Cryptomeria japonica: Climate Change, Cultivation, and Culture

Kira Bre Clingen and Edyth Jostol

Japanese cedar (*Cryptomeria japonica*), *sugi* in Japanese, is Japan's national tree and the most widely planted tree species in the country.[1] It was the backbone of a massive and successful afforestation project following World War II (1941-1945) and the Korean War (1950-1953).[2] Today, 70 percent of Japan is forested, and over 24 percent of this forest is made of cultivated plantations. However, the popularity of the tree that led to the widespread planting of the species has been negatively affected by the massive amounts of pollen that the male cones produce each spring[3], resulting in a drastic public health hazard. In fact, one–quarter of the country's population is afflicted with Japanese cedar pollinosis, an allergic reaction.

A plantation of Japanese cedars near the Nakagawa...

Cryptomeria japonica...

The Japanese cedar's cultural significance is well-documented throughout history. The story of Japanese cedar in the twentieth century tells how a single species can culturally, economically, and spiritually shape a national landscape. Today, as aging monocultural stands of sugi fall as they are logged and abandoned, the tree's symbolic role in the landscape is changing to adapt to the needs and concerns of the Japanese population.

A single Japaese cedar rising...

All in the Family

A ubiquitous evergreen conifer planted on all four of Japan's main islands, *Cryptomeria japonica* is native to Japan. Numerous archeological studies have examined buried traces of Japanese cedar pollen to trace its habitation patterns, confirming that the species has existed in small forested areas since around 13,000 BCE. Its presence on the island increased significantly following a change in climate that began in 5,000 BCE and continued into the Common Era, when the country's environment generally became colder and wetter, an ideal climate for cedar trees.[4]

A 300-year old Cryptomeria...

Cryptomeria japonica is a monoecious tree and the only species in the genus Cryptomeria. It is part of the Cupressaceae family found on all continents, which includes junipers, cypresses, and redwoods.[5] Its distinctive pyramidical form with tiered branching appears in traditional Japanese paintings of temples and shrine complexes, often creating a visual backdrop to isolate the sacred space from the wilderness. Associated with religious sites, Japanese cedars are used as an ornamental species and in large groves or to demarcate boundaries. There is a tradition of designating older, larger trees as sacred objects, ritually wrapping them in *shimenawa*, cloth pieces that demarcate places of spiritual significance. In such locations, Japanese cedars are prized, with each individual specimen receiving high levels of maintenance and stewardship.

Hagurosan no Jiji Sugi wrapped in shimenawa near Showai...

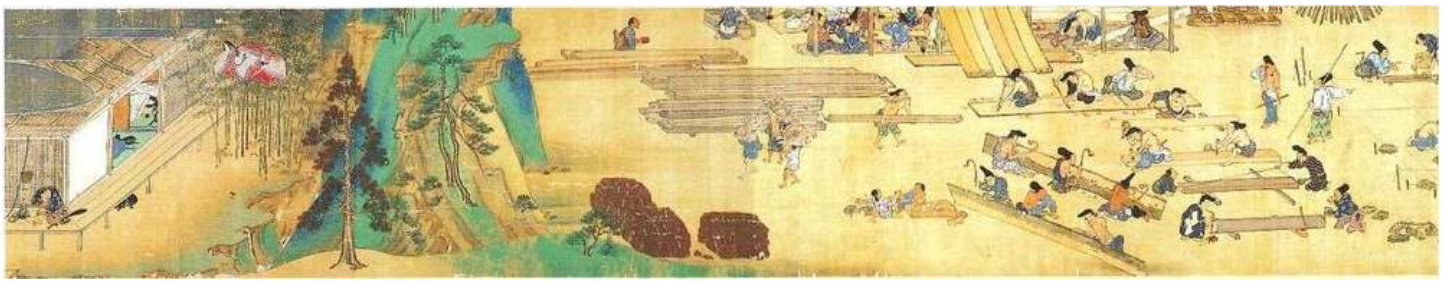
The distinctly...

Historical and Cultural Landscapes

Japanese cedars or *sugi* have been planted for their millennial-old cultural history, quality of timber, speed of growth, and suitability to the climate across the Japanese archipelago. *Nihon Shoki*, the second oldest Japanese historical record that dates from 720 CE, is the earliest written source to mention it. It refers to Susanoo, a multifaceted deity who created trees, including *sugi*, from his hair. *Nihon Shoki* also notes that *sugi* is an excellent material for building ships.[6][7]

Zen garden at Ryoan-ji, with two prominent cedars...

Sugi is depicted in the 1309 painted scrolls entitled Kasuga Gongen Genki. One image of the scrolls shows a single specimen, tall with tufts of needles. It stands alone, neither directly next to the Kasuga Shrine nor in the forest, dominating the foreground. Carefully maintained, the tree still stands in the Nara prefecture today, having withstood the building's reconstructions.[8]



One of the Kasuga Gongen Genki scrolls, showing a Japanese cedar. The set of 20 scrolls were produced by t...

Katsushika Hokusai's woodblock prints of Mishima Pass in Kai province, from the series *Thirty-Six Views of Mount Fuji*(1830-1832), is dominated by an enormous *sugi* trunk. The tree dwarfs the depicted travelers, some of whom are attempting to measure its size, and visually competes with the wonderment of Mount Fuji. Hokusai started this series when he was 70 years old in response to the cultural fascination with the mountain as an object of pilgrimage, due to its scenic beauty as well as mythical connection with immortality. Despite the identified location, this print may not be an accurate topographic representation but an attempt to capture the mood and character of the Japanese landscape.[9]

Mishima Pass in Kai, a woodprint of Mt. Fuji with...

Groves of *sugi* were typically associated with temple complexes. At Ryōan-ji, a temple in Kyoto celebrated for its Zen garden and originally constructed in the fifteenth century, the trees can both be seen in their natural, single-trunk form, reaching over 100 feet into the sky, and as *daisūgi*, a multi-stem coppicing technique that emerged during the Muromachi period (1336–1573) to create thinner posts for tea room construction.[10] Moreover, built in 1617, Nikko Tosho-gu Shrine showcases the grandeur of Japanese cedar trees. Its creation involved the planting of 40,000 specimens, most famously along the Cedars Avenue that led to the shrine. The 10,000 trees that still stand convey the site's spiritual power, which is not limited to the building but permeates the forested landscape.[11]

A temple on the Shikoku Pilgrimage trail, one of...

Established in 4 BCE, Ise Jingū Shrine is situated in a *chinju no mori* (a sacred shrine forest) of dense *sugi*. Historically, Ise has been closely related to both Japan's imperial power, due to ties to rulers, and artistic creation, for its capturing of national landscape ideals. Compared to Nikkō Tōshō-gū, Ise's architecture is simple, and has been positioned as being more "Japanese" than the later-built more baroque shrines, which are considered less harmonious with nature.[12] After World War II, when Shinto was disassociated from the government, the *sugi* forest became central to connecting Ise with the past.

A ukiyo-e depicting Emperor Meiji worshipping Ise...

During his travels in Japan in the late nineteenth century, Charles Sprague Sargent—an American botanist and the first director of the Arnold Arboretum of Harvard University—documented *sugi* as grown both as a timber tree and in temple groves. Noting its use in construction, he also reported the legend behind Nikko's Cedars Avenue. Sargent was told the trees were planted in 1616 by a poor feudal lord as a tribute to Japan's military ruler, the *shōgun*. As he wrote in his *Forest Flora of Japan*, "this avenue, if the story told of its origin is true, can teach a useful lesson, and caries hope to the heart of the planter of trees, who will see in it a monument more lasting than those which men sometimes erect in stone or bronze in the effort to perpetuate the memory of their greatness."[13]

Imaichi road in Nikko (hand-colored albumen print...

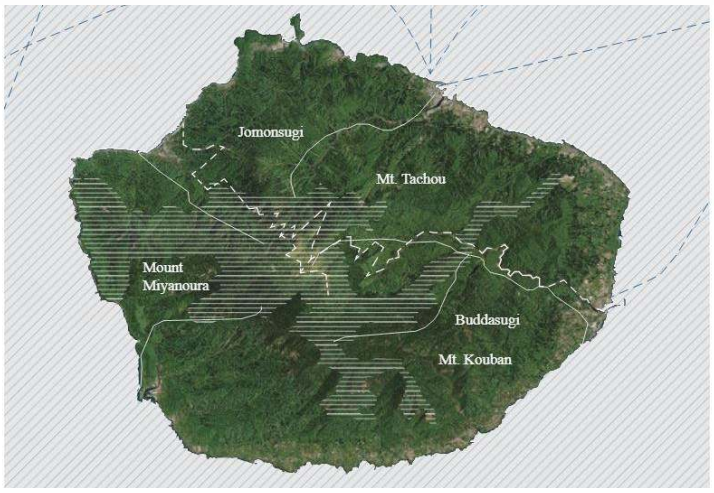
The Cryptomeria Avenue in Nikko, Japan. Publishe...

A View from Yakushima Island

Princess Mononoke, the 1997 fantasy film directed by Hayao Miyazaki and set in the Muromachi period (1336–1573), tells the story of a battle over the survival of the Great Forest Spirit, an animist deity who lives among ancient *sugi* trees.[14] For inspiration for his animated landscapes, Miyazaki traveled to Yakushima Island in the south-west of Japan. The island's environmental history offers a lens for understanding the complexity of Japan's forest history and policy. It is home to one of the last remaining primary *sugi* forests, and also houses the country's largest conifer tree, *Jōmon-Sūgi*, estimated to be over 2,170 years old. The tree grows alongside deciduous overstory species, such as oak and chestnut, with an evergreen broadleaf understory including rhododendrons and epiphytes that grow on branches.[15][16]

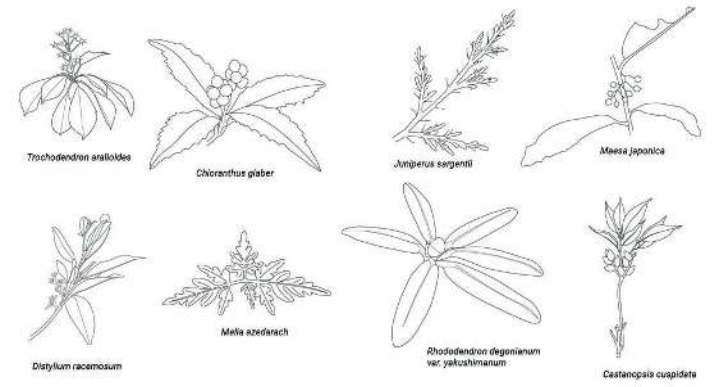
Jōmon-Sūgi on...

A photogrammetry...



A map of ferry routes and trees on Yakushima Islan...

This forest's composition is similar to that of Japan's prehistoric forests. Until roughly 6,000 years ago, northern Japan was covered with broadleaf deciduous species like oaks, with an understory of sedges that endured significant temperature fluctuations across the archipelago. *Cryptomeria* only became a prominent species across Japan 4,000 years ago, even before the Jōmon period (c. 14,000–300 BCE) in Japanese prehistory, when falling sea levels across Japan left behind a bed of clay soil that Cryptomeria thrives on.[17] On Yakushima Island, *sugi* were continuously cut down and replanted as plantations by foresters from the mid-seventeenth century onward. While 4,300 hectares of inland mountainous forest were designated as a research forest in 1922, a network of logging railroads and infrastructure was built to extract more trees during the same time.[18]

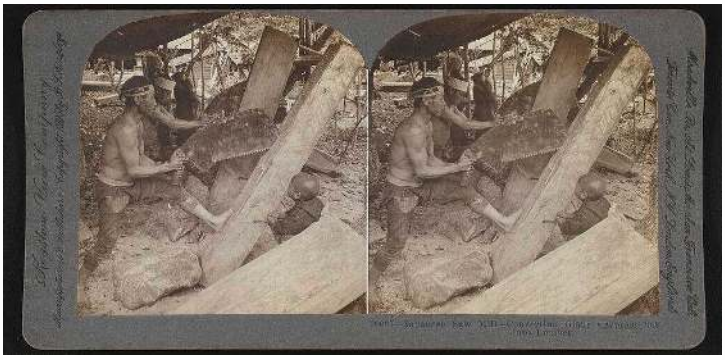


Some of the species that grow alongside Japanese...

The pace of deforestation increased as the Japanese Imperial Army demanded additional timber for ship construction during World War II and the Korean War. During times of shortage, across the Japanese archipelago from Yakushima to Hokkaido, citizens burned the old deciduous and conifer forests as biomass to generate electricity and fuel cooking fires. As a result, by the mid-twentieth century, Japan's landscape was radically transformed, having become sparsely forested.[19] In 1993, Yakushima was added to the World Heritage List for its ongoing geological processes, biological evolution, natural beauty, and significant habitat. The interior primary forest is still preserved and some plantations have been abandoned, while others are still logged to this day.

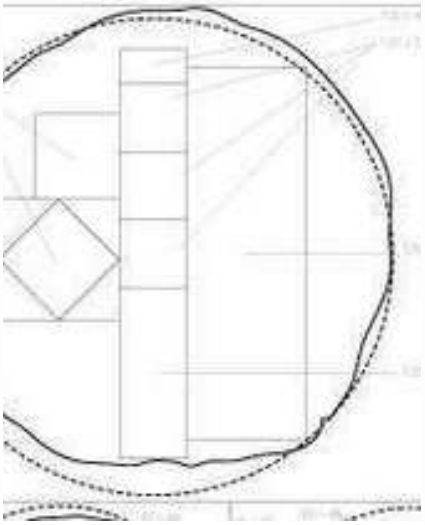
Cryptomeria in Yakushima Island's primary forest...

Crypto Currency: from Specimen Species to Monoculture Mascot


Sawmill workers chopping Japanese cedars into...

Following the World War II period, the Japanese government instigated a series of agrarian reforms that redistributed land from wealthy merchants to smaller tenant farmers.[20] These reforms incentivized forestry and crop practices that maximized short-term yield on limited space, including monoculture planting. Rhetoric around post-war reforestation focused on the need to restore the national landscape. The reform slogan was "[Making] the mountains green" ("*yama o midori ni*"), invoking the image of Japan as a green archipelago. The reforms targeted upland regions but the message was on a national scale, expanding the importance of these economies to the well-being of the country as a whole. The Emperor became a vocal supporter of and active participant in annual national tree planting ceremonies, and he always planted *sugi* when he participated.[21]

In 1964, the Forestry Basic Act was passed, which effectively established a national forest industry in Japan, including plans to build thousands of miles of roads across the nation to allow timber to be easily harvested from hilly, densely forested regions and shipped out to ports along the coast.[22] The Act aimed to build closer ties between urban and rural areas, linking previously separated parts of Japan through educational forestry programs and vocational training. The road network allowed for more than the transport of timber: it enabled the flow of knowledge and forestry practices from the urban centers to the once-isolated rural villages. The legislation also included guarantees from the Japanese government that forestry workers would receive subsidies in the event of a natural disaster or diminishing international markets.[23] The subsidies, which still exist today, included offsetting the harvest and transportation costs, allowing foresters to take advantage of ports and other international distribution points to sell their timber.[24]



The size of tree trunks...

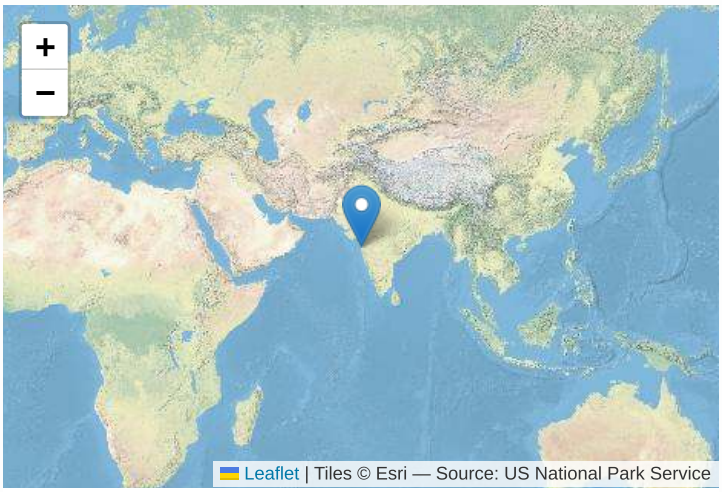
Japanese cedar cut into standard timber sizes to be...

The reforestation campaign focused on conifer plantings, with subsidies and compulsion, so following the success of these agrarian and forestry reforms, 4 billion cedar trees were planted across Japan between 1950 and 1970.[25] Since the 1970s, 16 million new cedar trees have been planted annually.[2627]

Wood shaving from timber...

In the 1980s, the value of tree species such as *Cryptomeria japonica* crashed as the demand for wood products lessened. The intention behind the reforestation plan was to build upland economies, but the increase in forestry support was too late and inflexible. By the time planted trees grew to size, demand had started to wane and Japan had begun to import international resources.[28] Cheaper plastics flooded the market, and other nations, including Portugal, began clearing their forest land to make room for *Cryptomeria* plantations. Tropical timber from islands such as Borneo, which was cheaper to harvest and of a higher quality, entered the market. This new international competition crippled the Japanese market. The promise of a thriving rural economy based on harvesting forest products and efficiently distributing them to urban centers died over the course of a single decade, leaving millions of acres of planted forests with little economic value. Furthermore, after the Great Hanshin earthquake devastated large areas of Japan in 1995, the government created strict regulations around the types of timber that it deemed suitable for domestic construction. Japanese cedar no longer met the new regulations, decreasing domestic demand for the tree.[29]

crypto-portugal

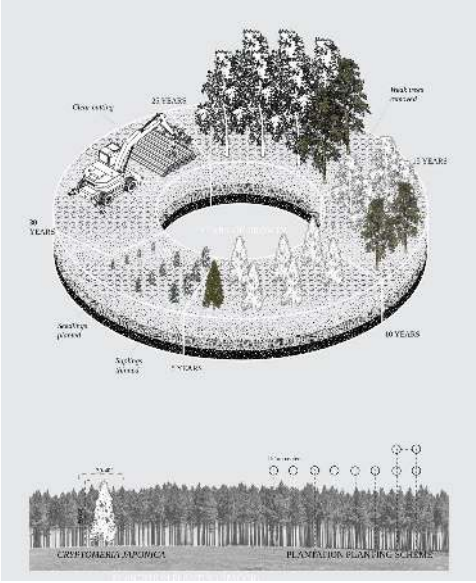


While the economic promises came up short, the idea of restoring the green archipelago seemingly was met. Japan's timber market came to rely on pollution exports from less wealthy countries while maintaining its national forests. But the artificially planted forests host a different environmental issue: undercutting and over-forestation. Conversations around forestry's lack of financial success has been framed as a personal failing, or blame the undercutting of the international market, largely ignoring the role of national reforestation efforts after World War II.[30]

The tree's trunk is covered in plastic while growing...

Growth in the Twenty-First Century

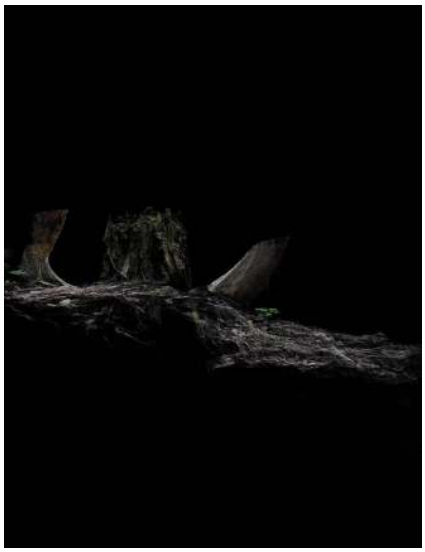
Today, because of the late twentieth-century afforestation policy, Japan is the most densely forested developed nation in the world.[31] But the massive swaths across the country of the monoculture plantations are aging. Many have been abandoned due to high management costs and low profits, despite government subsidies. The increase of unattended and aging stands presents new concerns.



The typical life cycle of a...

Monoculture plantings have changed every layer of the Japanese forest. The regimented distribution of trees at regular intervals destroys layers of understory vegetation that provides habitats for a variety of flora and fauna. On managed plots, foresters remove woody debris, leaving tightly packed vertical trunks. This careful spacing means that most plantations have a high level of living biomass that sequesters carbon. As plantations are abandoned, branches and trunks rot on the forest floor, releasing carbon that is taken up by fungi.[3233] Over time, such plantations may become carbon emitters instead of carbon sinks. Scientists are studying tree-thinning practices to determine the optimal way to maintain beneficial microfungi and introduce a spontaneous understory that colonizes under the plantation branches.[34]

Japanese cedar plantations established between 1900 and...



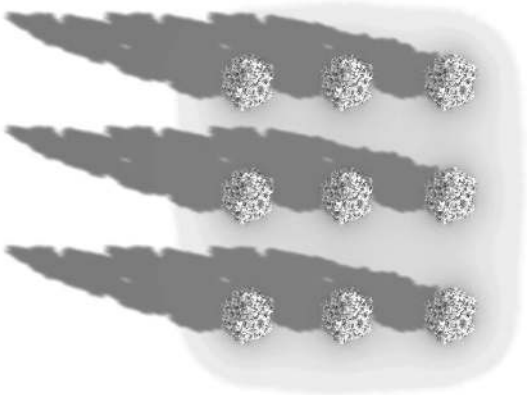
A photogrammetry...

Sugi plantations also pose a significant risk for avalanches and soil slides. The trees have horizontal, shallow roots, and are therefore in danger of falling and stripping away anything else in their path. Such risks are particularly high during heavy rainfall or typhoons, which are common across the archipelago and are projected to increase in intensity and frequency due to climate change.[35]

A landslide caused by a windstorm at a Cryptomer...

Transitioning to more diverse forestry species and practices is a lengthy process. For the 80 species of deciduous trees that grow in Japan to take root on plantations that have been planted in conifer monocultures, the seeds must blow in and have adequate sunlight to establish. Areas that have been completely cleared for *sugi* plantations resist diversification, as there are no local sources of seeds.[36] Even on abandoned plantation sites, regenerating cedars compete with spontaneously growing species, making it difficult for new woody plants to establish.[37] In order to increase the number of forest species, Japan's entire landscape, not just the individual plantations, need to be managed and diversified.

A Japanese cedar plot that has been partially...

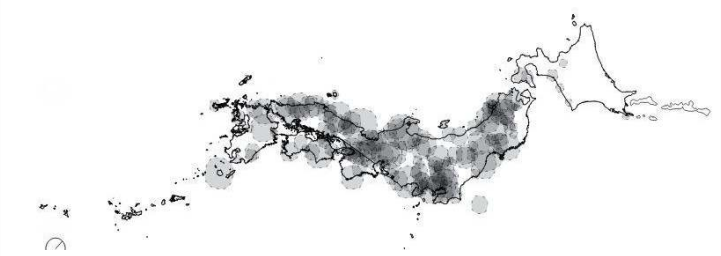


tree-shadows

Areas where *sugi* trees are growing will likely remain planted with conifers for hundreds of years, while areas where they have been cut down will see new species emerge on the forest floor, creating new types of plant communities. New forms of human stewardship have begun to gain popularity in response to both monoculture plantations and an increasingly urbanized population. Starting in the late 1990s, *satoyama*, the restoration of traditional agrarian landscapes started to gain traction, fueled by nostalgia and increased interest in biodiversity. Access to rural areas by city dwellers was increased through volunteer programs that aim to help clear land, plant native species, create habitat for foraging sought-after Matsutake mushrooms, and form connections with the landscape. The Nakagawa Revitalization Project is one example of this. Operated by retired professor Yoshiya Iwai, the project includes a community library, hosts events and home-stays and is expanding to include a hobbyist woodworking facility.[38] Once again, Japan's species composition will be transformed as its landscape is reshaped by human interaction. This new type of forest will require new management practices and a different approach: learning from connections within diverse ecosystems instead of merely dealing with plantations and spontaneously growing forest.

Japanese cedars near the Nakagawa Revitalization...

Pollen Nation



crypto-pollen2

The risk of pollinosis—a reaction to the pollen released every spring as *Cryptomeria* begins to breed— has changed the composition of Japanese plantations. Female trees release up to five pounds of pollen each spring, relying on pollinators and the wind to spread their seed. Across the country, 33 million people are affected by pollinosis in what becomes the nation's largest public health crisis each year. Japan's health and forestry agencies have developed a comprehensive public health campaign to limit exposure. Monitors throughout major cities and the countryside count the amount of pollen in the air and warnings to wear masks and avoid going outside are issued in urban areas by government agencies, universities, and public health clinics working together. In urban areas such as Tokyo, where tree plantations exist directly outside the city, containing pollinosis is challenging. High rooftops employ Cryptomeria canopies to collect pollen before it falls onto roadways where tires churn it up, creating a loop of resuspending pollen after it falls to the ground.[39]

Allergy-free Japanese cedar seedlings grown unde...

The Japanese government has worked to genetically alter the species, which would allow the rural forestry industry to continue in an era of increasing urbanization. It started a campaign to produce pollen without the allergens *Cry j1* and *Cry j2*, which create symptoms of pollinosis. Research agencies across the archipelago breed these hypoallergenic trees for future plantations. Since 2007, 130 different pollen-free varieties have been produced. The cost of these trees makes them a challenge to plant as an alternative to the nonmodified *sugi* trees. A program of subsidies from the Japanese government, however, attempts to lessen the burden on foresters.[40]

Taking a Stand

The *sugi* afforestation project shows the dangers of treating rural forest areas as an economic resource independent of international networks with little consideration for the industry's effect on local populations and environments. The policies of the Forestry and Forest Basic Act of 1964 enabled the creation of landscapes that now generate an annual public health crisis. The fallout of these policies reveals how interconnected urban and rural areas are: trees growing hundreds of miles from urban centers dramatically affect the lives of millions of city inhabitants. These issues are likely to continue until new species are introduced to *sugi* monocultures and forests are restored to a new kind of ecological balance, expanding the importance of maintaining a green archipelago that includes localized biodiversity. The story of *sugi*, or *Cryptomeria japonica*, suggests that falling stands can give rise to many models of regeneration and adaptation.

A photogrammetry composite image of 109 image...

Acknowledgments

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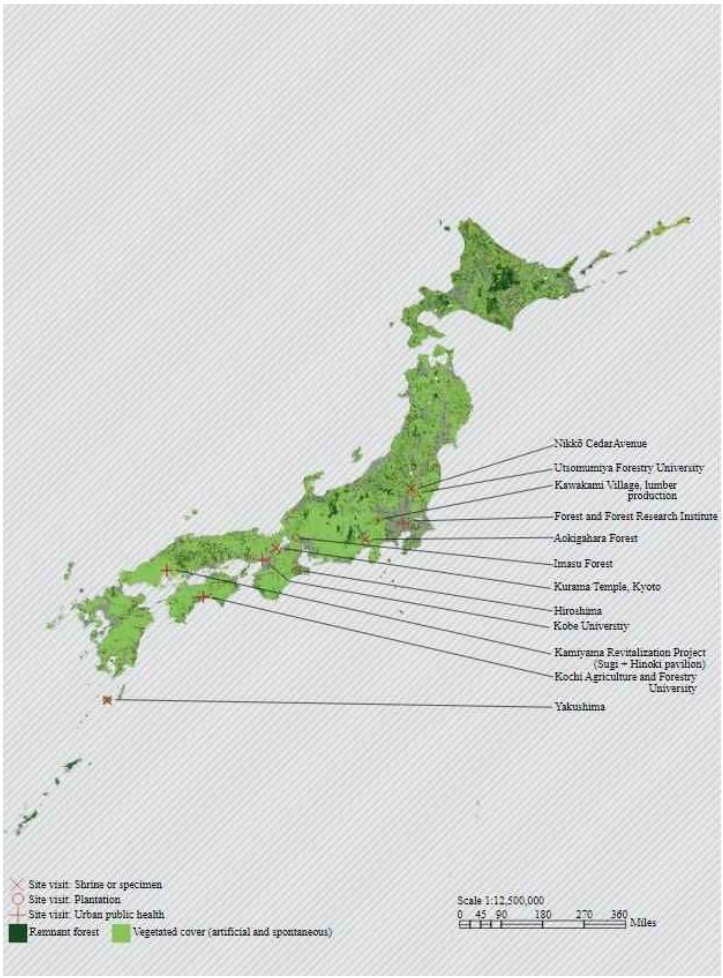

The sites visited by the authors during their trip in...

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