

A.D.– 400 A.D. —Native Ecosystems (this is the start of the timeline; native ecosystems have been evolving in the Hawaiian Islands for 30 million years!)

PLANTS AND ANIMALS THAT MAKE UP OUR NATIVE ECOSYSTEMS TODAY are the descendants of colonizers that survived the long journey over the Pacific. Blowing in the jet stream, floating across the wide expanse of sea, or arriving on or in birds, plants and animals slowly colonized the islands. Since the journey was so difficult, scientists estimate that new land birds probably arrived in the islands only once every 1,500,000 years. Flowering plants arrived and established themselves more frequently but only once every 30,000 years or so! More than 90 percent of the native plants and animals of Hawai‘i are *endemic*—that is, they occur nowhere else on the planet. How did Hawai‘i end up with so many unique species and why are so many of them endangered today? There are three main reasons that the islands have so many endemic plants and animals.

1) The Hawaiian Islands are ***the most isolated islands in the world***. This extreme isolation limited the number and kinds of successful colonizing plants and animals. No amphibians or reptiles reached the islands without the help of people and only two kinds of mammals—a bat and a monk seal—were successful pioneers. Before people arrived, there were no large mammalian predators. The colonizing plants and animals most likely had some forms of defenses against predators. But over time, through mutations or changes in their gene structure, some of these defenses were lost. Some plants lost thorns and poisonous saps that would repel grazing animals. Some birds and insects became flightless and the native stink bug became stinkless! Later, when people introduced invasive plants and animals, the native species were vulnerable. Many were defenseless or unable to successfully compete with the invaders.

2) The islands have ***a stable tropical climate*** that provided favorable growing conditions at lower elevations for newly arriving plants and animals. Because of the moderate climate, plants required no dormant period and annual plants that would have died in the winter found a continuous growing season in the islands. These plants could then grow year-round and some involved from small herbs to tall tree-like plants.

3) The islands have ***many different habitats in the mountainous terrain***. Temperature and rainfall varies from sea level to mountain crests and within valleys and on ridges. The result is more than 150 different natural communities, including dry coastal areas, rainforests and alpine shrublands and deserts. The variety of ecosystems provided a number of different habitats to the descendants of colonizing species. Many of these descendants gradually changed and adapted to the new habitats and became uniquely Hawaiian. The beautiful Hawaiian honeycreepers with their astonishing variety of bill shapes and the diverse group of lobelias that many of them pollinate are just a few examples of the evolution of unique plants and animals in the islands. A number of these unique species have or had relatively small populations that are adapted to limited habitats.

LOSS OF HABITAT AND THE INVASION OF ALIEN SPECIES INTO THE ISLANDS are the primary causes for the loss of native plants and animals in Hawai‘i. Of the 150 natural communities in the islands, 85 are considered to be critically endangered.

400 A.D.–1200 A.D. —Polynesian Introductions

IMAGINE BEING ONE OF THE FIRST POLYNESIAN SETTLERS of the Hawaiian Islands at least 1,500 years ago. If you had landed on a windward coast, you probably would have encountered mesic (moist) or wet shrublands and forest. In these environments were many unique and beautiful plants and animals found nowhere else in the world. You might have been disappointed by the limited number of edible plants in the forest, but the trees and shrubs would provide for other needs. In the upland forests were towering *koa* trees that would become your canoes, *‘ōhi‘a* trees would provide supports for your homes, and, hundreds of years later, the birds that fed on the *‘ōhi‘a* blossoms would provide feathers for cloaks, helmets and *kāhili*.

On the drier, leeward side of the islands you would have discovered dry forest, shrubland and grasslands. Some of these shrubs, like the native *ma‘o* (cotton) would provide you with a source of dyes for your *kapa* and medicine to relieve stomach cramps. The dryland forest you would find to be even richer in species than the rainforest. Eventually you would discover that the native *wiliwili* tree in this forest was a good source of lightweight wood to make surfboards. If you had ventured above 6,000 ft (1,830 m) on Maui or the Big Island you would have found the cool, subalpine forest, the alpine shrubland, and at the summit, the alpine desert.

The Polynesian settlers introduced pigs, dogs, chickens and 32 plant species. Stowaways on their canoes included Polynesian rats, land snails, three types of skinks and four species of geckos. The large animals they introduced were sources of food and did not appear to have any significant impact on native ecosystems. The Polynesian pig may have caused some damage to forests, but it dwelled primarily in the lowland settlements. Most of the plant species that Polynesians introduced can still be found growing in lowland environments. When hiking in valleys today, the most common Polynesian-introduced plants we find are *kukui*, *‘ōhi‘a ‘ai*, (mountain apple) and *kī*. *‘Ōhi‘a ‘ai* and *kī* are found as understory plants in many native forests where they may have replaced native species. *Kukui* seems to have had the greatest ability to invade lowland areas.

The Hawaiians created a new environment with their cultivation of their main food crop, *kalo*. In wet, windward valleys, they diverted water from streams into stone terraces (*lo‘i*) where the *kalo* was grown. As their population grew, more land was cultivated for *kalo*.

1200 A.D.–1778 A.D. —Hawaiian Land Use

AROUND 1200 A.D., A GROWING HAWAIIAN POPULATION began moving into drier leeward areas. Hawaiians used fire to clear lowland areas up to 1,500 feet (460 m) elevation to make way for homes and crops. Scientists studying pollen samples from old lowland deposits on leeward O‘ahu have found that *loulou* palms made up a large percentage of the pollen load. These native palms probably were a dominant tree in lowland forests that have since been lost. On the island of Hawai‘i and east Maui, Hawaiians completely cleared the original dry and mesic (moist) forest on leeward slopes to develop their dryland agriculture systems.

Archaeologists have a radiocarbon date of 1250 A.D. from old charcoal left from burning forests on the ‘Ewa Plain of O‘ahu. Below the charred area there are many shells of native tree snails; above the burn, the tree snails disappear and scientists found tiny snails that Polynesians introduced with their *kalo*. In Hālawā Valley on Moloka‘i, archaeologists have found evidence that tell a similar story of change. In soils that washed down from burned forest slopes above, the lower layers have lots of native tree snail shells. Above them is a layer of small chunks of black charcoal from when the forest was burned. Above the burn layer the native tree snail shells disappear.

Evidence of flightless birds that once lived in the islands has also been found in lava tubes and limestone sinkholes. At least 17 species of flightless birds, including large flightless geese and ibises lived in the islands. All but the Laysan flightless rail were lost to extinction before 1778. The Laysan rail became extinct in the 1940s.

Radiocarbon dates from artifacts found in the Mauna Kea adze quarries indicate that in the 1600s there was extensive use of these areas to make large *ko‘i* (adze). These *ko‘i* were used to harvest large trees before new forest areas were burned. By the time of Captain Cook’s arrival in 1778, most lowland areas in the islands had been cleared for agriculture and other uses. At this time, native ecosystems above approximately 2,500 ft (760 m) elevation were still intact.

1778 A.D.–1850 A.D. —European Animal and Plant Introductions

SINCE EUROPEANS ARRIVED IN THE ISLANDS, native ecosystems have changed dramatically. Captain Cook and Captain Vancouver introduced large grazing and browsing mammals that became feral (wild, not domesticated), multiplied, and spread into island natural communities. Cattle, goats, pigs, and sheep have been the most destructive feral animals. They feed on native plants, compact soil, and cause erosion and sedimentation of streams and reefs. Since vulnerable native plants of Hawai‘i evolved without these large mammals, they have no poisonous saps or thorns to repel them.

Cattle were introduced to the Big Island in 1793 by Captain Vancouver. Kamehameha I placed a *kapu* (taboo) on the animals to allow their population to grow. By 1850, the Big Island was estimated to have 12,000 wild cattle and these animals were so common on O‘ahu that they were rounded up in the streets of Honolulu. Grazing cattle have had a devastating impact on native forests on all of the main islands. Their grazing and trampling opens up the forest, destroys the forest understory and makes way for alien plants to take hold.

Goats can continue the damage that cattle begin and they can reach more inaccessible areas. Goats were introduced by Captain Cook on Ni‘ihau in 1778 and again by Captain Vancouver on the Big Island in 1792. By the 1820s, goats were spreading on O‘ahu and Kaua‘i. They eventually were introduced to all of the main islands and now occur on all islands except Ni‘ihau, Lāna‘i, and Kaho‘olawe.

Captain Cook also brought pigs (European boars) to the islands on his first voyage. A ten-year *kapu* was placed on the pigs and they multiplied quickly.

In 1826, the first mosquitoes arrived as larvae in the water barrels of a ship from Central America. A sailor dumped the water containing the mosquito larvae into a Maui stream. The larvae became adults and the adults reproduced. We now have a few different mosquito species all the major islands. Today, mosquitoes breed in pig wallows and spread diseases to native birds.

Sugar cane production was first attempted on O‘ahu as early as 1819. In 1835, the Kōloa Plantation on Kaua‘i was the beginning of a sugar venture that lasted many years. After the “Great Mahele” in 1848, which allowed foreigners to own land, more large-scale commercial agriculture took place, resulting in more clearing of upland forests and in the displacement of many Hawaiians from their land.

1850 A.D.–1930 A.D. —Rapid Change in a New Century

BY THE MIDDLE OF THE NINETEENTH CENTURY, low and middle elevation native ecosystems were impacted by cattle ranching, sugar cane plantations and *koa* and sandalwood logging. In the next few decades, cattle ranches spread higher into upland native forests, converting them to non-native pastureland. By 1890, most of the land in the islands was owned by the government. Three out of every four acres of non-government land were either owned or leased by foreigners. Most of it was purchased for growing sugar cane. During this time, songbirds were introduced to the islands to replace many native species that had been lost in the lowlands. Some birds were also introduced for hunting. Many of the alien birds have spread introduced diseases to the native birds and competed with them for habitat. Non-native birds also spread the seeds of invasive alien plants. Most of the birds you hear singing around your home and school, such as cardinals, house finches and Japanese white-eyes, were brought to the islands from other parts of the world.

Large mammals were also introduced to the islands for hunting. In 1868, axis deer were introduced to Moloka‘i. Over the next 80 years, axis deer were introduced to O‘ahu, Maui and Lāna‘i. On Moloka‘i, cattle and deer have had a devastating impact on native forests, degrading the plants and causing soil erosion. The deep mudflats along the leeward coast of Moloka‘i are made from soils that once supported rich native forests upslope. Small mammals create major problems in native ecosystems, too. Rats, particularly roof rats, prey on nestlings and feed on birds’ eggs. The mongoose was introduced at the end of the nineteenth century to control rats in sugar cane fields. Since the mongoose is active during the day and rats are nocturnal, this control never happened. Today rats and mongoose and feral cats have a devastating impact on native birds.

Many alien plants were introduced to the islands from all over the world. One tree from Portugal, the firetree, was brought to the Big Island before 1900 as a source of firewood and fruit for wine-making. Today it is a serious pest, spreading in forests and crowding out native trees. Another invader of wet forests is banana poka—a vine with attractive flowers that was introduced as a garden plant to the Big Island before 1921. It became naturalized and spread into native forests where it grows over native trees and smothers them. Today banana poka covers 90,000–97,000 acres (36,000–38,800 ha) combined on Hawai‘i, Kaua‘i, and Maui. This invasion is the size of Lāna‘i or one-quarter of O‘ahu. Other invaders that pose a serious threat to wet habitats are *Miconia*, strawberry guava, *Clidemia*, *Tibouchina*, ginger, raspberry, blackberry and common guava.

By the beginning of the twentieth century, low and middle elevations of the islands were becoming increasingly urbanized as the human population grew. At this time, growing demands for fresh water focused attention on the barren hillsides that needed to be reforested. Habitat protection in Hawai‘i began with the establishment of the Territorial forest reserve system in 1903. The main focus of the forest reserves was to protect the forested watersheds. In the 1920s, the Territory also began the largest fencing and feral animal removal projects. More habitat was protected when national parks and wildlife refuges were established in Hawai‘i.

1930 A.D.–Present —Repairing the Land

IN THE 1930S, A MASSIVE REFORESTATION EFFORT was begun by the Civilian Conservation Corps (CCC). To reforest damaged watersheds, foresters planted thousands of fast-growing, non-native trees that were not valued for timber so that later generations would not be tempted to cut the trees. They also planted experimental plots of trees from Asia and the Pacific. Two of the most widely planted alien trees, Cook pine (which resembles Norfolk Island Pine) and eucalyptus, are now common throughout the lower reaches of the forest. The State legislature increased habitat protection measures over the last 30 years by establishing the State Natural Area Reserves System and by establishing conservation zoning that recognizes the importance of native species' habitat. In the late 1960s, The Nature Conservancy of Hawai'i acquired its first preserve on Maui. The combined efforts of public and private agencies have preserved 500,000 acres (200,000 ha) of native communities, representing about 15 percent of the state's total land area.

A major challenge for preserve managers is to control the alien plants and animals in these preserves. Approximately 4,600 plants have been introduced to the Hawaiian Islands; 800–900 have become naturalized and more than 80 of them are serious pests. By 1980, 150,000 acres (60,730 ha) of conservation zoned forest land in the Islands had been invaded by pest plants. Mesic and dry habitats are dominated by alien plants today. Some of the worst invaders that threaten these habitats are firetree, silk oak, *koa haole*, lantana, Christmasberry and gorse. By the mid-1980s, firetree had infested more than 83,980 acres (34,000 ha) in the state, mostly on the Big Island, with smaller infestations on Maui, Lāna'i, O'ahu and Kaua'i.

The European boar continues to be a serious pest in rainforests on all main islands except Lāna'i where they were removed in the 1930s. Wild pigs are valued as food by many islanders who hunt them and want to have populations maintained for this purpose. Others would like to see all pigs removed from forests to protect native species. Maintaining sheep populations for hunting has posed similar problems on the Big Island. Due to sheep damage of its habitat, a native honeycreeper, the *palila*, was the first animal to serve as a plaintiff in a lawsuit—*Palila vs. the State of Hawai'i*.

Mouflon sheep were released on Lāna'i in 1954; eight years later they were released on the Big Island. On the Big Island today, Mouflon sheep are found in the Ka'ū district in mesic and subalpine forests. On Mauna Kea, both Mouflon sheep and feral domestic sheep were causing severe damage to the subalpine forest and alpine shrubland, threatening the survival of the endangered *palila* and silverswords. After a number of years, the lawsuit was settled. The *palila* won and the State was ordered to remove feral sheep from subalpine forests. As a result of a later lawsuit, the State was also ordered to remove the Mouflon from the alpine shrubland on Mauna Kea in order to protect the silverswords. On Lāna'i, these sheep inhabit dry *kiawe* forest and do not appear to be moving into the native forest.

In the last 200 years, people have introduced plants and animals at a much faster rate than the native species dispersed to the islands. Species that arrived here naturally had millions of years to settle in. Today, we are flooding the islands with non-native species at an alarming rate (***approximately a million times greater than the natural rate of dispersal***). This invasion poses the single greatest threat to the survival of remaining native ecosystems.