades in advance when the seeds are planted. On the other hand, plantation forestry offers several compensating advantages compared to cutting naturally sown forests. You can plant just preferred valuable tree species, instead of having to accept whatever sprouts in the forest. You can maximize the quality of your trees and the price received for them, for instance by trimming them as they grow to obtain eventually straight and well-shaped logs. You can pick a convenient site with low transport costs near a city and near a river suitable for floating logs out, instead of having to haul logs down a remote mountainside. You can space out your trees at equal intervals, thereby reducing the costs of eventual cutting. Some Japanese plantation foresters specialized in wood for particular uses and were thereby able to command top prices for an established "brand name." For instance, Yoshino plantations became known for producing the best staves for cedar barrels to hold sake (rice wine).

The rise of silviculture in Japan was facilitated by the fairly uniform institutions and methods over the whole country. Unlike the situation in Europe, divided at that time among hundreds of principalities or states, Tokugawa Japan was a single country governed uniformly. While southwestern Japan is subtropical and northern Japan is temperate, the whole country is alike in being wet, steep, erodable, of volcanic origins, and divided between steep forested mountains and flat cropland, thus providing some ecological uniformity in conditions for silviculture. In place of Japan's tradition of multiple use of forests, under which the elite claimed the timber and the peasants gathered fertilizer, fodder, and fuel, plantation forest

became specified as being for the primary purpose of timber production, other uses being allowed only insofar as they did not harm timber production. Forest patrols guarded against illegal logging activity. Plantation forestry thereby became widespread in Japan between 1750 and 1800, and by 1800 Japan's long decline in timber production had been reversed.

An outside observer who visited Japan in 1650 might have predicted that Japanese society was on the verge of a societal collapse triggered by catastrophic deforestation, as more and more people competed for fewer resources. Why did Tokugawa Japan succeed in developing top-down solutions and thereby averting deforestation, while the ancient Easter Islanders, Maya, and Anasazi, and modern Rwanda (Chapter 10) and Haiti (Chapter 11) failed? This question is one example of the broader problem, to be explored in Chapter 14, why and at what stages people succeed or fail at group decision-making.

The usual answers advanced for Middle and Late Tokugawa Japan's success—a supposed love for Nature, Buddhist respect for life, or a Confucian outlook—can be quickly dismissed. In addition to those simple phrases not being accurate descriptions of the complex reality of Japanese attitudes, they did not prevent Early Tokugawa Japan from depleting Japan's resources, nor are they preventing modern Japan from depleting the resources of the ocean and of other countries today. Instead, part of the answer involves Japan's environmental advantages: some of the same environmental factors already discussed in Chapter 2 to explain why Easter and several other Polynesian and Melanesian islands ended up deforested, while Tikopia, Tonga, and others did not. People of the latter islands have the good fortune to be living in ecologically robust landscapes where trees regrow rapidly on logged soils. Like robust Polynesian and Melanesian islands, Japan has rapid tree regrowth because of high rainfall, high fallout of volcanic ash and Asian dust restoring soil fertility, and young soils. Another part of the answer has to do with Japan's social advantages: some features of Japanese society that already existed before the deforestation crisis and did not have to arise as a response to it. Those features included Japan's lack of goats and sheep, whose grazing and browsing activities elsewhere have devastated forests of many lands; the decline in number of horses in Early Tokugawa Japan, due to the end of warfare eliminating the need for cavalry; and the abundance of seafood, relieving pressure on forests as sources of protein and fertilizer. Japanese society did make use of oxen and horses as draft animals, but their numbers were allowed to decrease in response to deforestation and loss of forest fodder, to be replaced by people using spades, hoes, and other devices.

The remaining explanations constitute a suite of factors that caused both the elite and the masses in Japan to recognize their long-term stake in preserving their own forests, to a degree greater than for most other people. As for the elite, the Tokugawa shoguns, having imposed peace and eliminated rival armies at home, correctly anticipated that they were at little risk of a revolt at home or an invasion from overseas. They expected their own Tokugawa family to remain in control of Japan, which in fact it did for 250 years. Hence peace, political stability, and well-justified confidence in their own future encouraged Tokugawa shoguns to invest in and to plan for the long-term future of their domain: in contrast to Maya kings and to Haitian and Rwandan presidents, who could not or cannot expect to be succeeded by their sons or even to fill out their own term in office. Japanese society as a whole was (and still is) relatively homogeneous ethnically and religiously, without the differences destabilizing Rwandan society and possibly also Maya and Anasazi societies. Tokugawa Japan's isolated location, negligible foreign trade, and renunciation of foreign expansion made it obvious that it had to depend on its own resources and wouldn't solve its needs by pillaging another country's resources. By the same token, the shogun's enforcement of peace within Japan meant that people knew that they couldn't meet their timber needs by seizing a Japanese neighbor's timber. Living in a stable society without input of foreign ideas, Japan's elite and peasants alike expected the future to be like the present, and future problems to have to be solved with present resources.

The usual assumption of Tokugawa well-to-do peasants, and the hope of poorer villagers, were that their land would pass eventually to their own heirs. For that and other reasons, the real control of Japan's forests fell increasingly into the hands of people with a vested long-term interest in their forest: either because they thus expected or hoped their children would inherit the rights to its use, or because of various long-term lease or contract arrangements. For instance, much village common land became divided into separate leases for individual households, thereby minimizing the tragedies of the common to be discussed in Chapter 14. Other village forests were managed under timber sale agreements drawn up long in advance of logging. The government negotiated long-term contracts on government forest land, dividing eventual timber proceeds with a village or merchant in return for the latter managing the forests. All these political and social

factors made it in the interests of the shogun, daimyo, and peasants to manage their forests sustainably. Equally obviously after the Meireki fire, those factors made short-term overexploitation of forests foolish.

Of course, though, people with long-term stakes don't always act wisely. Often they still prefer short-term goals, and often again they do things that are foolish in both the short term and the long term. That's what makes biography and history infinitely more complicated and less predictable than the courses of chemical reactions, and that's why this book doesn't preach environmental determinism. Leaders who don't just react passively, who have the courage to anticipate crises or to act early, and who make strong insightful decisions of top-down management really can make a huge difference to their societies. So can similarly courageous, active citizens practicing bottom-up management. The Tokugawa shoguns, and my Montana landowner friends committed to the Teller Wildlife Refuge, exemplify the best of each type of management, in pursuit of their own long-term goals and of the interests of many others.

In thus devoting one chapter to these three success stories of the New Guinea highlands, Tikopia, and Tokugawa Japan, after seven chapters mostly on societies brought down by deforestation and other environmental problems plus a few other success stories (Orkney, Shetland, Faeroes, Iceland), I'm not implying that success stories constitute rare exceptions. Within the last few centuries Germany, Denmark, Switzerland, France, and other western European countries stabilized and then expanded their forested area by top-down measures, as did Japan. Similarly, about 600 years earlier, the largest and most tightly organized Native American society, the Inca Empire of the Central Andes with tens of millions of subjects under an absolute ruler, carried out massive reafforestation and terracing to halt soil erosion, increase crop yields, and secure its wood supplies.

Examples of successful bottom-up management of small-scale farming, pastoral, hunting, or fishing economies also abound. One example that I briefly mentioned in Chapter 4 comes from the U.S. Southwest, where Native American societies far smaller than the Inca Empire attempted many different solutions to the problem of developing a long-lasting economy in a difficult environment. The Anasazi, Hohokam, and Mimbres solutions eventually came to an end, but the somewhat different Pueblo solution has now been operating in the same region for over a thousand years. While the Greenland Norse disappeared, the Greenland Inuit maintained a self-

sufficient hunter-gatherer economy for at least 500 years, from their arrival by A.D. 1200 until the disruptions caused by Danish colonization beginning in A.D. 1721. After the extinction of Australia's Pleistocene megafauna around 46,000 years ago, Aboriginal Australians maintained hunter-gatherer economies until European settlement in A.D. 1788. Among the numerous, self-sustaining, small-scale rural societies in modern times, especially well-studied ones include communities in Spain and in the Philippines maintaining irrigation systems, and Swiss alpine villages operating mixed farming and pastoral economies, in both cases for many centuries and with detailed local agreements about managing communal resources.

Each of these cases of bottom-up management that I have just mentioned involves a small society holding exclusive rights to all economic activities on its lands. Interesting and more complex cases exist (or traditionally existed) on the Indian subcontinent, where the caste system instead operates to permit dozens of economically specialized sub-societies to share the same geographic area by carrying out different economic activities. Castes trade extensively with each other and often live in the same village but are endogamous—i.e., people generally marry within their caste. Castes coexist by exploiting different environmental resources and lifestyles, such as by fishing, farming, herding, and hunting/gathering. There is even finer specialization, e.g., with multiple castes of fishermen fishing by different methods in different types of waters. As in the case of Tikopians and of the Tokugawa Japanese, members of the specialized Indian castes know that they can count on only a circumscribed resource base to maintain themselves, but they expect to pass those resources on to their children. Those conditions have fostered the acceptance of very detailed societal norms by which members of a given caste ensure that they are exploiting their resources sustainably.

The question remains why these societies of Chapter 9 succeeded while most of the societies selected for discussion in Chapters 2–8 failed. Part of the explanation lies in environmental differences: some environments are more fragile and pose more challenging problems than do others. We already saw in Chapter 2 the multitude of reasons causing Pacific island environments to be more or less fragile, and explaining in part why Easter and Mangareva societies collapsed while Tikopia society didn't. Similarly, the success stories of the New Guinea highlands and Tokugawa Japan recounted in this chapter involved societies that enjoyed the good fortune to be occupying relatively robust environments. But environmental differences aren't the whole explanation, as proved by the cases, such as those of Greenland