Transported Landscapes

Long before Captain Cook discovered Hawaii, the islands and their flora and fauna had been transformed by Polynesian settlers

by Patrick V. Kirch

During the ten million years or more that the main Hawaiian Islands have existed as an archipelago, they have received a stream of colonists, ranging from passively dispersed seed plants and insects to migratory or wayward birds. From such progenitors evolved distinctive flora and fauna of marvelous and often bizarre forms. Because they evolved in isolation, however, these endemic life forms were extremely vulnerable to outside competitors. No more than about 1,600 years ago, some new colonists—Polynesians—arrived on the scene, culminating the greatest human dispersal of all time, the "conquest" of the Pacific by Oceanic peoples. This conquest went far beyond the discovery of the most isolated islands on earth. The story of Polynesia is one of interaction between people and island ecosystems that had for millions of years evolved in the absence of humans and other large terrestrial animals. While the Polynesians had to adapt to the conditions and challenges posed by island life, this was no passive adaptation. Rather, the Polynesians modified and at times drastically altered their island homes.

The impact of the prehistoric Polynesians on Hawaii has not always been appreciated by biologists and anthropologists. Biologists have often assumed that the major decline and extinction of native species occurred only in the past two centuries, following the advent of Europeans with their introduced weeds, insects, cattle, goats, sheep, and so on. Similarly, many anthropologists—intrigued by the conservation techniques sometimes practiced by Oceanic peoples, including the Hawaiians—assumed that there was a sort of harmonious relationship between the Polynesians and their environment.

Evidence that the early Polynesian settlers in Hawaii drastically altered their environment has slowly been accumulating for decades, but it was a serendipitous discovery in 1976 that startled archeologists and biologists into realizing that their data formed a coherent picture of prehistoric human impact. Bishop Museum archeologist Akihiko Sinoto found large quantities of well-preserved bird bones in several limestone sinkholes situated in an ancient elevated reef at Barbers Point, Oahu. Sinoto had been testing these sinks for evidence of human use, either for habitation or for agriculture. The surprise came when these semifossil bones were submitted to paleobiologists Storrs Olson and Helen James of the Smithsonian Institution, who determined that several unknown and bizarre species of birds were represented by this material, including a large, flightless goose. The Barbers Point material was unusual not only for the extent and diversity of the extinct species present but also because it showed that many of these birds had survived well into the period of human occupation of the islands. Had the Polynesians been in some way responsible for the reduction of this bird fauna?

In an effort to reconstruct the environmental context of these birds and any role that humans may have played in altering this environment, Carl Christensen, a Bishop Museum malacologist, and I began a study of the abundant fossil shells of terrestrial snails that had been observed in the same limestone sinks that contained the bird bones. Land snails are known to be good indicators of local environmental conditions, and in a manner analogous to pollen analysis, the relative frequencies of species through a sequence of sedimentary deposits may be used as evidence of environmental changes.

In analyzing our column samples from the Barbers Point sinkholes, we made several significant findings. First, in the upper levels of the sinks, where the extinct bird bones were concentrated, several endemic species of land snails declined greatly in abundance, while certain other species increased. Significantly, the species that became more abundant were those that continue to demonstrate that they are good competitors, surviving in the Hawaiian lowlands even in the face of a variety of more recently introduced species. Far more interesting, however, was the appearance in these same stratigraphic levels of *Lamellaxis gracilis*, a particular species of land snail known to have been transported by humans with soil and plants over much of the tropical world. Shells of *Lamellaxis* had been recovered from prehistoric archeological sites in the South Pacific dating to as early as 1200 B.C., and we suspected that the early Polynesians had also brought this species to Hawaii as a stowaway on plant stocks. We also found other clues—the bones of *Rattus exulans*, a small rat associated with Polynesian settlements, and of a gecko and a skink, two species frequently dispersed by humans.

A consistent picture thus emerged from the Barbers Point investigation: at the time that the now-extinct birds were dying and their bones were being deposited in large numbers, the local environment was undergoing a radical change. Not only did the land snails indicate changing vegetation conditions, but the *Lamellaxis*, rats, geckos, and skinks indicated that humans were present in the area and suggested that their actions were in some way responsible for these changes. The extinction of the birds was probably due to the alteration of their habitats rather than to direct predation by the Polynesians. Recent evidence, however, does suggest that now-extinct birds were also hunted and eaten by the early Hawaiians. During the past two to three years, additional major archeological projects—mostly under the aegis of the Bishop Museum—have provided more information concerning the past environment of various areas of Hawaii and the role of humans in changing the landscape and its life forms.

The Polynesian alteration of the Hawaiian ecosystem began with the initial human colonization of the archipelago early in the first millennium A.D. In their original state, the Oceanic islands—including Hawaii—offered little in the way of terrestrial food resources for human settlers. Certainly, rich shellfish beds, abundant fishes and turtles, and large populations of nesting sea birds would have provided a good supply of protein for the first colonists, but edible food plants, particularly farinaceous staples, were lacking (an exception was the indigenous tree fern, whose starchy pith was utilized by the Polynesians in times of famine). To establish themselves on the islands, the Polynesians transported with them a range of crop plants, domesticated species primar-

On Captain Cook's third voyage of discovery, portraits of native Hawaiians were drawn by John Webber and later published as engravings. The man, below, wears a mask made from a bottle gourd, one of the plants that the Polynesians brought with them when they settled the islands.
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ily of Southeast Asian origin, such as taro, yams, bananas, and breadfruit. Breeding populations of the domestic pig, dog, and jungle fowl were brought along as well, to provide additional food sources in the new landfall. The introduction of these crop plants and animals (at least sixteen species in all), and the clearance of native forest to accommodate gardens and orchards, marked the beginnings of what, over several centuries, became a radical alteration of the Hawaiian environment.

In their double-hulled voyaging canoes, the Polynesians carried far more than a set of crop plants and domestic animals. We have already seen that land snails (not only *Lamellaxis*, but probably also *Lamellidea oblonga* and *Gastrocopta pediculus*) and a small rat, geckos, and skinks were introduced to Hawaii. These species were presumably all inadvertent stowaways on the voyaging canoes, and once released in their new island environment, they must have undergone rapid population expansion—particularly since the native fauna were unaccustomed to serious competition. We know also, from the records of botanist David Nelson, who accompanied Capt. James Cook on his third voyage of 1778 (the European "discovery" of Hawaii), that well established in the lowlands were a number of tropical weeds that also must have been dispersed by the Polynesians. These weeds included water purselane, which frequents wet habitats such as irrigated pond fields of taro, and crabgrass, which abounds around pigpens. Like snails, rats, and lizards, these weeds are powerful competitors; they must have immediately begun to replace endemic lowland plants wherever the Polynesians settled.

Both the purposeful and the inadvertent introductions to Hawaii of a range of competitive species by the Polynesians provide a classic example of what the botanist Edgar Anderson called "man's transported landscapes." Not only did the Polynesians surround themselves with an imported flora and fauna; they also undertook to actively modify and manipulate their insular environment according to cultural concepts that they had inherited from their ancestors in the South Pacific and, ultimately, Southeast Asia. Having arrived in this remote Pacific archipelago, the Polynesians did not simply adapt passively to its constraints and limitations, for like all human groups, they had their own ideas and values concerning how the world was to be ordered. As anthropologist Marshall Sahlins put it, the "action of nature is mediated by a conceptual scheme," a scheme that for the Polynesians included such concepts as the efficacy of fire in clearing forest for garden land, the feasibility of diverting streams to feed irrigated pond fields, and the suitability of broad coastal mudflats for the construction of large fishponds. In short, the Polynesians saw their island world as a plastic landscape to be molded to suit the needs and purposes of a growing human community.

As with other species that had preceded them to these shores, the Polynesians who colonized Hawaii underwent a rapid population explosion, growing from probably fewer than 100 persons at the time of first settlement to somewhere between 200,000 and 300,000 at the time of Captain Cook's first contact in 1778. During the first few centuries after settlement,

the population remained small and the impact of human activities on the native environment was probably slight. But, as the population increased at a geometric rate, and the need for new agricultural land and the exploitation of wild food resources increased, this impact became correspondingly greater. By 1200 the population had multiplied to a point where the more marginal leeward coasts of the main islands were being permanently settled, and by 1400 large tracts of leeward parkland and forest were being cleared to make way for extensive field systems of cultivated sweet potato and taro. At the same time, valley bottoms were being converted to irrigated complexes, and the broad reef flats of Kauai, Oahu, and Molokai were modified by the construction of several hundred stone-walled fishponds for the husbanding of mullet fish. By 1600, probably 80 percent of all of the lands in Hawaii below about 1,500 feet in

An inland view of Waimea, Kauai, by shipboard artist John Webber shows the dispersed settlement pattern that characterized the Hawaiian landscape at the time of Captain Cook's arrival in 1778. The early Hawaiians made extensive use of fire to clear forest for agriculture and to maintain grasslands.

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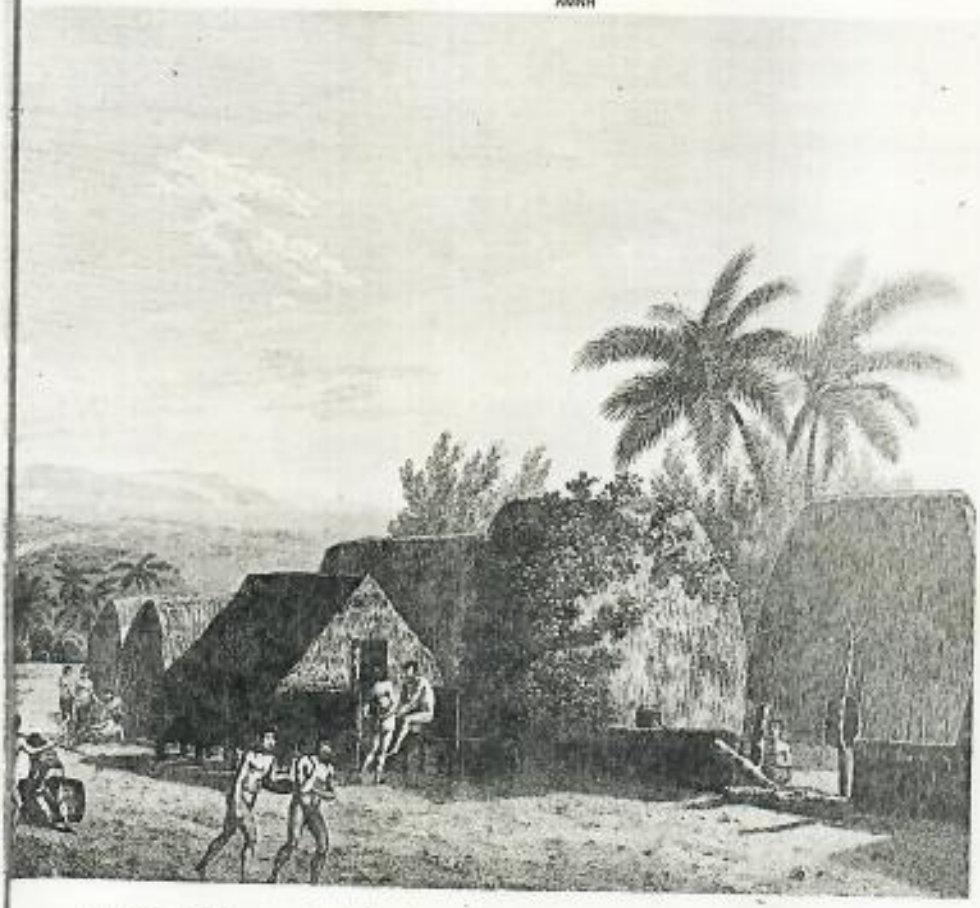

elevation had been extensively altered by the human inhabitants. Today, only a few small areas of remnant dry or moderately moist forest hint at the former diversity of life in the lowland areas. Clearing of these habitats to make way for agricultural fields resulted in the extinction of untold numbers of species of plants, arthropods, land snails, and birds.

Like tropical agriculturists everywhere, the Polynesians made extensive use of one great tool, fire. Polynesian agriculture was essentially a form of shifting cultivation: tracts of forest or bush were cleared and burned to create garden plots; after several years of cultivation, these would be abandoned to secondary vegetation, and new plots would be cleared. As the population of the islands increased, however, many areas were gradually converted to more or less permanent cultivation, either dry-field systems on the leeward slopes or irrigated pond fields in valley bottoms.

Fire was also used to maintain tracts of grasslands created through removal of forest. Archibald Menzies, who was with the explorer Capt. George Vancouver in 1792, observed a great fire that burned off thousands of acres of dry tanglehead (*pili*) grass. Menzies reported that the Hawaiians purposely set such fires every year or so, as "the next crop of grass grew up clear and free of stumps, and was therefore better adapted for thatching their houses."

The clearance of large tracts of leeward slope and valleys, and the replacement of native forest with cultivations and secondary-growth shrubs and grasses, had an impact not only on the life forms of the islands but also on the physical landscape itself. Removal of native vegetation had the effect of exposing hillsides and slopes to erosion, and it now appears that the rate of erosion in some areas increased significantly after the human colonization of Hawaii. On Molokai Island, extensive alluvial deposits at the base of the Halawa Valley have been dated to the thirteenth century and are believed to reflect erosion caused by forest clearance on the valley sides. Charcoal in the erosional deposits indicates that fire was used in the forest clearance. The deposits also contain—in the lower levels—thousands of shells of endemic land snails that testify to the diversity of the original forest habitat prior to clearance.

The increased erosion and deposition of alluvial sediments in valley bottoms certainly had consequences for the Polynesians themselves. In the upper Makaha Valley on Oahu, forest clearance on steep ridges caused a major mudslide that buried the fields and ditches of a complex of irrigated taro fields under thousands of cubic yards of sediment. Archeological excavations in this field complex revealed this major geomorphic event and further showed that the valley's occupants had laboriously dug themselves out of the mud and rebuilt the irrigation complex. Probably not all erosion had such deleterious effects. In some areas, such as Kahana Valley on Oahu, increased deposition of sediments may have helped create alluvial flood plains more suited to the construction of irrigated fields than the original valley bottoms.

In the past decade, archeological investigation in Hawaii has disproved the old assumption that the Polynesians did not have a major impact on their island environment. We now have evidence that at the time of initial settlement by Polynesians from the South Pacific, the Hawaiian Islands supported a much more diverse flora and fauna than were recorded by the early European naturalists some fourteen centuries later. The impact of the Polynesians was, naturally, strongest in the lowlands, where they transformed vast areas of native forest into a cultural landscape of agricultural fields, grasslands, and habitations. While we are still just beginning to understand the scale of this human modification of a remote oceanic archipelago, the Hawaiian case serves to remind us once again that the study of nature is in many ways inseparable from the study of culture. □