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Hawai‘i Nontimber Forest Products: Cultural and Economic Foundations

Katie L. Kamelamela, James Chamberlain, Ashley D. Lehman, Irene Sprecher, James B. Friday, and Tamara Ticktin

Authors

Katie L. Kamelamela (kkamelam@asu.edu) is an assistant professor, Arizona State University, and a researcher, Center for Global Discovery and Conservation Science, 60 Nowelo Street, Hilo, HI 96720; **James Chamberlain** (james.l.chamberlain@usda.gov) is a research forest products technologist, U.S. Department of Agriculture, Forest Service, Southern Research Station, 1710 Research Center Drive, Blacksburg, VA 24060; **Ashley D. Lehman** (ashley.d.lehman@usda.gov) is a supervisory biological scientist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 161 E 1st Avenue, Door 8, Anchorage, AK 99501–1639; **Irene Sprecher** (Irene_Sprecher@forestsolutionsinc.com) is the president of Forest Solutions Inc., 42–378 Kalapahapuʻu Road, Paʻauilo, HI 96776; **James B. Friday** (jbfriday@hawaii.edu) is an extension forester, University of Hawaiʻi at Mānoa, College of Tropical Agriculture and Human Resources, Komohana Research and Extension Center, 875 Komohana Street, Hilo, HI 96720; **Tamara Ticktin** (ticktin@hawaii.edu) is a professor of conservation biology and ethnoecology, University of Hawaiʻi at Mānoa, School of Life Sciences, 2500 Campus Road, Honolulu, HI 96822.

Cover photo: Women compete in the 2016 Merrie Monarch Festival hula competition in Hilo, Hawaiʻi, wearing maile (*Alyxia stellata*) leis and floral hair and neck pieces. Photo courtesy of Extreme Exposure.

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Abstract

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The Hawaiian Islands are an isolated archipelago in the Pacific Ocean with diverse forests covering 1.5 million ac—36 percent of Hawai‘i’s total land area. These forests produce wood for local use and support trade, yet large-scale timber production has never been significant in Hawai‘i. In contrast, nontimber forest products (NTFPs), have been foundational to the culture and economy of the state throughout history and continue to be elemental to contemporary society. The rich variety of NTFPs sourced from Hawaiian forests can be observed at diverse social events and informal gatherings. Species used as NTFPs are harvested for a wide range of reasons, including food, medicine, art, textiles, floral garments, floral displays, weaving, and cultural ceremonies. They are harvested and used by people of all ages and socioeconomic classes and support cultural heritage, identity, and connection to nature. Despite these values, there is little information on the reliance, variety, and amounts of NTFPs harvested from Hawaiian forests. Documenting the types, amounts, spatial distribution of harvesting, and current and projected demand and uses for NTFPs is critical to understanding the management needs of these forests and their social, ecological, and economic values to Hawai‘i residents.

This study used multiple methods to document NTFPs, their uses, and significance. Methods included summarizing state collection permits, interviewing and surveying stakeholders, and observing uses at cultural events. We identified more than 140 plant species harvested and used as NTFPs. Thirty-eight percent were native or endemic to Hawai‘i. Almost all the permits issued by the state were for personal use. Interviews and surveys indicated a strong link between product use and people’s connections to spiritual values, cultural rights, and the land. We found that endemic species, such as maile (*Alyxia stellata*), palapalai (*Microlepia strigosa*), ‘ōhi‘a lehua (*Metrosideros polymorpha*), and koa *(Acacia koa*) had high market value, were under extreme pressure, and would benefit as priority targets for management, conservation, and nature-based development. Findings from this study could guide management plans and actions to conserve Hawai‘i’s vast forest diversity and cultural economy.

Keywords: biodiversity, culture, economy, forest products, harvest permits, Hawai‘i.

Preface

The intent of this study was to use a replicable method to identify, describe, and document nontimber forest products (NTFPs) in the state of Hawai‘i and to estimate their economic values. In 2010, the U.S. Department of Agriculture (USDA), Forest Service, Forest Inventory and Analysis (FIA) program formed a partnership with the state of Hawai‘i and the University of Hawai‘i to establish permanent forest monitoring plots across the state to provide a comprehensive assessment of Hawaiian ecosystems and monitor changes. A fundamental element of the FIA program is to assess the value of industrial and nonindustrial uses of roundwood by state. Given the absence of significant timber harvesting in Hawai‘i, the state requested the FIA program to instead examine the role of NTFPs. A cooperative agreement with the University of Hawai‘i was established to explore the breadth of plant species being harvested and used as NTFPs across the state. This study used a variety of methods to explore and understand the cultural values and economic contributions of NTFPs to communities in Hawai‘i. The goals of this study were to highlight the species collected and used for personal use or sold at markets and create a replicable approach for subsequent studies to assess changes in quantities and locations of harvest as well as overall NTFP use in Hawai‘i. This work presents an approach that may be replicated for similar studies in other regions and states.

Contents

Introduction

Nontimber forest products (NTFPs) are gathered from forests of the United States and around the world and provide a diversity of values to society, including economic livelihoods, support of cultural practices, and community well-being (Chamberlain et al. 2018, Shackleton et al. 2011). NTFPs originate from parts of plants (e.g., fruits, flowers, leaves, barks, saps, roots, branches, stems, and boles) and fungi that are harvested from forests. Typically, they do not include products made from sawnwood, although they may be made from wood, such as carvings. In general, NTFPs are considered specialty forest products within niche markets. In this study, we make an exception because wood products are of such cultural and economic significance to society and industry, and they would benefit from fair and equitable examination. Often it is difficult to discern if a wood product is from sawn lumber or roundwood gathered from forests. Wood turnings are often from cants (partially sawn logs with one or more flat sides) cut from sawnwood, although some woodworkers use stems and burls cut from live trees. Wood used to make a ‘ukulele is from sawnwood and veneers. Without tracking to the source, determining if a specialty wood product is in fact a nontimber product is challenging. Likewise, determining if wood products are from sawnwood is challenging without tracking to the source. For these reasons, we include wood products, particularly koa (*Acacia koa*) and sandalwood (*Santalum* sp.), in this assessment. The appendix provides a complete list of plant species mentioned in this report, including scientific names, authorities, locally known common names, and sources.

These products provide societal needs for food, medicine, crafts, and housing and support the arts, ceremonies, and other cultural practices. NTFPs support subsistence practices and can subsidize household income (Shackleton et al. 2011), while contributing to a state’s economy. They are harvested and used by people of all ages and socioeconomic classes, support cultural heritage and identity, and sustain human connection to the natural environment and places of personal and community significance. Sustainable harvest of NTFPs may help conserve cultural and biological diversity and contribute to local livelihoods, serving as a buffer against poverty (Anderson-Fung and Maly 2009, Cocks et al. 2011, Ticktin and Shackleton 2011), yet determining harvest levels and practices that are sustainable remains a critical unanswered research question.

NTFPs have a long history of use in Hawai‘i (Abbott 1992, Handy et al. 1991, Hiroa 2003, Krauss 1993, Pukui 1983) and continue to be important to the livelihoods of communities (Kamelamela 2011, Keali‘ikanaka‘oleohaililani 2016, Matsuoka et al. 1994, McMillen and Kamelamela 2014). This report identifies the extensive historical and contemporary uses of NTFPs in Hawai‘i, identifies species harvested, examines the geographic distributions of harvest, and provides insights into their local market economic contributions and cultural significance.

Hawaiian Island Ecology

Hawai‘i is the southernmost state in the United States and the most isolated landmass in the world. The main islands (Ni‘ihau, Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, Kaho‘olawe, and Hawai‘i) span more than 400 mi (643.7 km) and encompass a land area of 6,423 mi^2 (16 635.4 km^2). The highest points, Mauna Kea and Mauna Loa on the island of Hawai‘i, are almost 14,000 ft (4200 m) in elevation. Most soils in Hawai‘i are derived from volcanic rock, although they differ greatly in age and degree of weathering. The oldest soils in the archipelago are more than 5-million-year-old Oxisols, while the newest land on the island of Hawai‘i is volcanic lava only days old. The windward, montane areas of Hawai‘i are some of the wettest in the world, receiving more than 300 inches of rain annually (Giambelluca et al. 2013). Conversely, leeward areas can receive less than 10 inches of rain a year. Windward areas with deep soils support large-stature tropical forests, while dry leeward areas and alpine deserts support sparse shrublands (Asner et al. 2016). Although grasslands are extensive today, most were created as a result of hundreds of years of clearing forests for pastures, other agricultural activities, and harvesting forest products such as firewood. About half of the original native ecosystems have been converted to some other land use, and the remaining natural habitats have been altered by introduction of invasive plants, animals, pests, and diseases, with effects ranging in severity (Selmants et al. 2017).

About 90 percent of the about 1,300 vascular plant taxa are endemic as indicated by the Bishop Museum's *Hawaiian Native and Naturalized Vascular Plants Checklist* (Imada 2012) and the *Manual of the Flowering Plants of Hawai‘i* (Wagner et al. 1999). We used Wagner et al. (1999) to identify species and authorities for plants mentioned in this report. One species, ‘ōhi‘a lehua or ‘ōhi‘a (*Metrosideros polymorpha*) dominates 80 percent of the native forests. Yet, the flora of the Hawaiian Islands has evolved from arrivals that originated in Asia, America, and Oceania. Seeds transported by wind, ocean currents, and migrating or storm-stranded birds reached the Hawaiian Islands and occasionally flourished. Those that thrived led to some of the most intricate adaptive traits in plants (e.g., Hawaiian silverswords [*Argyroxiphium*]) and in animals (e.g., Drepanididae,

Hawaiian honeycreepers). Native forests are affected by invasive woody species (e.g., strawberry guava [*Psidium cattleianum*] and Christmas berry [*Schinus terebinthifolius*]) and introduced grasses (e.g., fountaingrass [*Cenchrus setaceus*], buffelgrass [*Pennisetum ciliare*], and kikuyugrass [*Cenchrus clandestinus*]). Some trees that are now invasive were planted more than a century ago in the Forest Reserve System by the Territorial Government, which advocated that there was no reason to plant native species as native forests were already destined to be invaded (Lyon 1918). Importation of ornamental plants has led to introduction of pests and diseases, many of which attack native Hawaiian plants. The most significant new disease is rapid ‘ōhi‘a death, a vascular wilt caused by two pathogenic fungi, *Ceratocystis lukuohia* and *C. huliohia*. Rapid ‘ōhi‘a death was first identified in 2014; by 2017, it had spread to more than 135,000 ac on the island of Hawai‘i, killing millions of ‘ōhi‘a trees. As ‘ōhi‘a trees die, pristine, upper elevation forests affected by the disease are likely to remain dominated by native plants, while lower elevation forests are being taken over by invasive plant species.

Historical Uses

The use of NTFPs in Hawai‘i dates back to when humans first came to the islands. Early Hawaiians adapted to their environments and began adding value to the largely endemic plants. Prior to European contact, most plants were used for personal consumption. For example, Hawaiian sandalwood (‘iliahi) was gathered for medicine and to add scent to tapa (also known as kapa) (bark) cloth, which was made from the inner bark of wauke (*Broussonetia papyrifera*) or māmaki (*Pipturus albidus*) (Abbott 1992). Applying learned technologies and experimenting with new species, Hawaiians fashioned fibers from endemic olonā (*Touchardia latifolia*) into robust rope for international maritime trade. Although the fiber quality was the highest caliber at that time, and the rope was the “finest cordage made in the Pacific basin” (Krauss 1993), synthetic cord eventually replaced olonā rope. Today, the species is uncommon, and the knowledge of how to cultivate the plant and harvest and spin the fibers is disappearing, although attempts have been made to revive the practice (Wichman 2012).

The intentional introduction of plant species began with arrival of Polynesian voyagers more than 1,000 years ago (Athens et al. 2014). They brought more than 20 plant species, including taro (*Colocasia esculenta*), sweet potato (*Ipomoea batatas*), bananas (*Musa* sp.), and breadfruit (*Artocarpus altilis*) (Abbott 1992, Balick and Cox 1996, Krauss 1993). These mainstay plants provided the new settlers with materials for food, fiber, medicine, ceremony, leisure, and adornments (Abbott 1992, Hiroa 2003). Some species, such as taro, bananas, sugarcane (*Saccharum officinarum*), and kukui (*Aleurites moluccana*) were planted in forests as seed

banks in preparation for possible natural disasters and droughts (Handy et al. 1991). Today, they are referred to as Polynesian introductions, and many are naturalized in Hawai‘i. Krauss (1993) defined the term “Polynesian-introduced plants” in strictly botanical circles and did not consider them to be native.

In the early 1800s, Hawaiian newspapers documented key forest species used for cord, fabric, and containers, as well as other functional products, such as canoes, paddles, and digging sticks. These essential products came from a mix of native and Polynesian-introduced species. Pukui (1983) recorded the historical use of native trees, such as ‘ūlei (*Osteomeles anthyllidifolia*), pāpala kēpau (*Pisonia umbellifera*), and māmane (*Sophora chrysophylla*) for daily or ritual fires. These native shrubs and trees have been documented for many uses, such as house construction, fishing scoop nets, medicine, lei (garlands), and glue for bird and small-animal traps (Abbott 1992, Medeiros et al. 1999). Handy et al. (1991) identified 14 native and Polynesian-introduced plant species that were traditionally consumed as food (e.g., fern pith, shoots, small-tree and herb leaves, berries, and fruits), which are still consumed today. Many had multiple uses. For example, the hāpu‘u (*Cibotium* spp.) was used for food, medicine, preparing bodies for burial, and for building structures (Chun 1994, Handy et al. 1972, Krauss 1993).

Indeed, NTFPs played important roles in the livelihoods of Native Hawaiians and influenced development of today’s society and forest resources. Hawaiian-language newspapers publish proverbs, songs, and stories that are treasures of traditional plant uses and place names. Species such as hāpu‘u, olonā, and sandalwood have deep cultural ties with long histories and commercial values in the islands. In short, the range of species that were gathered was highly diverse and founded on a long history of usage. Further, the uses of NTFPs were diverse, spanning all aspects of human well-being (food, shelter, medicine, ritual, etc.) and based on a long history of trial-and-error usage.

Commercialization

Early 19th to 20th century industries, based on whaling, sandalwood, and later sugarcane, structured domestic and international political, colonial, and territorial relations that influenced NTFP harvesting. Although these industries were led by people not from Hawai‘i (Borreca 1999), they involved complex networks uniting offshore demand with local harvesters, producers, and distributors. With the arrival of whaling ships, markets opened for NTFPs from the Hawaiian Islands. For example, beginning in the early 1800s, forests near Hawai‘i’s ports were denuded to meet the demand for firewood that fueled boilers for reducing whale blubber into oil (Cuddihy and Stone 1990). While whaling declined, demand for firewood grew in the early 1900s to support the processing of sugarcane. Another example was the thriving export of the fine “hairs” (pulu) of the tree fern to meet demand for pillow

and mattress stuffing. According to Cuddihy and Stone (1990), several hundred thousand pounds of pulu were collected annually from the Kīlauea region on the island of Hawai‘i and exported to North America from 1851 to 1884. Export peaked in 1862 when more than 738,000 lb were shipped in one year but collapsed in the 1880s with the substitution for pulu of superior materials (Cuddihy and Stone 1990).

Contemporary Harvest

Harvesting NTFPs provides significant economic, social, and cultural benefits to Hawai‘i and its inhabitants. Gathering and sharing products are key aspects of Hawaiian social resilience, supporting subsistence and cash economies (Matsuoka et al. 1994, McMillen and Kamelamela 2014). NTFPs are shared, gifted, traded, or sold through formal and informal market channels, such as cultural events and retail outlets. Stewardship and removal of invasive species by gatherers has improved the status of some NTFP populations (Ticktin et al. 2006, 2007), while others have declined over time. Two trees, koa and sandalwood, are used to make specialty wood products with exceptional commercial value and are included in this discussion of NTFPs.

Koa, a large forest tree, is one of the predominant forest products supplying a specialty market. About half of the original koa forests have been converted to other uses, mainly pasture (Baker et al. 2009). Koa wood ranges in color from golden yellow to dark red or brown and has a unique grain. Traditionally, koa trees up to 100 ft tall were carved into canoes. Today, koa wood is used for furniture, interior paneling, cabinets, picture frames, guitars and ‘ukuleles, turned bowls, and crafts. Sections of logs that cannot be milled into lumber are cut and sold as bowl stock. Turned koa bowls are very valuable, with large pieces selling for hundreds or thousands of dollars. Straight logs are occasionally carved into highly prized racing canoes and featured in koa-canoe-only racing events. Koa stumpage prices—the price a logger pays a landowner for the right to harvest wood—have increased from $150 per 1,000 board ft in the 1980s to more than $6,000 per 1,000 board ft in 2017. Despite these high prices, koa plantations are limited, and natural stands are scarce. This is owing in part to risks that private landowners face, including uncertain economic analysis, pests and diseases such as the pathogenic fungus *Fusarium oxysporum* Schlecht., and regulatory uncertainties (Pejchar and Press 2006).

Six species of sandalwood are native to Hawai‘i, although the only remaining merchantable stands are of *Santalum paniculatum*, located on the leeward side of the island of Hawai‘i. A resurgence of harvesting sandalwood has occurred in the past decade, as several ranches have started marketing products and reforesting. Products marketed internationally include solid wood, chips for oil extraction, and fine dust for incense sticks. Almost all sandalwood harvested in Hawai‘i is

Figure 1—Left: maile (*Alyxia stellata)* harvested in the wild. Right: the plant after harvest, ready for crafting lei. Photos by Katie Kamelamela.

used in the state to manufacture sandalwood oil, which is sold to the cosmetics and essential oil industries for sunscreens, soaps, and therapeutic oils. In 2017, sandalwood oil was advertised for more than $1,350 per pound. Small amounts of sandalwood oil are used locally to manufacture lotions and soaps. Although oil is extracted from many species of *Santalum* around the Pacific, oil from the Hawaiian species, *S. paniculatum*, is prized for its chemical characteristics and commands a premium price.

Perhaps the most prominent nonwoody NTFP comes from vines harvested from the endemic plant maile, which is used to make highly fragrant lei. Typically, only the new growth is harvested, particularly stem sections that contain leaves (fig. 1). Most of the local harvest is from the islands of Hawai‘i and Kaua‘i. Notably, most of the maile used for lei in Hawai‘i is imported from the Cook Islands and Tonga (O’Connell 2009). In 2001, maile was the fifth most sold type of lei on the island of O‘ahu and the most expensive at $18 to $35 per lei (Watanabe and Fujita 2001).

Historically, Hawaiians harvested hō‘i‘o (*Diplazium arnottii* and *D. sandwichianum*) for food (Hiroa 2003, Pukui 1983), but with the introduction and naturalization of *D. esculentum* (hō‘i‘o) along forest streams, the latter species is predominantly harvested and sold today. These fern shoots and fiddleheads are cooked or served raw in many restaurants and homes throughout Hawai‘i. Other fern shoots reported to be purchased are known as kakuma (*Cibotium* sp.). Other native species bought or sold at formal or informal markets include ‘ōhi‘a, koa, and ‘ōhelo (*Vaccinium* spp.) berries.

NTFP harvest involves a wide range of people who harvest for a variety of reasons. For just one ahupua‘a (a division of land ownership based on access to resources; nearly 400 exist across Hawai‘i), people harvested 44 plant species for food, fiber, fuel, hula, musical instruments, and ceremonies (Kamelamela 2019). Eight of the species were nonnative and considered invasive (Hawaii Invasive Species Council, Coordinating Group on Alien Pest Species 2023). Sixty-eight percent of the harvested plants were in some way managed by the collectors, including monitoring, planting, pruning, weeding, or seed harvesting. Some nonnative plants, such as kiawe (*Prosopis pallida*), are preferred for creating "imu," a traditional underground cooking technique used to bake or steam food, such as taro, breadfruit, pork, and chicken. Kamelamela (2019) found that more than 90 percent of imu gatherings used firewood from forests, and about 67 percent reported harvesting the leaves for the "hāli‘i," which covers the food while cooking in the imu. Over 93 percent of the people practicing imu gathered kīawe. Eighty four percent of respondents preferred Kīawe for imu over other wood options. Guava (*Psidium guajava*) was the second most commonly gathered firewood species, while ōhi‘a was the second most preferred firewood species. The most preferred and used species for the hāli‘i (cover) was banana, while ti leaf (*Cordyline fruticosa*) was the second most preferred species. The gathering of firewood and leaves for imu has strong cultural values that are often considered in harvest management.

Land Ownership and Implications to Gathering

Native Hawaiians developed a land stewardship system that provided access to forest resources for gathering NTFPs before European contact. Although private ownership did not exist, boundaries were established to restrict access to the resources. Hawai‘i land stewardship developed within a land tenure system made up of political ecological structural units called "ahupua‘a" (Handy et al. 1991, Minerbi 1999). Ahupua‘a are often delineated by ridgelines with boundaries extending to the ocean (fig. 2); they are still used by land managers, landowners, and other community members. Today, ahupua‘a place names often provide relevant NTFP information, including insights into the availability of resources. Most resources, such as water, needed to sustain a family or community can be obtained within an ahupua‘a, which serves as a sociopolitical management unit (Abbott 1992, Kame‘eleihiwa 1992). Historically, forest gatherers who were found harvesting resources from an ahupua‘a that was not under their control were punished (Gomes 2016).

Figure 3 illustrates the division of lands within the state today. The ahupua‘a system and community-based resource management were converted into these three land classes in 1848: (1) privately owned fee simple, (2) lands reserved for the government, (3) lands reserved for the Crown. Today, lands once reserved for the Crown, described as ceded lands, are administered by state and federal

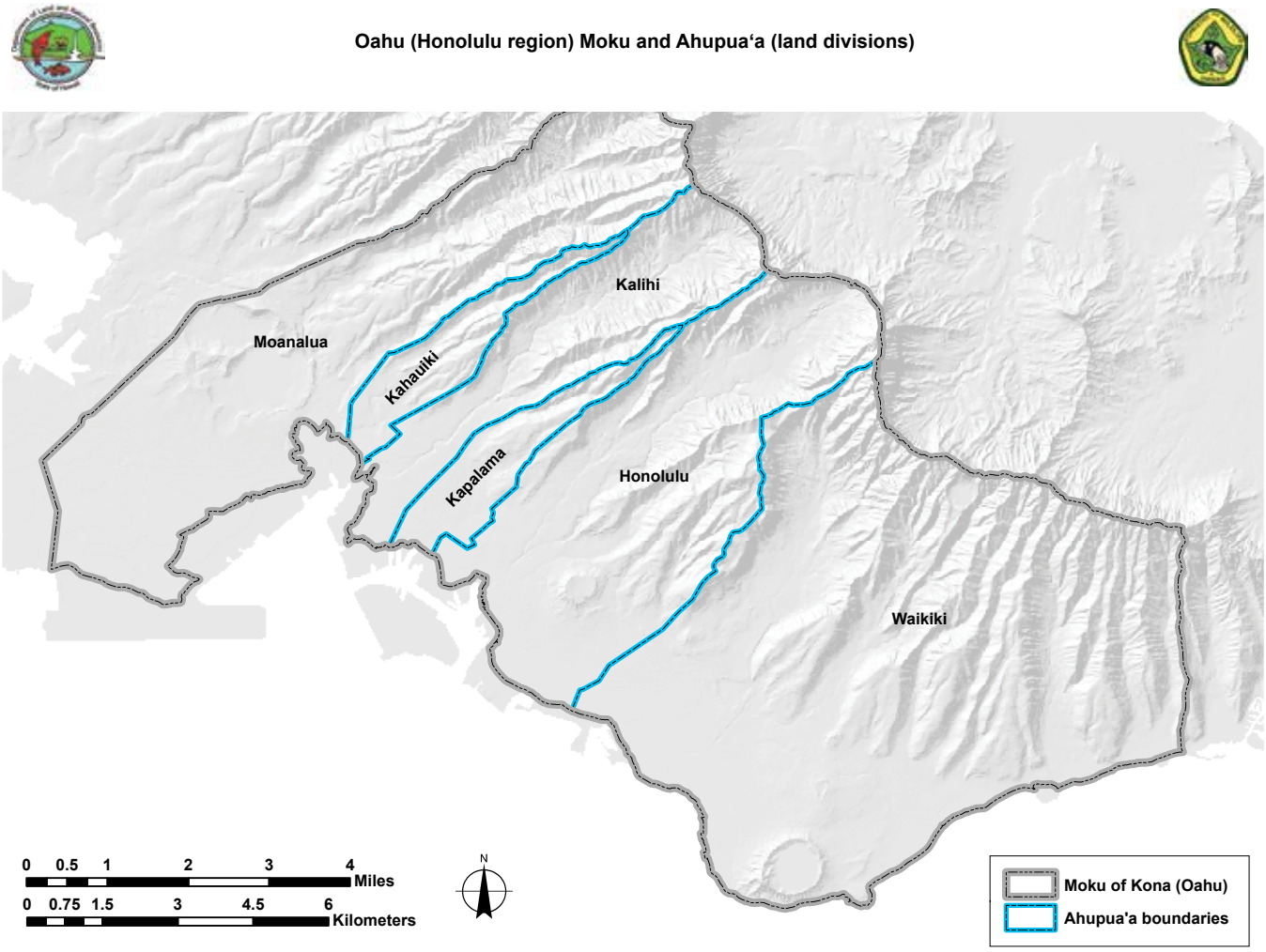

Figure 2—An ahupua‘a is a typical land division in Hawai‘i that is often guided by ridgelines and extends to the ocean (see outline in blue); moku divisions within an island (black lines) can include multiple ahupua‘a.

governments. About 66 percent of Hawai‘i’s 1.8 million acres of forest land is privately owned, and much of it is held by a few large landowners (DLNR 2017). Land reserved for the government and portions of Crown land are held in trust for the Hawaiian people by the state of Hawai‘i. State forest lands are managed primarily by the Hawai‘i Department of Land and Natural Resources (DLNR), which oversees forest reserves, natural area reserves, wildlife sanctuaries, unencumbered lands, and lands leased to private users. The U.S. Department of Defense, U.S. Department of the Interior National Park Service and Fish and Wildlife Service, Department of Hawaiian Homelands, and Office of Hawaiian Affairs also manage forest lands in Hawai‘i. Understanding differences among these ownerships is important because they affect NTFP accessibility, management, and uses, while privatization has fragmented resource access, use, and stewardship responsibilities.

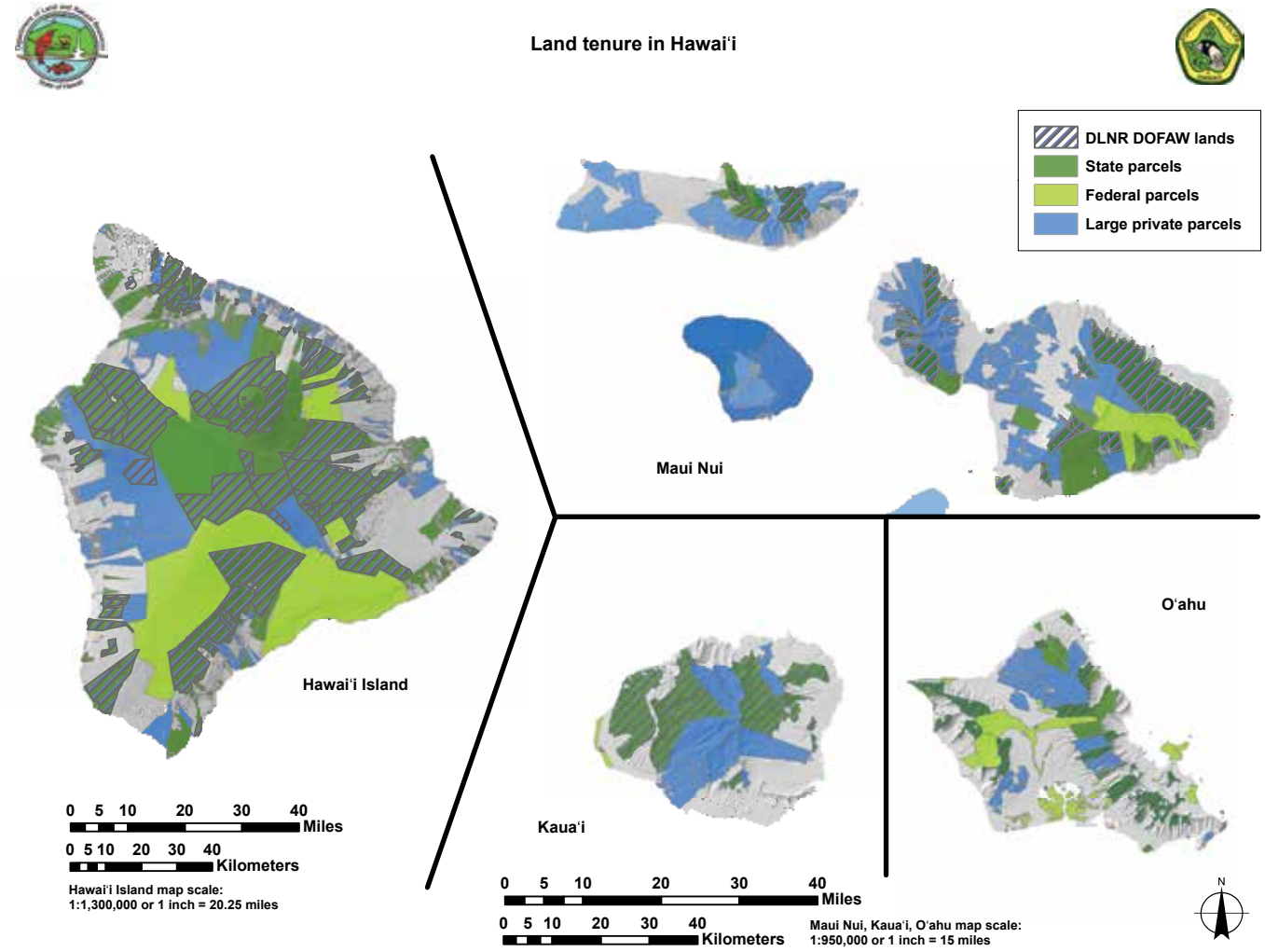

Figure 3—Contemporary Hawai‘i land tenure system. Courtesy of Hawai‘i Department of Land and Natural Resources (DLRN), Division of Forestry and Wildlife (DOFAW). Ni‘ihau Island is not shown.

Native Hawaiian access and gathering laws—

The right to gather forest products was codified in the Kuleana Act of 1850 by King Kauikeaouli (Kamehameha III). This law revived as Hawai‘i Revised Statutes 7-1 and provides that, “When the landlords have taken allodial titles to their lands, the people on each of their lands shall not be deprived of the right to take firewood, house-timber, ‘aho cord, thatch, or k[ī] (ti) leaf, from the land on which they live, for their own private use, but they shall not have a right to take such articles to sell for profit” (Hawai‘i Legislative Reference Bureau 2015). Hawai‘i Revised Statutes section 1.1, originally adopted in 1892, acknowledged traditional and customary Native Hawaiian practices “established by Hawaiian usage.” Gathering was further codified in article 12 (Hawaiian Affairs), section 7 (Traditional and Customary Rights) of the state’s constitution, which secures the rights of Native Hawaiians to gather resources for subsistence, cultural, and religious purposes and including a wide range of practices. Native Hawaiians have unique traditional and customary rights and public and private lands throughout Hawai‘i (Hawai‘i Legislative Reference Bureau 2015).

Native access to gathering NTFPs in Hawai‘i has been upheld in the courts. In Public Access Shoreline Hawai‘i vs. Hawai‘i County Planning Commission, the court decided that “Native Hawaiian interests are different from those of the public at large” and that “Native Hawaiians will retain rights regarding undeveloped lands, to pursue traditional activities” (Sproat 1998). Gathering NTFPs is integral for hula, which is a critical aspect of retaining Hawaiian traditions (Ticktin et al. 2006). Hula is just one of many cultural practices protected under Native Hawaiian legal rights to gather NTFPs.

General public access—

State forest reserves cover about 20 percent of lands on the eight main Hawaiian Islands (fig. 4). They are the primary public forest lands for NTFP collection and cover more than 675,000 ac across the islands of Hawai‘i, Maui, Moloka‘i, O‘ahu, and Kaua‘i. The island of Hawai‘i has 20 forest reserves covering about 479,000 ac;

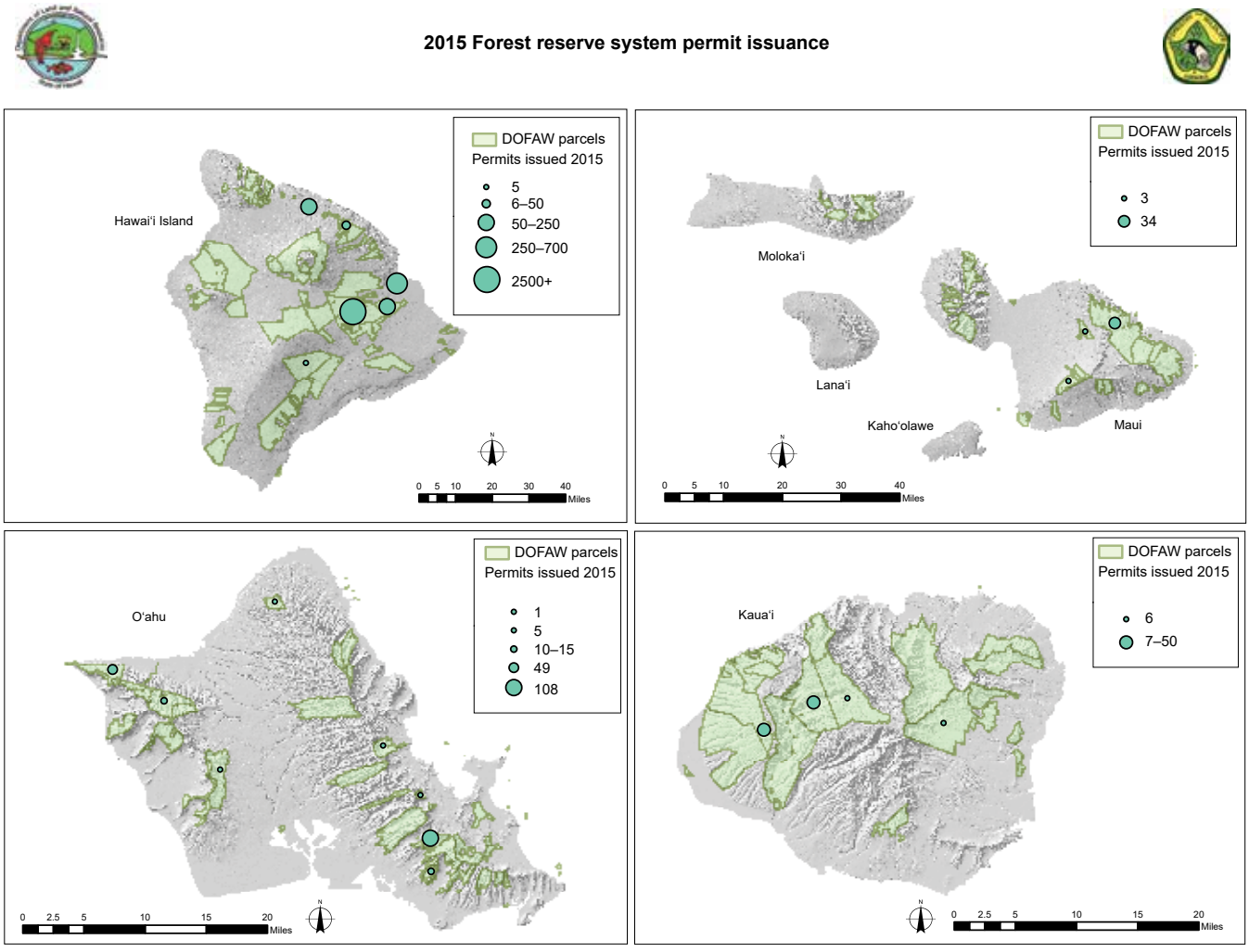

Figure 4—State forest reserves on all main Hawai‘i islands with the number of nontimber forest product harvest permits issued in 2015 identified with blue circles. Courtesy of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW). Ni‘ihau Island is not shown.

Maui and Moloka‘i together have 9 forest reserves covering about 79,000 ac; O‘ahu has 17 forest reserves at roughly 39,000 ac; and Kaua‘i has 9 forest reserves at roughly 86,000 ac. Hawai‘i’s forest reserve system is governed by Hawai‘i Revised Statutes (HRS) §183 and Hawai‘i Administrative Rule (HAR) §13-104 and managed by the DLNR Division of Forestry and Wildlife (DOFAW).

To gather NTFPs from the Forest Reserve System, citizens submit personal use permits as governed by HAR §13-104-21 or commercial use permits regulated by HAR §13-104-22 from monitoring DOFAW branch offices on their respective islands. To collect, possess, transport, or propagate federal- or state-designated threatened or endangered species requires a federal license (HAR §13-107-4) issued by DOFAW. These permits are primarily used for traditional Native Hawaiian practices (HAR §13-107-2). To gather NTFPs and other resources on private property, permission must be obtained from the owner. Consent is required for gathering from federal lands in designated areas (McMillen and Kamelamela 2014).

Goal and Objectives

The overall goal of this study was to provide an assessment of contemporary NTFP uses and values in Hawai‘i. The objectives were to identify (1) NTFP species harvested in the state, (2) cultural values of the species, and (3) NTFP market values. Understanding contemporary NTFP uses and values is critical to documenting the social, ecological, and economic contributions of forests to Hawai‘i residents. This knowledge will aid in guiding management planning and implementation, including the conservation of native plant species needed to perpetuate Hawai‘i’s cultural traditions, and fostering recognition that many cultural practices are tied to the resiliency of Hawai‘i’s forests.

Methods

We used multiple methods to investigate NTFP status and use in the state. In general, five approaches were used: (1) we examined NTFP state harvest (collection) permits, which are official Hawai‘i state records that provide baseline information on plants being gathered from forest reserves, (2) we interviewed gatherers and market vendors to summarize the types of NTFPs that are harvested to compare with the information from the state harvest permits, (3) we attended cultural events around the state to augment data found in previous methods and quantify the cultural NTFP usage, (4) we conducted an online survey to examine cultural and social reasons for gathering NTFPs, and (5) we surveyed in-person and online markets around the state to understand the extent to which resources from Hawai‘i are being distributed and to obtain price points not available through other sources.

State Harvest Permits

Paper and electronic copies of permits to harvest from state forest reserves were available from DOFAW branch offices across the state. Each branch office manages the forest reserves for each county. These main counties include Oʻahu, Hawaiʻi, Kauaʻi, and Maui Nui (including: Lānaʻi, Niʻihau, Kahoʻolawe, and Molokaʻi [except a tiny area called Kalawao County]). Prior to 2015, Oʻahu, Hawaiʻi, Maui, and Kauaʻi each had different permitting systems. In 2015, DOFAW switched to a statewide database into which all counties can input permits in a connected network. Both cultural permits and threatened and endangered species licenses require the presence of a forest or branch manager during weekday harvest events. When needed, we requested hardcopies from DOFAW branches statewide and transcribed them into the Microsoft Access database.

Permit data were provided for Kauaʻi and Hawaiʻi Islands (December 2011 through December 2017), for Oʻahu Island (September 2014 through December 2017), and for Maui Island (April 2015 through December 2017). The datasets for the islands of Oʻahu and Maui (2012 through 2014) were incomplete (permits were not available for each month); therefore, volumes are estimated only for 2015 through 2017 permit data for all four islands. There were no permit records for Molokaʻi, and there are no state forest reserves on Lānaʻi or Niʻihau. The island of Kahoʻolawe has a separate permit system (HR §§6K-3) that focuses mainly on ocean harvest and is managed by the Kahoʻolawe Island Reserve Commission; we did not include it in this study. All gathering on land or ocean must remain within the Kahoʻolawe Island Reserve; commercial gathering, use, and sale of products from Kahoʻolawe is prohibited.

In some situations, permits were issued for multiple days and for multiple people. In these cases, we entered days and people separately. For example, on Oʻahu and Hawaiʻi prior to 2016, permits were issued for several people spanning multiple days. These were parsed to separate days and people on one permit. Permits issued on Kauaʻi and Maui for more than 1 day on the same permit for multiple people were not parsed as requested by the DOFAW administrator on those islands. Permits for commercial, personal, cultural, and threatened and endangered species were accounted for by island, year, and species to the extent possible. Permits for commercial harvest of endemic species, cultural use species, and threatened and endangered species are of particular interest to DOFAW. The DOFAW administrator reviews threatened and endangered species permits in Oʻahu before sending them to DOFAW branch offices for implementation.

Interviews

We used the snowball approach, as described by Alexiades and Sheldon (1996) and Bernard (2006), to select people to interview. Participants were asked to recommend other individuals known for their NTFP experience as a “kumu”

(teacher). Semistructured and structured interviews focused on what plant species are used and how frequent participants gather plants as well as why, how, when, and where they gather plants. We obtained University of Hawai‘i Institutional Review Board approval (IRB reference CHS#18007) and provided prior informed consent to all participants. Answers were summarized and coded for themes according to methods expressed by Alexiades and Sheldon (1996) and Bernard (2006). We used voice recorders and handwritten notes when participants allowed us to document their responses.

Online Survey

We developed an online survey based on information from a 2011 pilot study on NTFP use and information recorded during interviews, cultural events, and markets (Kamelamela 2011). The questionnaire was shared with interested participants from the 2011 pilot study via Twitter, Instagram, and Facebook. The survey consisted of 21 required questions and 10 optional questions and was administered for two months in 2016. Questions included the respondent's demographic information, how they learned about gathering forest plants, the frequency of their harvests, where they typically gather plant material, and the type of harvest. Respondents could choose from a list of plant species that included common and scientific names or input a species or NTFP not on the list. Optional questions were added to learn more about the respondent's concerns with access and management of the forest.

Cultural Events

Cultural events are a major part of contemporary society in Hawai‘i and often feature nonmarket NTFPs. The Hawai‘i Tourism Authority identifies eight major annual cultural events throughout the state, which it promotes to enhance economic opportunities for the state. To assess the importance and extent of the cultural use of NTFPs, we examined NTFPs used at three of these cultural events: the Merrie Monarch Festival on the island of Hawai‘i, the Lei Day festivals on the islands of O‘ahu and Hawai‘i, and the King Kamehameha Day Parade on the island of O‘ahu. For each of these, we identified and tallied plant species and parts that were used.

The Merrie Monarch Festival is the largest and most important hula festival in the world. We obtained valuable insight about NTFP species used and volumes harvested for hula fabrication by attending the hula competitions in 2016 and 2017. During performances, we recorded the number of dancers; the plant species of lei worn by the dancers around the head (lei po‘o), neck (lei ‘ā‘ī), wrists and ankles (kūpe‘e); and the plant parts that were used. Following methods developed by Blair-Stahn (2014) for the 2012 Merrie Monarch Festival, we estimated the volume of NTFPs harvested for the 2016 and 2017 hula competition by multiplying the number of dancers using specific types of lei and the mean number of plant parts needed to

make that particular lei. We then multiplied the total estimated plant material by the average cost of that product (see table 10).

Lei Day festivals, held on the first of May each year, are a time when lei makers compete to see who makes the best product. We attended the Lei Day competition in Honolulu, Oʻahu, in 2015 and 2016 and the Hilo Lei Day festival in 2015 to identify the most commonly used NTFPs. We recorded observations and information on NTFP species and materials used to craft lei.

King Kamehameha celebrations are held each June in commemoration of Hawaiʻi's first monarch. Celebrations occur statewide, but the major events take place in Honolulu, Oʻahu, and Hilo and Kohala, Hawaiʻi. The celebrations include draping lei over a statue of King Kamehameha and a parade with riders on horses that are adorned with multiple lei. All floats of these parades are covered with plant material, many of which are NTFPs. We attended the 2015 King Kamehameha Day celebrations in Kohala on the island of Hawaiʻi, which is the smallest of the three festivals. We recorded the presence and frequency of NTFPs that adorned performers, horseback riders, floats, and vehicles at these celebrations.

In-person and Online Market Surveys

We conducted in-person market surveys by visiting the Merrie Monarch Invitational Hawaiian Arts Fair, farmers markets, and lei vendors to learn about markets for products sourced from Hawaiian forests. We searched Craigslist™ [1] and conducted an Internet search for products observed at the Merrie Monarch Festival to provide insight into products from Hawaiian forests. We did not include products sold at these venues but not sourced from Hawaiʻi in the analysis. In-person and online market data were analyzed to identify species presence, plant parts used, price points, and value-added product uses.

Merrie Monarch Invitational Hawaiian Arts Fair—
This market occurs during the Merrie Monarch Festival in Hilo and is a premier showcase of NTFPs in the state. We visited the arts fair in 2015 and 2016 to observe vendors and to record their use of NTFPs. We focused on vendors who sold wild-harvested NTFPs. The results in this study are from surveys of 18 woodwork vendors in 2015 and 14 vendors in 2016. We surveyed 15 lei vendors in 2015 and 16 vendors in 2016, and we surveyed 7 lauhala (woven *Pandanus tectorius* [hala] leaf) vendors in 2015 and 8 vendors in 2016. Prices and descriptions of items were recorded, and when possible, we asked vendors where and how much of the product was gathered. We took notes and photographs of products and booths, when permitted.

[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture for any product or service.

Farmers markets—
We looked for specific NTFPs at markets based on knowledge gained from interviews and observations at cultural events. Because farmers markets occur frequently, we visited as many as we could multiple times. There are more than 80 farmers markets across the state; we visited 25 markets—15 on O‘ahu, 3 on Kaua‘i, and 7 on the island of Hawai‘i. We visited some markets multiple times in 2015 and 2016 to identify seasonal items. When an NTFP was identified, we recorded the species, market location, unit, market price, and product type. When allowed by vendors, we took pictures of the product. When possible, we talked with vendors to understand the background of a product (i.e., resource, processing of value-added product, gathering rituals).

Lei vendors—
NTFPs crafted into lei are sold in retail stores throughout the state. We visited six lei shops in the Chinatown area in Honolulu, O‘ahu, and three general stores in Hilo, Hawai‘i. These stores are permanent, year-round locations where customers can purchase products made from NTFP species. At each site, we examined NTFP species for sale and their year-round prices.

Craigslist market review—
NTFPs are bought and sold on Craigslist on island-specific submarkets as recorded by Kamelamela (2011). To get an idea of the diversity, volumes, and prices of NTFPs marketed on Craigslist, we monitored the Craigslist Hawai‘i “Farm & Garden” section from December 2015 to June 2016. For the first 2 months, we recorded postings of all plant species; the following months, we recorded only NTFPs identified as potential wild harvest, the product for sale, NTFP species, vendor contact, and price. Craigslist market surveys were conducted passively in real time, as there was no active search of products or species within this marketplace.

Internet market search—
We conducted an Internet search for all NTFPs observed at the Merrie Monarch craft fair. The search occurred once using the common and scientific names, individual plant parts, and specific value-added products. Review of some products resulted in more indepth investigations of second- or third-party sellers. We only included listings that could be verified as marketing NTFPs collected in Hawai‘i, even if the sellers were based outside of Hawai‘i. For plants such as kukui and coconut (*Cocos nucifera*), which are common ingredients in many soaps, perfumes, and other body-care items, we recorded only products in which these were one of the principal ingredients. We documented the product for sale, the main NTFP species, vendor location, and price. Species were noted as readily available (easily found via online searches) or limitedly available (requiring intense online searches to find).

Results

Analysis of the DOFAW permits, interviews, and observations of cultural events and markets provided government, community, cultural, and economic perspectives on NTFPs throughout the state. Results provided a baseline of NTFP harvests and use practices in Hawai‘i.

State Harvest Permits

The state of Hawai‘i requires a permit to harvest on state forest reserves (fig. 4); permit types vary based on the purpose of harvest. Cultural permits (formally known as special use permits) are infrequent and require records of species to be harvested along with quantities and intended purpose prior to gathering. Threatened and endangered species federal license requests have similar requirements, though these have an additional mandatory community service component.

The DOFAW standardized harvest permits in 2015, which allowed for summarizing these data across the state. Table 1 summarizes permits issued for gathering NTFPs from 2015 through 2017. Permits provide information on common and scientific names, type of collection, and units of measure for the product. Harvest amounts recorded on permits reflect preharvest estimates, and actual harvests may be significantly different. About 99 percent of the permits were issued for personal use, and most were on the island of Hawai‘i. More than 50 genera were identified from the permits. Of those that were identifiable to the species, maile had the most permits, followed by palapalai. Ten products were identified only by their common names. Of the unidentified species, permits for foliage amounted to more than 4,300 permits.

There were a few NTFP species permitted across the 3 types of permits (personal, commercial, and cultural). For example, we observed overlap between personal and commercial harvest of fern shoots, greenery/foliage, evergreens, and the NTFP species hāpu‘u and uluhe (false staghorn fern, *Dicranopteris linearis*. The most common commercial permit was for clubmoss or wāwae‘iole (*Lycopodiella cernua*).

Nine units of measure were used on permits to document how much a person can harvest. The most common unit of measure was a 5-gallon bucket. Other units of measure were species specific; permits to harvest bamboo (*Bambusa*, *Phyllostachys*, *Sasa*, and *Schizostachyum* spp.) shoots are for up to three stalks, while permits for kakuma (hāpu‘u) fiddleheads were issued for “one regular size burlap bag.” For the fragrant vines of maile, permits were issued for “4′–6′ strands.” To harvest ‘ōhelo berries, a permit was issued for 1 quart, while permits to harvest mokihana (*Melicope anisata*) was for 1 gallon. Permits to harvest Christmas trees were for one tree.

We recorded a total of 14,298 permits across the four main islands in April 2015 through the end of 2017 (table 2). Over these 3 years, 14,206 personal use

Table 1—Nontimber forest products identified on Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife harvest permits from 2015 through 2017

			Permits by type					Permits by island/county				
Common name	Scientific name	Unit of measure	Personal	Commercial	Cultural	T/E license	Total	Hawai'i	Maui	O'ahu	Kaua'i	Total
			Number of permits									Number of counties
Koa	*Acacia koa*	Board ft	0	2	0	0	2	2	0	0	0	1
Black wattle	*Acacia mearnsii*	Board ft	1	1	0	0	2	0	0	1	1	2
Kauila	*Alphitonia ponderosa*	License	0	0	0	1	1	1	0	0	0	1
Maile	*Alyxia stellata*	4–6-ft strands	2,649	1	0	0	2,650	1,678	7	7	958	4
Norfolk pine branch	*Araucaria heterophylla*, *Araucaria columnaris*	5-gal bucket	23	0	0	0	23	0	0	23	0	1
Bamboo orchids	*Arundina graminifolia*	5-gal bucket	0	1	0	0	1	1	0	0	0	1
Bamboo	*Bambusa*, *Sasa*, *Phyllostachys*, or *Schizostachyum* spp.	Up to 3 stalks	432	27	0	0	459	6	50	387	16	4
Bamboo shoots	*Bambusa*, *Sasa*, *Phyllostachys*, or *Schizostachyum* spp.	5-gal bucket	72	1	0	0	73	0	48	25	0	2
Pīkōnia	*Begonia* sp.	5-gal bucket	6	0	0	0	6	0	0	6	0	1
Moss	Bryophyta sp.	5-gal bucket	28	0	0	0	28	0	0	1	27	2
Uhiuhi	*Mezoneuron kavaiense*	License	0	0	0	1	1	1	0	0	0	1
Pua kalaunu	*Calotropis gigantea*	5-gal bucket	16	0	0	0	16	0	0	0	16	1
Ironwood	*Casuarina equisetifolia*	5-gal bucket	1	0	0	0	1	0	0	1	0	1
Kakuma	*Cibotium* spp.	"Regular size burlap bag"	733	0	0	0	733	733	0	0	0	1
Hāpu'u	*Cibotium* spp.	Up to 10 logs	2	0	0	0	2	1	0	1	0	2
Coffee	*Coffea arabica*	5-gal bucket	2	0	0	0	2	0	0	2	0	1
Ti	*Cordyline fruticosa*	5-gal bucket	11	0	0	0	11	0	0	11	0	1
Rough tree fern	*Cyathea australis*	5-gal bucket	1	0	0	0	1	0	0	1	0	1
Juniper	*Juniperus* sp.	5-gal bucket	3	0	0	0	3	0	0	2	1	2
'Uluhe	*Dicranopteris linearis*	5-gal bucket	10	3	0	0	13	7	0	6	0	2
'A'ali'i	*Dodonaea viscosa*	5-gal bucket	36	0	0	0	36	4	0	7	25	3
Song of India	*Dracaena reflexa*	5-gal bucket	6	0	0	0	6	0	0	0	6	1

Table 1—Nontimber forest products identified on Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife harvest permits from 2015 through 2017 (continued)

			Permits by type					Permits by island/county				
Common name	Scientific name	Unit of measure	Personal	Commercial	Cultural	T/E license	Total	Hawai‘i	Maui	O‘ahu	Kaua‘i	Total
			Number of permits									Number of counties
Eucalyptus	*Eucalyptus* sp.	5-gal bucket	2	0	0	0	2	0	0	2	0	1
Swamp mahogany	*Eucalyptus robusta*	Board ft	3	0	0	0	3	0	0	0	3	1
Tropical ash	*Fraxinus uhdei*	Board ft	0	2	0	0	2	0	0	2	0	1
Silky/silver oak	*Grevillea robusta*	5-gal bucket	22	0	0	0	22	0	1	0	21	2
Heliconia	*Heliconia* spp.	5-gal bucket	7	0	0	0	7	0	0	7	0	1
Pili grass	*Heteropogon contortus*	Bundle	1	0	1	0	2	2	0	0	0	1
Hau	*Hibiscus tiliaceus*	5-gal bucket	1	5	0	0	6	0	0	6	0	1
Hydrangeas	*Hydrangea* sp.	5-gal bucket	7	0	0	0	7	0	0	0	7	1
Holly	*Ilex* spp.	5-gal bucket	10	0	0	0	10	0	0	9	1	2
Pūkiawe	*Leptecophylla tameiameiae*	5-gal bucket	45	0	0	0	45	0	39	6	0	2
Haole koa pods	*Leucaena leucocephala*	5-gal bucket	3	0	0	0	3	0	0	0	3	1
Kuhi‘aikamo‘owahie	*Lobelia hypoleuca*	1-gal bucket	1	0	0	0	1	0	0	1	0	1
White honeysuckle	*Lonicera albiflora*	5-gal bucket	1	0	0	0	1	0	0	0	1	1
Lycopodium	Lycopodiaceae	5-gal bucket	0	5	0	0	5	5	0	0	0	1
Wāwae‘iole	*Lycopodiella cernua*	5-gal bucket	3	1	0	0	4	4	0	0	0	1
Mokihana	*Melicope anisata*	1-gal bucket	483	0	0	0	483	0	0	0	483	1
‘Ōhi‘a lehua	*Metrosideros polymorpha*	5-gal bucket	159	0	0	0	159	13	0	10	136	3
Palapalai	*Microlepia strigosa*	5-gal bucket	1,821	0	0	0	1,821	1,749	1	16	55	4
Swiss-cheese plant leaves	*Monstera deliciosa*	5-gal bucket	18	0	0	0	18	0	0	10	8	2
Banana (bunch, stumps)	*Musa* sp.	Bunch	23	0	0	0	23	0	0	13	10	2
Kōlea lau li‘i	*Myrsine sandwicensis*	5-gal bucket	6	0	0	0	6	0	0	6	0	1
‘Oliwa	*Olea europaea*	5-gal bucket	2	0	0	0	2	0	0	0	2	1
Liliko‘i	*Passiflora edulis*	5-gal bucket	1	0	0	0	1	0	0	1	0	1
Pine boughs	*Pinus* spp.	Up to 5 gal	114	5	0	0	119	14	5	28	72	4
Matsu	*Pinus* spp.	5-gal bucket	4	0	0	0	4	0	1	3	0	2

Table 1—Nontimber forest products identified on Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife harvest permits from 2015 through 2017 (continued)

			Permits by type					Permits by island/county				
Common name	Scientific name	Unit of measure	Personal	Commercial	Cultural	T/E license	Total	Hawai'i	Maui	O'ahu	Kaua'i	Total
			Number of permits									Number of counties
Māmaki	*Pipturus albidus*	5-gal bucket	1	0	0	0	1	1	0	0	0	1
Loulu hiwa	*Pritchardia martii*	1-gal bucket	1	0	0	0	1	0	0	1	0	1
Strawberry guava (waiāwi)	*Psidium cattleianum*	Up to 5 gal	126	1	1	0	128	115	0	9	4	3
Guava	*Psidium guajava*	5-gal bucket	22	2	0	0	24	1	13	9	1	4
Moa	*Psilotum nudum*	5-gal bucket	6	0	0	0	6	0	0	0	6	1
Pussy willow	*Salix discolor*	5-gal bucket	1	0	0	0	1	0	0	0	1	1
Christmas berry	*Schinus terebinthifolius*	5-gal bucket	5	0	0	0	5	0	0	5	0	1
Pala'ā	*Sphenomeris chinensis*	5-gal bucket	25	0	0	0	25	0	0	1	24	2
Australian red cedar	*Toona ciliata*	Board ft	0	1	0	0	1	0	1	0	0	1
'Ōhelo ('ai)	*Vaccinium reticulatum*	1 qt	675	0	0	0	675	670	0	0	5	2
Ginger	Zingiberaceae	5-gal bucket	10	1	0	0	11	0	0	7	4	2
Wild ginger	Zingiberaceae	5-gal bucket	1	0	0	0	1	0	0	1	0	1
Blank permits	No identified species	5-gal bucket	20	8	0	0	28	8	2	12	6	4
Bloodwood	Multiple species	Board ft	0	2	0	0	2	2	0	0	0	1
Christmas tree	No identified species	Tree	4	12	0	0	16	0	11	5	0	2
Dead branches	No identified species	5-gal bucket	4	0	0	0	4	0	0	0	4	1
Ferns	No identified species	5-gal bucket	29	0	0	0	29	0	5	3	21	3
Ferns (nonnative)	No identified species	5-gal bucket	81	0	0	0	81	8	1	9	63	4
Firewood	No identified species	5-gal bucket	1	3	0	0	4	0	2	0	2	2
Foliage	No identified species	5-gal bucket	4,328	4	0	0	4,332	4,231	3	31	67	4
Fruits	No identified species	3-gal bucket	2,083	0	0	0	2,083	2,081	0	2	0	2
Various species	No identified species	5-gal bucket	14	0	0	0	14	10	0	4	0	2
Total			14,206	88	2	2	14,298	11,348	190	700	2,060	

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name. Permits by county show dispersal of permit application types across the state of Hawai'i. For generalized categories (i.e., ferns, firewood, foliage), no species or family assignments were indicated on the state permit or federal license.

T/E = threatened and endangered species.

Table 2—Number of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife harvest permits issued by year, type, and county annually from 2015 through 2017

County	Permit type	Permits per year			Permits per type
		2015	2016	2017	
		Number of permits			
Hawai‘i	Personal	5,816	3,746	1,766	11,328
	Commercial	14	0	2	16
	Cultural	2	0	0	2
	Threatened/endangered	1	1	0	2
Total		5,833	3,747	1,768	11,348
Kaua‘i	Personal	522	588	947	2,057
	Commercial	2	0	1	3
	Cultural	0	0	0	0
	Threatened/endangered	0	0	0	0
Total		524	588	948	2,060
Maui	Personal	44	73	51	168
	Commercial	4	13	5	22
	Cultural	0	0	0	0
	Threatened/endangered	0	0	0	0
Total		48	86	56	190
O‘ahu	Personal	232	233	188	653
	Commercial	14	23	10	47
	Cultural	0	0	0	0
	Threatened/endangered	0	0	0	0
Total		246	256	198	700
Total		6,651	4,677	2,970	14,298

permits, 88 commercial use permits, 2 cultural permits, and 2 threatened and endangered species licenses were issued. In 2015, 6,651 NTFP harvest permits were issued—6,614 for personal use and 34 for commercial collection. Permit numbers declined over time. More than 46 percent of the permits were issued in 2015, while 32 percent were issued in 2016, and 21 percent were issued in 2017. More than 50 percent of the commercial use permits were issued on O‘ahu, while 25 percent were issued on Maui. During these years, 11,348 permits were issued on the island of Hawai‘i; 2,060 permits were issued on Kaua‘i; 190 permits were issued on Maui; and 700 permits were issued on O‘ahu. Over all islands and years, about 79 percent of the permits were issued on the island of Hawai‘i, and 14 percent were issued on Kaua‘i.

Permitted NTFP gathering happens in many of the state's forest reserves; however, some reserves are used more often than others. The Upper Waiākea Forest Reserve on the island of Hawai‘i (fig. 4) is the most frequented reserve for NTFPs; 3,093 permits were issued for the island in 2015. On Maui, there were 38 applications for harvest permits on the Ko‘olau Forest Reserve in 2015. On O‘ahu, the Nu‘uanu Forest Reserve granted 106 permits in 2015. The largest allocation of permits on Kaua‘i were assigned broadly to the Forest Reserve System and did not identify specific forest reserves.

In general, there was some seasonality in the issuance of harvest permits, though permits issued on the island of Hawai‘i occurred consistently throughout the year. Peak seasons for permits coincided with major cultural events, such as March and April for the Merrie Monarch Festival and November and December for Christmas and New Year's celebrations. Similarly, Maui and O‘ahu exhibited peak harvesting in December and again in May. May also marks the beginning of graduation season and lei are commonly given to new graduates.

The process of applying for a cultural permit requires specific reporting for amounts that exceed personal permit harvest requests. The application requires the harvest size, quantity, species, and cultural purpose (e.g., community benefit).

Licenses for the harvest of threatened and endangered species for research, restoration work, collection for propagation, and cultural rights from Hawai‘i's Forest Reserve System requires examination by the DOFAW rare plant coordinator. Threatened and endangered harvest permits require an educational or service component focused on giving back to the forest. Only two of this type of permit were issued from 2015 through 2017. Threatened and endangered permits were issued for uhiuhi (*Mezoneuron kavaiense*) and kauila (*Colubrina oppositifolia*), both endangered and threatened by invasive species and pests.

Three product types and six species dominated the permits (table 1). Product types most used were foliage (4,332 permits), fruits (2,083 permits), and pine boughs (119 permits). Maile was the most permitted species (2,650 permits), followed by palapalai (1,821 permits). Kakuma (733 permits), mokihana (483 permits), and ‘ōhelo (675 permits), also accounted for a significant portion of issued permits. The introduced species strawberry guava had 128 permits over the 3-year timeframe.

The most commonly issued permit on O‘ahu was for common bamboo (*Bambusa vulgaris*) harvest. Bamboo is used in Japanese traditions for welcoming the new year in an arrangement known as "kadomatsu" (Brandon and Stephan 1994, Takayama 2012). Other uses of bamboo include food (bamboo shoots, or "takenoko" in Japanese), building material, and musical instruments.

Statewide, the largest number of permits were issued to harvest foliage—flowers, fungi, leaves, and plant tips. Species gathered for foliage may have included

ʻōhiʻa, koa, pūkiawe (*Leptecophylla tameiameiae*), ʻōhelo (*Vaccinium reticulatum*), ʻaʻaliʻi (*Dodonaea viscosa*), staghorn clubmoss or uki grass (*Cladium jamaicense*), and the fern palapalai.

Some species were identified by multiple common names, depending on the plant part used. For example, in the case of *Cibotium* spp., the Japanese common term "kakuma" refers to the unfurled shoot and stem, whereas the Hawaiian name "hāpuʻu" refers to the whole tree fern that is harvested. Because these NTFPs both have the same scientific name, permits were requested for kakuma or hāpuʻu specifically. This also applies to permits for bamboo harvest; permits were issued to accommodate requests specifically for both stems (used for construction and crafts) and for shoots (used for food). These results were summarized separately although they are for the same species because different parts of the plant were harvested for two distinct NTFPs. Conversely, permits for ginger and wild ginger do not identify the species; we applied the family-level designation, Zingiberaceae, to all species of ginger.

We determined the parts of plants gathered from DOFAW permits and through structured online surveys. Of the 141 species, the plant parts most frequently used were stems (72 species), leaves (63 species), wood (46 species), flowers (41 species), fruit (38 species), seeds (26 species), whole plant (16 species), roots (4 species), and bark (4 species). We were unable to confirm the plant part used for 8 species.

The fruit of some plants are harvested for consumption, for making dyes, or for making lei. Some permits indicated that plants were harvested for food, such as bamboo shoots. Fern shoots from kakuma or shoots from warabi (*Diplazium* spp.) were harvested by Hawaiian, Japanese, and community members of other ethnicities for consumption. Also included in this category are trees managed by the DOFAW in the Hilo arboretum and in the Hilo Forest Reserve. Fruits are also harvested from ʻōhelo and ʻākala (the endemic Hawaiian raspberry, *Rubus hawaiensis*), mostly from the island of Hawaiʻi. The latter also is used to make a red dye. On Kauaʻi, the fruit of the endemic shrub mokihana (*Melicope anisata*) is commonly harvested for making lei.

Interviews

We contacted 50 people for interviews and completed 14 semistructured interviews of people from the islands of Hawaiʻi, Molokaʻi, Maui, Oʻahu, and Kauaʻi. Interviewees harvested from wide-ranging ecosystems, represented a diversity of cultural practices, and supported a broad range of commercial vendors. The skills of interviewees overlapped, including five lei makers, four hula teachers, four weavers of lauhala, three practitioners of lāʻau lapaʻau (Hawaiian traditional herbal medicine), and two lei vendors. Interviewees also included one tapa (bark cloth)

maker, one imu (earth oven) enthusiast and kīawe vendor, and one conservationist. Not all interviewees were Native Hawaiian, but all interviewees self-identified as Hawaiian cultural practitioners, except for the lei vendors. Lei-, lauhala-, lā‘au lapa‘au-, kiawe-, and hula-related gatherings resulted in monetary exchanges, either in market settings- or as donations; however, not all interviewees harvested for financial gain or accepted offers of monetary compensation.

Interviewees indicated that the most common reason for gathering NTFPs was “mana,” which Pukui and Elbert (1986) described as a supernatural energy or divine power that can be found in people, places, or objects. Eight interviewees said that they harvested NTFPs for hula and lei making. Five interviewees said that the “best quality” resources are available only through harvesting NFTPs themselves, their main reason for harvesting was to gather medicine, and their rights to harvest from the forest were protected. Just under a quarter of the interviewees said that the indigenous belief that the gathered plants were “kinolau,” or manifestations of Hawaiian deities (Pukui and Elbert 1986), was their impetus for gathering, and forest harvesting was a “way of life.” One participant indicated that collecting building materials was an important reason for gathering.

Interviewees for this study identified 23 commonly harvested plant species (table 3). These include 12 native and endemic species, 5 Polynesian introductions, and 6 recent introductions. The most commonly used were hala, liko (‘ōhi‘a), palapalai, māmaki, maile, and strawberry guava. Interviewees also provided information on products that they aspired to harvest. Four respondents identified maile, ti leaf, ‘ōhi‘a, palapalai, laua‘e ferns (*Phymatosorus grossus*), māmaki, and strawberry guava as plant species that they aspired to harvest. Half of those interviewed expressed interest in harvesting maile. More than a quarter of respondents mentioned hula plants (‘ōhi‘a, palapalai, laua‘e). Two respondents specifically identified a “red” hala as desirable. One respondent identified ‘ilima (*Sida fallax*), Polynesian ‘ohe (*Schizostachyum glaucifolium*), loulu (Hawaiian fan palms, *Pritchardia* spp.), and makaloa (*Cyperus laevigatus*), all of which were not recorded as currently harvested by interviewees.

When asked about how much product they harvested, interviewees overwhelmingly said that they only harvested “what is needed” and that there should be “no waste.” Main factors that influenced harvest were the time of year and daily weather conditions. Harvest occurred during the coolest periods of the day—in the morning before 10 a.m. or in the afternoon after 4 p.m. Harvest times also were dependent on when the NTFPs were needed.

Table 3—Nontimber forest product species reported harvested by study interviewees

Common name	Scientific name	Number of respondents	Origin
Maile	*Alyxia stellata*	4	E
ʻŌlapa	*Cheirodendron trigynum*	1	E
Kaunaʻoa pehu	*Cuscuta sandwichiana*	2	N
	Cassytha filiformis	2	I
Kou	*Cordia subcordata*	2	P
Ti	*Cordyline fruticosa*	5	P
ʻIeʻie	*Freycinetia arborea*	1	N
Hau	*Hibiscus tiliaceus*	1	P
Hinahina	*Heliotropium anomalum*	1	E
Spanish moss	*Tillandsia usneoides*	1	I
Mokihana kūkae moa	*Melicope hawaiensis*	1	E
Liko[a]	*Metrosideros polymorpha*	5	E
Palapalai	*Microlepia strigosa*	5	N
Noni	*Morinda citrifolia*	2	P
Lauhala	*Pandanus tectorius*	7	N
Lauaʻe	*Phymatosorus grossus*	4	I
Mamakī	*Pipturus albidus*	5	E
Laukahi	*Plantago major*	1	I
Kiawe	*Prosopis pallida*	1	I
Strawberry guava	*Psidium cattleianum*	4	I
ʻIlima	*Sida fallax*	1	N
Palaʻā	*Odontosoria chinensis*	1	N
ʻUhaloa	*Waltheria indica*	2	N

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.

N = native (not endemic); E = endemic species; P = Polynesian introduction; I = introduced (not Polynesian).

[a] Lehua was also listed for *Metrosideros polymorpha*.

Online Surveys

We identified products harvested, reasons for harvesting, and harvester demographics from 108 online survey respondents. Respondents were 52 percent female and 48 percent male and ranged in age from 18 to 68; the mean age was 42. Respondents self-identified using diverse ethnic and racial demographic categories (more than one could be chosen): Hawaiian (62 percent), Caucasian (49 percent), Japanese (29 percent), Chinese (25 percent), Portuguese (22 percent), Irish (22 percent), Filipino (17 percent), German (16 percent), French (13 percent), Spanish (8 percent), Cherokee (5 percent), Samoan (3 percent), African American

(3 percent), Korean (2 percent), and Ukrainian (2 percent). It is worth noting that respondents need not have been of Hawaiian ethnicity to identify with Hawaiian culture, and chosen demographic categories do not necessarily indicate cultural upbringing. Most participants lived on the islands of Hawai‘i (49 percent) and O‘ahu (41 percent).

Most (57 percent) respondents to the online survey indicated that they harvest NTFPs fewer than 14 days per year. One quarter of the respondents, however, reported that they harvest more than 31 days per year. About 10 percent of the respondents indicated that they harvest 15 to 30 days per year. Two respondents said that they no longer harvest NTFPs.

The reasons most online survey respondents gave for NTFP harvest were lei or flower arrangements (44), food (42), cultural traditions (42), and medicine (41). Fewer respondents said they harvest for hula (29), native plant conservation (26), home garden transplants (24), and crafts (23). Even fewer respondents said they harvest for woodworking (16), building materials (12), art (11), and the market (4). More than 25 percent of online respondents said they consumed hō‘i‘o fern fronds.

We found that most respondents harvested NTFPs for special occasions—ceremonies (42); family gatherings (32); first-baby “luau” or birthdays (30); performance/exhibition (29); graduations (28); school events (27); funerals/memorials (26); weddings (23); Christmas (16); competitions including hula, lei, and art (16); Thanksgiving (10); fundraising (8) and New Year’s Day (7). Seven respondents said they harvest for work.

Online survey respondents also indicated a wide variety of NTFPs—91 species—from Hawai‘i forests that they harvested directly or for which they purchased or sold (table 4). Eleven species were gathered by more than 20 percent of survey respondents. Twenty-four additional species were filled in on the survey list by respondents under the other category. Of the plant species reported, 25 were native, 9 were Polynesian introduced, and 13 were introduced (table 4). More than 70 percent of the participants reported harvesting coconut and palapalai. More than 60 percent of respondents reported harvesting ti, māmaki, ‘ōhi‘a, maile, and ‘a‘ali‘i. The eight species that more than 60 percent of respondents reported are consistent with those reported as commonly harvested from the DOFAW permits.

About 6 percent of the respondents said that they harvest NTFPs to sell in the market, 33 percent reported purchasing or selling the native forest species maile, and 25 percent reported the same for māmaki. Forty-six percent of the respondents reported purchasing kalo (taro) from the market, and 38 percent of respondents reported purchasing mango (*Mangifera indica*). Respondents identified 53 species of forest plant resources that were purchased or sold in Hawai‘i markets (table 4).

Table 4—Nontimber forest product species reported by online surveyees as harvested or sold or purchased

Common name	Scientific name	Harvested	Sold or purchased	Species origin
		Percentage of respondents		
Black-eyed Susan	*Abrus precatorius*	6	ND	I
Koa	*Acacia koa*	44	24	E
Koaiʻa	*Acacia koaia*	19	ND	E
Albizia	*Falcataria moluccana*	3	ND	I
Monkeypod	*Samanea saman*	14	ND	I
Kukui	*Aleurites moluccana*	60	25	P
Maile, mailelauliʻi	*Alyxia stellata*	65	38	N
Cook pine[a]	*Araucaria columnaris*, *A. heterophylla*	2	ND	I
ʻUlu	*Artocarpus altilis*	57	24	P
Bamboo orchids	*Arundina graminifolia*	13	16	I
Anthurium[a]	*Anthurium* sp.	2	ND	I
Koʻokoʻolau[a]	*Bidens* spp.	2	ND	E
Kukunaokalā (mangrove)	*Bruguiera gymnorrhiza*, *Rhizophora mangle*	13	5	I
Moss	*Bryophyta* spp.	27	ND	I
Kamani	*Calophyllum inophyllum*	33	3	P
Ironwood	*Casuarina equisetifolia*	14	ND	I
Fern shoots, kakuma	*Cibotium* spp.	51	16	E
Hāpuʻu	*Cibotium* spp.	32	11	E
ʻŌlapa[a]	*Cheirodendron trigynum*	2	ND	E
ʻĀheahea (ʻāweoweo)	*Chenopodium oahuense*	22	2	E
Uki	*Cladium jamaicense*	27	2	N
Coconut, nui	*Cocos nucifera*	71	35	P
Coffee	*Coffea arabica*	17	37	I
Pūʻoheʻohe	*Coix lachryma-jobi*	24	2	I
Kalo	*Colocasia esculenta*	38	46	P
Kauila	*Colubrina oppositifolia*, *Alphitonia ponderosa*	19	2	E
Honohono	*Commelina diffusa*	19	ND	I
Kou	*Cordia subcordata*	11	5	N
Ti	*Cordyline fruticosa*	68	19	P
Kaunaʻoa pehu[a]	*Cuscuta sandwichiana*, *Cassytha filiformis*	3	ND	E
ʻŌlena[a]	*Curcuma longa*	2	ND	P
Uluhe	*Dicranopteris linearis*	29	ND	E
Kūkaepuaʻa	*Digitaria pruriens*	11	ND	N
Lama	*Diospyros sandwicensis*	30	2	E
Hōʻiʻo	*Diplazium* spp.	51	25	I
ʻAʻaliʻi	*Dodonaea viscosa*	63	10	N
Blue marble[a]	*Elaeocarpus angustifolius*	2	ND	I
Eucalyptus	*Eucalyptus* spp.	16	5	I
Sydney blue gum	*Eucalyptus saligna*	3	5	I
Wiliwili	*Erythrina sandwicensis*	27	5	E
ʻIeʻie[a]	*Freycinetia arborea*	2	ND	N

Table 4—Nontimber forest product species reported by online surveyees as harvested or sold or purchased (continued)

Common name	Scientific name	Harvested	Sold or purchased	Species origin
		Percentage of respondents		
Pili grass	*Heteropogon contortus*	22	3	N
Hau	*Hibiscus tiliaceus*	51	5	N
Heliconia	*Heliconia* spp.	22	11	I
Hinahina[a]	*Heliotropium anomalum*	2	ND	N
Juniper[a]	*Juniperus* spp.	2	ND	I
Pūkiawe	*Leptecophylla tameiameiae*	35	2	E
Haole koa	*Leucaena leucocephala*	10	2	I
Wāwae‘iole	*Lycopodiella cernua*	33	ND	N
Macadamia[a]	*Macadamia* sp.	3	ND	I
Bingabing	*Macaranga* spp.	2	ND	I
Mango	*Mangifera indica*	46	38	I
Mokihana kūkae moa[a]	*Melicope hawaiensis*	2	ND	E
‘Ōhi‘a lehua	*Metrosideros polymorpha*	67	16	N
Palapalai	*Microlepia strigosa*	70	13	N
Noni[a]	*Morinda citrifolia*	2	ND	P
Banana	*Musa* spp.	46	25	P
Pepeiao[a]	*Numerous species of fungi*	5	ND	I
‘Ūlei	*Osteomeles anthyllidifolia*	24	2	N
Hala	*Pandanus tectorius*	59	13	P
Liliko‘i[a]	*Passiflora edulis*	2	ND	I
Avocado[a]	*Persea americana*	2	ND	I
Laua‘e	*Phymatosorus grossus*	52	5	I
Loblolly pine[a]	*Pinus taeda*	2	ND	I
Māmaki	*Pipturus albidus*	67	25	E
‘Awa[a]	*Piper methysticum*	2	ND	P
Pine	*Pinus* spp.	16	2	I
Kiawe	*Prosopis pallida*	43	10	I
Plum[a]	*Prunus* sp.	2	ND	I
Peach[a]	*Prunus persica*	2	ND	I
Strawberry guava	*Psidium cattleianum*	52	5	I
Guava	*Psidium guajava*	52	19	I
‘Akala	*Rubus hawaiensis*	22	2	E
‘Iliahi	*Santalum* spp.	25	13	E
Christmas berry[a]	*Schinus terebinthifolius*	2	ND	I
Bamboo	*Bambusa* sp., *Phyllostachys* spp., *Sasa* spp., *Schizostachyum* spp., and others	56	3	P
Octopus tree	*Schefflera actinophylla*	13	2	I
‘Ilima	*Sida fallax*	33	13	N
Pōpolo	*Solanum americanum*	35	2	N
Māmane	*Sophora chrysophylla*	22	ND	E
Pala‘ā	*Odontosoria chinensis*	40	2	N
Java plum	*Syzygium cumini*	16	3	I

Table 4—Nontimber forest product species reported by online surveyees as harvested or sold or purchased (continued)

Common name	Scientific name	Harvested	Sold or purchased	Species origin
		Percentage of respondents		
ʻŌhiʻa ʻai	*Syzygium malaccense*	43	11	P
Tamarind	*Tamarindus indica*	21	10	I
False Kamani	*Terminalia catappa*	11	ND	I
Milo	*Thespesia populnea*	27	3	N
ʻOlonā[a]	*Touchardia latifolia*	2	ND	E
ʻŌhelo	*Vaccinium reticulatum*	52	16	E
Chaste tree	*Vitex* sp.	3	ND	I
ʻUhaloa[a]	*Waltheria indica*	2	ND	N
ʻAwapuhi[a]	*Zingiber zerumbet*	2	ND	P

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.

N = native (not endemic) species; E = endemic; P = Polynesian introduction; I = introduced (not Polynesian); ND = no data (plant not designated as sold or purchased).

[a] Species name provided by surveyees.

Cultural Events

Merrie Monarch Festival—

The NTFPs used in the Merrie Monarch Festival hula competition were more often gathered from the forest than purchased. Overall, 15 species were recorded as being used by dancers in 2016 and 2017 Merrie Monarch Festival hula competitions (table 5). Nine of them were native to Hawaiʻi (five endemic), five were Polynesian introductions, and one was a recent introduction. Eleven plant species were used in traditional hula (five native species) and modern-style hula (seven native species). Women used seven native species, and men wore parts of five species. The three most common plant species used were palapalai, maile, and ʻōhiʻa (though this diminished with the presence of rapid ʻōhiʻa death and is reflected in the 2017 results). The leaves, stems, flowers, fruits, inner bark, nuts, bracts, and liana of plants were used in various forms for lei around the head, neck, wrists, and ankles in hula performances.

We estimated that more than 10,000 palapalai fronds were used in 2016, and 17,000 fronds were used in 2017. Further, we estimated that about 3,500 stems of maile were used in 2016, and about 4,500 stems were used in 2017 (table 6). Our 2016 estimates were more than double that of Blair-Stahn (2014) for the 2012 Merrie Monarch Festival (5,815 palapalai fronds and 2,065 ft of maile stems). Additionally, annual use at 17 other hula festivals was about 31,875 palapalai fronds; 8,925 ft of maile stem; and 54,825 "pua lehua" (ʻōhiʻa flowers) (Blair-Stahn 2014), indicating high use of these NTFPs by the hula community.

The estimated economic contribution of NTFPs used for the Merrie Monarch Festival hula competition focuses only on the potential value of resources gathered from Hawaiʻi forests. By our estimates, the economic contribution of lei used in the 2016 and 2017 Merrie Monarch Festivals totaled about $76,130. Palapalai accounted

Table 5—Nontimber forest product species used by 2016 and 2017 Merrie Monarch Festival hula competition performers

Common name	Scientific name	Origin	Year	Plant part				Performer type				Type of adornment				Performer total
										Wāhine						
				Leaf	Stem	Flower	Other	Kahikō (Traditional)	ʻAuana (Contemporary)	(female)	(male)	ʻĀʻī (lei for neck)	Kupeʻe (garlands)	Poʻo (lei for head)	Skirt	
Kukui	*Aleurites moluccana*	P	2016	3	3	3	Nut	2	–	2	–	2	2	2	–	2
			2017	3	3	3	Nut	4	4	3	5	4	2	3	–	8
Maile	*Alyxia stellata*	E	2016	—	—	—	Liana	5	5	9	1	10	—	—	—	10
			2017	—	—	—	Liana	11	6	13	4	17	—	—	—	17
Kukunaokalā (mangrove)	*Bruguiera gymnorrhiza*, *Rhizophora mangle*	I	2017	—	—	—	Bract	1	—	—	1	1	—	—	—	1
ʻŌlapa	*Cheirodendron trigynum*	E	2017	1	1	—	—	1	—	—	1	—	—	1	—	1
Kou	*Cordia subcordata*	P	2016	—	—	2	—	—	2	2	—	2	—	—	—	2
			2017	—	—	1	—	—	1	1	—	1	—	—	—	1
Ti leaf	*Cordyline fruticosa*	P	2016	8	8	—	—	3	5	3	5	—	1	1	7	8
			2017	15	15		—	10	5	7	8	1	2	1	14	15
ʻAʻaliʻi	*Dodonaea viscosa*	N	2016	1	1	1	Fruit	—	1	1	—	1	—	—	—	1
			2017													
Wiliwili	*Erythrina sandwicensis*	E	2016	—	—	—	Seed	—	1	1	—	1	—	—	—	1
Hinahina	*Heliotropium anomalum*	E	2016	1	1	1	—	—	1	1	—	1	—	—	—	1
ʻŌhiʻa lehua	*Metrosideros polymorpha*	E	2016	1	1	1	—	3	3	4	2	6	1	2	—	6
Palapalai	*Microlepia strigosa*	N	2016	21	21	—	—	17	4	14	7	18	16	16	—	21
			2017	29	29	—	—	25	4	20	9	17	23	20	—	29
Palaʻā	*Odontosoria chinensis*	N	2017	1	1	—	—	1	—	—	1	1	—	1	—	1
Hala	*Pandanus tectorius*	P	2016	—	—	—	Fruit, sheath	2	1	3	—	3	—	—	—	3
			2017	1	—	—	Fruit	2	3	4	1	4	—	—	1	5
ʻIlima	*Sida fallax*	N	2017	—	—	3	—	1	2	2	1	2	—	1	—	3
Milo	*Thespesia populnea*	P	2017	1	1	—	—	1	—	1	—	1	—	—	—	1

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.

N = native (not endemic) species; E = endemic; P = Polynesian introduction; I = introduced (not Polynesian); (—) indicates none.

Table 6—Estimated number of plant parts harvested for lei used for the 2016 and 2017 Merrie Monarch Festival hula competitions

	Palapalai (fronds)	Maile (liana stems)	Pua lehua, ʻōhiʻa lehua (flowers)
2016	10,179	3,451	≤23
2017	16,717	4,482	2,520

for the largest proportion at about $59,790; while ʻōhiʻa accounted for about $1,920 (reflecting the limited use of this species as advised by cultural leaders and program coordinators). We estimate that the value of lei for all festivals across the state was more than $647,000 annually (table 7).

Table 7—Estimated value of plant material used in lei for the 2016 and 2017 Merrie Monarch Festival hula competitions and other hula festivals

	Palapalai	Maile	ʻŌhiʻa lehua	Total value
		U.S. dollars		
Merrie Monarch Festival 2016	25,020	5,705	450	31,175
Merrie Monarch Festival 2017	34,770	8,715	1,470	44,955
Other hula festivals[a]	508,215	122,570	16,320	647,105

[a] Includes more than 17 other hula festivals across Hawaiʻi annually.

Lei Day festivals—

Twenty-eight plant species (24 native) were observed in use at the three Lei Day festivals analyzed (table 8). The most frequently used species was palapalai, observed on 54 lei. Ti leaves appeared on 32 lei, and hinahina (*Heliotropium anomalum* var. *argenteum*) was observed on 22 lei. The next most frequently observed NTFPs were ʻaʻalii and moa (*Psilotum* spp.). Fewer native plants were used in the celebration on the island of Hawaiʻi. Distinct from the 100-year-old Oʻahu lei celebration, 2016 was the island of Hawaiʻi's first organized lei event. In general, this is consistent with results from analysis of harvest permits, reports by harvesters, and observations at the Merrie Monarch Festival hula competition. Introduced species, such as haole koa, (*Leucaena leucocephala*) and cultivated species, such as *Plumeria* spp., were used in Lei Day festivals, though these were not recorded in table 8 as they were not seen at events on the islands of Oʻahu and Hawaiʻi.

Kamehameha Day parade—

We observed 15 forest plant species used in the 2015 Kohala Kamehameha Day parade (table 9). The most commonly used species were fern, palapalai, and ʻōhiʻa. Some less-common species, such as ʻilima, kukui, mokihana, hinahina, and kaunaʻoa (*Cuscuta sandwichiana*), represent the different islands for the female

Table 8—Nontimber forest products in lei observed at Lei Day festivals on O‘ahu in 2015 and 2016 and on the island of Hawai‘i in 2015

Common name	Scientific name	Species origin	Number of lei	O‘ahu	Hawai‘i
Koai‘a	*Acacia koaia*	E	1	N/O	X
Kukui	*Aleurites moluccana*	P	6	X	N/O
Maile	*Alyxia stellata*	E	8	X	N/O
Kaluaha	*Astelia menziesiana*	E	5	X	N/O
Kamani	*Calophyllum inophyllum*	P	1	X	N/O
Kou	*Cordia subcordata*	N	2	X	X
Ti	*Cordyline fruticosa*	P	32	X	X
Kauna‘oa pehu	*Cuscuta sandwichiana*,	E	3	X	N/O
	Cassytha filiformis	I		X	N/O
Uluhe	*Dicranopteris linearis*	E	10	X	X
‘A‘alii	*Dodonaea viscosa*	N	19	X	X
Ma‘o	*Gossypium tomentosum*	E	1	X	N/O
Hinahina	*Heliotropium anomalum*	N	22	X	N/O
Pūkiawe	*Leptecophylla tameiameiae*	N	10	X	X
Wāwae‘iole	*Lycopodiella cernua*	N	3	X	N/O
Palapalai	*Microlepia strigosa*	N	54	X	X
Kulu‘ī	*Nototrichium sandwicense*	N	2	X	N/O
Pala‘ā	*Odontosoria chinensis*	N	5	X	N/O
‘Ūlei	*Osteomeles anthyllidifolia*	N	3	X	N/O
Hala	*Pandanus tectorius*	P	2	X	N/O
Laua‘e	*Phymatosorus grossus*	I	3	X	X
Moa	*Psilotum nudum*	N	14	X	N/O
‘Iliahi	*Santalum* sp.	E	1	N/O	X
Naupaka kauhiwi	*Scaevola gaudichaudiana*	E	1	N/O	X
Naupaka	*Scaevola taccada*	N	1	N/O	X
‘Ilima	*Sida fallax*	N	2	X	N/O
Kolokolo kahakai (beach vitex)	*Vitex rotundifolia*	N	4	X	N/O
‘Ākia	*Wikstroemia* spp.	N	1	X	N/O
Total			216	24	11

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.

N = native (not endemic) species, E = endemic; P = Polynesian introduction; I = introduced (not Polynesian); X = observed; N/O = not observed.

horseback riders (Pa‘ū). The king was draped with lei made of maile, while the queen was adorned with lei made of pīkake (*Jasminum sambac*) or pakalana (*Telosma cordata*) and maile. Each member of the royal court was adorned with lei made from plants representing respective islands. Plant species include ‘ōhi‘a, lokelani (damask rose) (*Rosa* × *damascena*), kukui, kauna‘oa, hinahina, ‘ilima, and mokihana.

Table 9—Nontimber forest product species observed at the Kamehameha Day Festival, 2015

Common name	Scientific name	Species origin	Number of lei
Lantern ʻilima	*Abutilon menziesii*	E	1
Kukui	*Aleurites moluccana*	P	2
Red ginger	*Alpinia purpurata*	I	2
Pua kalaunu	*Calotropis gigantea*	I	2
Kaunaʻoa pehu	*Cassytha filiformis* (N), *Cuscuta sandwichiana* (E), *Cuscuta campestris* (I)	N/A	1
Pūʻoheʻohe	*Coix lachryma-jobi*	I	1
Cordyline	*Cordyline* sp.	P	1
Ti	*Cordyline fruticosa*	P	1
ʻAʻaliʻi	*Dodonaea viscosa*	N	1
Yellow ginger	*Hedychium flavescens*	I	1
Mokihana kūkae moa	*Melicope hawaiensis*	N	1
ʻŌhiʻa lehua	*Metrosideros polymorpha*	E	4
Palapalai	*Microlepia strigosa*	N	5
Monstera	*Monstera deliciosa*	I	1
Fern	Numerous	N/A	7
ʻIlima	*Sida fallax*	N	1
Pele's hair, Tillandsia	*Tillandsia* sp.	I	1
Total			33

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.

N = native (not endemic) species; E = endemic; P = Polynesian introduction; I = introduced (not Polynesian); N/A = not applicable.

In-person and Online Market Surveys

Merrie Monarch Invitational Hawaiian Arts Fair—

In 2015 and 2016, we visited all vendors at the Merrie Monarch Invitational Hawaiian Arts Fair and recorded NTFP plant species for sale, alone or in combination, and the prices of the final products. In 2015, 40 of the 145 vendors were marketing NTFPs, and in 2016, 38 of 147 vendors were marketing NTFPs. The major types of NTFPs for sale at the arts fair were specialty wood products, lei, and lauhala. Wood products included carvings, bowls, and lua (traditional Hawaiian martial art) weapons. Lei were sold fresh or dried, and many vendors were creating new products during the event. Lauhala items included hats, purses, bracelets, water bottle covers, slippers, headbands, flowers, and fans. One vendor was selling honey from ʻōhiʻa and koa, and another was selling tea made from koʻokoʻolau (*Bidens* spp.), māmaki, and ʻuhaloa (*Waltheria indica*).

All together, we observed 39 NTFPs, of which 25 were native or endemic, and 14 were introduced or Polynesian introduced (table 10). Three endemic species were used for lei and woodworking. Nineteen species were used for specialty

wood products, 23 species were used for lei, and 2 species were used to weave. Six different plant parts were used for crafting specialty products; wood was used the most, followed by seeds. Stems, flowers, seed pods, and fruit were also used. Some species, particularly ‘a‘ali‘i, māmane, ‘ōhi‘a, pūkiawe, and wiliwili (*Erythrina sandwicensis*), were harvested for two or more plant parts.

The species most commonly sold at the Merrie Monarch Invitational Hawaiian Arts Fair were consistent with species we recorded from the DOFAW harvest permits, interviews, and cultural events. Maile, hala, ‘ōhi‘a, and palapalai were regular elements of most products. The Polynesian-introduced ti also was common in various products. Endemic species were used in various NTFPs, including jewelry from wiliwili and māmane seeds, hats from loulu palms (*Pritchardia* spp.), and specialty wood products such as musical instruments (e.g., ‘ukulele from ‘uhi‘uhi and ‘iliahi [*Santalum* spp.] wood).

The NTFP product prices ranged widely. For example, lauhala products cost from $5 to $2,000. Specialty wood products that sold for more than $1,000 included items made from māmane, wiliwili, and milo. Several NTFPs sold for more than $100; these were made from maile, bamboo, Pū‘ohe‘ohe (*Coix lachryma-jobi*), and kukui.

Table 10—Nontimber forest products sold at the 2015 and 2016 Merrie Monarch Invitational Hawaiian Arts Fair

Common name	Scientific name	Species origin	Plant parts used	Product type
Koa	*Acacia koa*	E	Wood	Woodwork
Koai‘a	*Acacia koaia*	E	Wood	Woodwork
False wiliwili	*Adenanthera pavonina*	I	Seed	Lei
Kukui	*Aleurites moluccan*a	P	Wood, nut	Lei
Kauila	*Alphitonia ponderosa*	E	Wood	Woodwork
Maile	*Alyxia stellata*	E	Seed, leaf	Lei
Bamboo	*Bambusa* spp.	P	Wood	Woodwork
Kukunaokalā (mangrove)	*Bruguiera gymnorrhiza*, *Rhizophora mangle*	I	Bract	Lei
Kamani	*Calophyllum inophyllum*	P	Wood	Woodwork
‘Uki grass	*Cladium jamaicense*	N	Flower	Lei
Pū‘ohe‘ohe	*Coix lachryma-jobi*	I	Seed	Lei
Kauila	*Colubrina oppositifolia*	E	Wood	Woodwork
Kou	*Cordia subcordata*	N	Wood	Woodwork
Lama	*Diospyros sandwicensis*	E	Wood	Woodwork
‘A‘ali‘i	*Dodonaea viscosa*	N	Leaf, stem, flower, fruit	Lei
Wiliwili	*Erythrina sandwicensis*	E	Wood, seed	Woodwork, lei
Hinahina	*Heliotropium anomalum*	N	Seed, leaf	Lei
Hau	*Hibiscus tiliaceus*	N	Inner bark	Woodwork
Pūkiawe	*Leptecophylla tameiameiae*	E	Leaf, stem, flower, fruit	Lei
Haole koa	*Leucaena leucocephala*	I	Seed, seedpod	Lei

Table 10—Nontimber forest products sold at the 2015 and 2016 Merrie Monarch Invitational Hawaiian Arts Fair (continued)

Common name	Scientific name	Species origin	Plant parts used	Product type
Wāwaeʻiole	*Lycopodiella cernua*	N	Stem	Lei
Mgambo, hua weleweka	*Majidea zanguebarica*	I	Seed	Lei
Turtleback, ceara rubber tree	*Manihot carthagenensis* ssp. *glaziovii*	I	Seed	Lei
ʻŌhiʻa lehua	*Metrosideros polymorpha*	E	Wood, leaf, stem, flower	Woodwork, lei
Uhiuhi	*Mezoneuron kavaiense*	E	Wood	Woodwork
Palapalai	*Microlepia strigosa*	N	Leaf, system	Lei
Cow-itch plant	*Mucuna urens*	N	Seed	Lei
Lauhala	*Pandanus tectorius*	N	Leaf	Lauhala
Loulu	*Pritchardia* sp.	E	Leaf	Lauhala
Kiawe	*Prosopis pallida*	I	Wood	Woodwork
Guava	*Psidium guajava*	I	Wood	Woodwork
Moa tree	*Psilotum nudum*	N	Stem	Lei
Alaheʻe	*Psydrax odorata*	N	Wood	Woodwork
ʻIliahi	*Santalum* spp.	E	Wood	Woodwork
Octopus tree	*Schefflera actinophylla*	I	Fruit	Lei
Christmas berry	*Schinus terebinthifolius*	I	Wood	Woodwork
Māmane	*Sophora chrysophylla*	E	Wood, seed, stem	Woodwork, lei
Milo	*Thespesia populnea*	N	Wood	Woodwork
Cat's claw	*Uncaria tomentosa*	I	Seed	Lei

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.
N = native (not endemic) species; E = endemic; P = Polynesian introduction; I = introduced (not Polynesian).

Farmers markets—

Eight NTFP species were observed at farmers markets (table 11). Five of the species were products made from trees, and four of these were made into specialty wood products. Two species observed at the farmers markets were used for cultural products, such as decorative displays, and three species were sold as food—edible kakuma and hōʻiʻo fronds and bamboo shoots. The fern hōʻiʻo was the most common edible forest product observed at farmers markets. Prices ranged from $1 to $3 per pound; however, informal conversations with restauranteurs revealed that they could sell for nearly twice that outside of farmers market settings. One online advertisement offered fronds at $13 per pound. Bamboo was the only multipurpose species used for both food and cultural purposes.

Wreaths made of combined native (ʻōhiʻa, ʻaʻaliʻi, wāwaeʻiole [*Lycopodiella* sp.]) and introduced Pinaceae species were observed at Honolulu markets during the Christmas season. Often, Japanese kadomatsu arrangements of pine, bamboo, and Japanese "ume" (*Prunus mume*) are sold prior to New Year's Eve celebrations. Turned wooden bowls and lids of Norfolk pine (*Araucaria columnaris*) also were observed.

There were eight vendors at a farmers market in Hilo that sold about 20 bunches of hōʻiʻo fronds per day. We estimated that at least 320 lb of hōʻiʻo could

Table 11—Nontimber forest product species observed for sale at farmers markets, 2015 through 2016

Common name	Scientific name	Origin	Plant part	Product type	Price per product
Koa	*Acacia koa*	E	Wood	Wine cork, cutting board	$10 $30
Albizia	*Falcataria moluccana*	I	Wood	Cutting board	$30
Monkeypod tree	*Samanea saman*	I	Wood	Cutting board	$30
Norfolk pine	*Araucaria columnaris*	I	Wood	Bowl	$400
Bamboo	*Bambusa, Phyllostachys*, *Sasa*, or *Schizostachyum* spp.	N/A	Stalk, shoot	Kadomatsu decoration or fresh bunch for food	$15–100
Kakuma	*Cibotium* spp.	E	Frond, stalk	Food	$3 per ¼ lb
Hō‘i‘o	*Diplazium* spp.	E	Frond, stalk	Food	$1–30 per lb
Pine	*Pinus* spp.	I	Stems	Bracelet	$10

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.
E = endemic; I = introduced (not Polynesian); N/A = not applicable; kadomatsu = traditional Japanese New Year’s arrangement.

be sold at a market value of $640 per week (8 vendors × 20 bunches/day × 2 major selling days × $2/bunch). As the fronds are available throughout the year, this equates to about 16,600 lb of hō‘i‘o fronds sold for about $33,300 annually at the Hilo market. Hō‘i‘o in Hilo is cheaper, more abundant, and fresher than other markets visited on the Hawaiian Islands. In Hilo, hō‘i‘o is sold daily in multiple farmers and commercial markets.

Lei vendors—

We observed lei vendors at the Merrie Monarch Invitational Hawaiian Arts Fair and interviewed proprietors of six permanent lei shops in the Chinatown area in Honolulu, O‘ahu, and three general stores in Hilo, Hawai‘i. Hilo maile was the only NTFP species observed. On the island of Hawai‘i, prices for maile ranged from $15 to $30 for three to four vines braided together of the locally sourced lei. All vendors reported that Hawai‘i-sourced maile is hard to find. Some vendors said they had not carried Kaua‘i-sourced maile for 10 to 15 years but expressed interest in selling it if it became available.

Craigslist market review—

During 7 months of monitoring the Craigslist Hawai‘i classified advertisements website, we documented more than 1,400 advertisements for products derived from plants that represent 204 species, including cultivated plants and 33 NTFP species (table 12). Eighteen species were identified as being gathered from forests, including six species native to the state (i.e., koa, ‘ōhi‘a, maile, kauila, hala, hau [*Hibiscus tiliaceus*]). One well-known, nonnative, invasive species (kīawe) was observed. The highest price recorded was for a specialty wood product (i.e., a lazy Susan) made from koa; and the lowest price was for hau rope. Common items included Christmas wreaths (fig. 5), ‘ōhi‘a poles, maile lei, koa bowls, and kauila tobacco pipes. All species had been observed in markets or mentioned in interviews or surveys.

Table 12—Nontimber forest product species recorded from Craigslist and Internet market searches

Common name	Scientific name	Origin	Product type
Koa	*Acacia koa*	E	Woodwork
False wiliwili	*Adenanthera pavonina*	I	Seed
Kukui	*Aleurites moluccana*	P	Nut
Kauila	*Alphitonia ponderosa*, *Colubrina oppositifolia*	E	Woodwork
Maile	*Alyxia stellata*	N	Lei
Norfolk pine	*Araucaria heterophylla*, *A. columnaris*	I	Woodwork
Bamboo	*Bambusa, Phyllostachys*, *Sasa*, or *Schizostachyum* spp.	N/A	Stem
Koʻokoʻolau	*Bidens* spp.	I	Food
Kukunaokalā (mangrove)	*Bruguiera gymnorrhiza*, *Rhizophora mangle*	I	Lei
Kamani	*Calophyllum inophyllum*	P	Woodwork
Hāpuʻu	*Cibotium* spp.	I	Stem
ʻUki	*Cladium jamaicense*	N	Wreath
Pūʻohe‘ohe	*Coix lachryma-jobi*	I	Extract
Kou	*Cordia subcordata*	N	Woodwork
Lama	*Diospyros sandwicensis*	E	Woodwork
Hōʻiʻo	*Diplazium* sp.	N	Food
ʻAʻaliʻi	*Dodonaea viscosa*	N	Seed
Wiliwili	*Erythrina sandwicensis*	E	Lei
Hau	*Hibiscus tiliaceus*	N	Inner bark
Pūkiawe	*Leptecophylla tameiameiae*	N	Seed
Haole koa	*Leucaena leucocephala*	I	Lei
Mgambo	*Majidea zanguebarica*	I	Seed
Turtleback, ceara rubber tree	*Manihot carthaginensis* ssp. *glaziovii*	I	Seed
ʻŌhiʻa lehua	*Metrosideros polymorpha*	E	Woodwork, wreath
Cow-itch plant	*Mucuna urens*	N	Jewelry
Lauhala	*Pandanus tectorius*	N	Woodwork
Māmaki	*Pipturus albidus*	E	Food
Kiawe	*Prosopis pallida*	I	Woodwork
Strawberry guava	*Psidium cattleianum*	I	Decoration
Guava	*Psidium guajava*	I	Woodwork
Monkeypod tree	*Samanea saman*	I	Woodwork
ʻIliahi	*Santalum* spp.	E	Woodwork
Āulu	*Sapindus oahuensis*	E	Lei
Milo	*Thespesia populnea*	N	Woodwork
Cat’s claw	*Uncaria tomentosa*	I	Extract
ʻŌhelo	*Vaccinium reticulatum*	E	Food
ʻUhaloa	*Waltheria indica*	N	Seed
Total species: 37			

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.
N = native (not endemic) species; E = endemic; P = Polynesian introduction; I = introduced (not Polynesian); N/A = not applicable.

Internet market search—

Thirty-seven plant species that had been observed at the Merrie Monarch Invitational Hawaiian Arts Fair (table 12) were identified as being for sale by searching the Internet. Ten species of NTFP advertised online were priced at $1,000 or more. Eight of these were made from wood, and two were from the inner bark or a nut (kukui). As expected, the most expensive item was made from koa wood, and the least expensive items were foods, seeds, jewelry, leis, wreaths, and bamboo stems. Products made from kauila (*Alphitonia ponderosa* Hillebr. or *Colubrina oppositifolia*), mānele (Hawaiian soapberry, *Sapindus* spp.), turtleback (ceara rubber tree) (*Manihot carthagenensis* ssp. *glaziovii*), cat's claw (*Uncaria tomentosa*), and haole koa were limited in their availability. Two of the products were made from native species, and one was made from an endangered species (kauila). Two of the introduced species also are invasive species (haole koa and cat's claw).

Comparison of species across different methods—

Further categorization reveals much about the distribution of species. Table 13 presents a summary of the 142 species harvested from Hawai‘i forests by data collection method. Fifty-three (38 percent) are native, including 33 endemic species. Eighty-eight (62 percent) are introduced, of which 16 are Polynesian introductions. Online and in-person surveys generated the highest species counts, with 124 (88 percent) species; followed by markets, with 72 (50 percent) species; and cultural events, with 36 (26 percent) species. Thirty-six species were common to markets and cultural events (table 14). Twenty-one of these species are native, of which 11 are endemic. Fifteen species are introduced, of which five are Polynesian introductions. Table 15 identifies 54 native and endemic NTFP species harvested by people associated with the online and in-person surveys, cultural events, permits, the arts fair, farmers markets, and lei vendor surveys. Seven of these were common between all methods. Nine were common to three methods. Sixty-eight percent were endemic to the state, while 32 percent were native.

Table 13—Distribution of nontimber forest product species across data collection methods

Origin	DOFAW permits	Interviews	Surveys	Cultural events	Markets	Species observed using all methods
	Number of species					
Native[a]	23 [15]	41 [27]	45 [30]	23 [11]	27 [19]	53 [33]
Introduced[b]	36 [4]	60 [16]	79 [16]	13 [7]	45 [11]	89 [16]
Total	59	101	124	36	72	142

Note: Only plants identified to species level are included. Multiple common names for the same species are counted once only (e.g., kakuma, hāpu‘u). Common names for multiple species are counted individually (e.g., kauila). Products that contain multiple species are counted once (e.g., bloodwood, Christmas tree, kauna‘oa). Common names that have no identifiable species are not included (e.g., kakalia). General category mentions, such as branches, foliage, or flowers are not included.

[a] Numbers in brackets represent the number of native plant species that are endemic.

[b] Numbers in brackets represent the number of introduced plant species that are of Polynesian origin.

DOFAW = Division of Forestry and Wildlife of the Hawai‘i Department of Land and Natural Resources.

Table 14—Nontimber forest product species common across markets and cultural events

Common name	Scientific name	Origin
Koa	*Acacia koa*	E
Kukui	*Aleurites moluccana*	P
Kauila	*Alphitonia ponderosa*	E
Maile	*Alyxia stellata*	E
ʻOhe, common bamboo	*Bambusa vulgaris*	I
Kukunaokalā (mangrove)	*Bruguiera gymnorrhiza*, *Rhizophora mangle*	I
Kamani	*Calophyllum inophyllum*	P
Kaunaʻoa pehu	*Cassytha filiformis* (N), *Cuscuta sandwichiana* (E), *Cuscuta campestris* (I)	
Hāpuʻu	*Cibotium glaucum*	E
Pūʻohe‘ohe	*Coix lachryma-jobi*	I
Kou	*Cordia subcordata*	P
Ti	*Cordyline fruticosa*	P
ʻAʻaliʻi	*Dodonaea viscosa*	N
Wiliwili	*Erythrina sandwicensis*	E
Hinahina	*Heliotropium anomalum*	N
Pūkiawe	*Leptecophylla tameiameiae*	E
Haole koa	*Leucaena leucocephala*	I
Wāwaeʻiole, Lycopodium	*Lycopodium* spp., *Lycopodiella cernua, Huperzia* spp.	N
Mokihana kūkae moa	*Melicope hawaiensis*	E
ʻŌhiʻa lehua	*Metrosideros polymorpha*	E
Palapalai	*Microlepia strigosa*	N
Lauhala	*Pandanus tectorius*	N
Māmaki	*Pipturus albidus*	E
Kiawe	*Prosopis pallida*	I
Strawberry guava	*Psidium cattleianum*	I
Guava	*Psidium guava*	I
Moa	*Psilotum nudum*	N
ʻIliahi	*Santalum* spp.	E
Christmas berry	*Schinus terebinthifolius*	I
ʻIlima	*Sida fallax*	N
Pālaʻa	*Sphenomeris chinensis*	N
Milo	*Thespesia populnea*	P
ʻUhaloa	*Waltheria indica*	N

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.
N = native (not endemic); E = endemic; P = Polynesian introduction; I = introduced (not Polynesian).

Table 15—Native and endemic nontimber forest products identified through four methods of inquiry

Common name	Scientific name	Species origin	Survey	Cultural event	Market	Harvest permit
Koa	*Acacia koa*	E	X	X	X	X
Koai‘a	*Acacia koaia*	E	X	N/O	X	N/O
Kauila	*Alphitonia ponderosa*, *Colubrina oppositifolia*	E	X	N/O	X	N/O
Maile	*Alyxia stellata*	E	X	X	X	X
Ko‘oko‘olau	*Bidens* spp.	E	X	N/O	X	N/O
Kauna‘oa pehu	*Cassytha filiformis* (N), *Cuscuta sandwichiana* (E), *Cuscuta campestris* (I)	N/A	X	X	X	N/O
‘Ōlapa	*Cheirodendron trigynum*	E	X	X	N/O	N/O
‘Āheahea (‘āweoweo)	*Chenopodium oahuense*	E	X	N/O	N/O	N/O
Hāpu‘u	*Cibotium* spp.	E	X	N/O	X	X
Kauila	*Colubrina oppositifolia*	E	X	N/O	X	N/O
‘Aiakanēnē (kūkaenēnē)	*Coprosma ernodeoides*	E	X	N/O	N/O	N/O
Makaloa	*Cyperus laevigatus*	E	X	N/O	N/O	N/O
Uluhe	*Dicranopteris linearis*	E	X	X	N/O	X
Lama	*Diospyros sandwicensis*	E	X	N/O	X	N/O
‘A‘ali‘i	*Dodonaea viscosa*	E	X	X	X	X
Wiliwili	*Erythrina sandwicensis*	N	X	X	X	N/O
‘Ōhelo papa	*Fragaria chiloensis*	E	X	N/O	N/O	N/O
‘Ie‘ie	*Freycinetia arborea*	N	X	N/O	N/O	N/O
Ma‘o	*Gossypium tomentosum*	E	N/O	X	N/O	N/O
Hinahina	*Heliotropium anomalum*	E	X	X	X	N/O
Pili	*Heteropogon contortus*	N	X	N/O	N/O	X
Kāwa‘u	*Ilex anomala*	N	X	N/O	N/O	X
Pūkiawe	*Leptecophylla tameiameiae*	E	X	X	X	X
Kuhi‘aikamo‘owahie	*Lobelia hypoleuca*	E	X	N/O	N/O	X
Wāwae‘iole, Lycopodium	*Lycopodium* spp., *Lycopodiella cernua*, *Huperzia* spp.	N	X	X	X	X
Mokihana	*Melicope anisata*	E	X	N/O	N/O	N/O
Mokihana kūkae moa	*Melicope hawaiensis*	E	X	X	X	X
‘Ōhi‘a lehua	*Metrosideros polymorpha*	E	X	X	X	X
Uhiuhi	*Mezoneuron kavaiense*	E	X	N/O	X	X
Palapalai	*Microlepia strigosa*	N	X	X	X	X
Ka‘e‘e‘e	*Mucuna gigantea* ssp. *gigantea*	N	N/O	N/O	X	N/O
Kōlea lau li‘i	*Myrsine sandwicensis*	E	X	N/O	N/O	X
Kulu‘ī	*Nototrichium sandwicense*	N	N/O	X	N/O	N/O
Pala‘ā	*Odontosoria chinensis*	N	X	X	N/O	N/O
‘Ūlei	*Osteomeles anthyllidifolia*	N	X	X	N/O	N/O
Māmaki	*Pipturus albidus*	E	X	N/O	X	X
Loulu	*Pritchardia* spp.	E	X	N/O	X	N/O
Loulu hiwa	*Pritchardia martii*	E	X	N/O	N/O	X

Table 15—Native and endemic nontimber forest products identified through four methods of inquiry (continued)

Common name	Scientific name	Species origin	Survey	Cultural event	Market	Harvest permit
Moa	*Psilotum nudum*	N	X	X	X	X
Alahe‘e	*Psydrax odorata*	N	X	N/O	X	N/O
‘Ākala	*Rubus hawaiensis*	E	X	N/O	N/O	N/O
‘Iliahi	*Santalum* spp.	E	X	X	X	N/O
Naupaka mauka	*Scaevola* spp.	E	N/O	X	N/O	N/O
Naupaka kahakai or makai	*Scaevola sericea*	N	N/O	X	N/O	N/O
‘Ohai	*Sesbania tomentosa*	E	N/O	N/O	X	N/O
‘Ilima	*Sida fallax*	N	X	X	N/O	N/O
Pōpolo (glossy nightshade)	*Solanum americanum*	N	X	N/O	N/O	N/O
Māmane	*Sophora chrysophylla*	E	X	N/O	X	N/O
Olonā	*Touchardia latifolia*	E	X	N/O	N/O	N/O
‘Ōhelo kau lā‘au	*Vaccinium calycinum*	E	X	N/O	N/O	N/O
‘Ōhelo ‘ai	*Vaccinium reticulatum*	E	X	N/O	X	X
Kolokolo kahakai (beach vitex)	*Vitex rotundifolia*	N	N/O	X	N/O	N/O
‘Uhaloa	*Waltheria indica*	N	X	N/O	X	N/O
‘Ākia	*Wikstroemia* spp.	N	N/O	X	N/O	N/O

Note: In most cases, the common name is the Hawaiian name referenced from Wagner et al. (1999), unless there is no Hawaiian name.
N = native; E = endemic; N/A = not applicable. X = observed; N/O = not observed.

Discussion

NTFPs are deeply embedded in the culture and economy of Hawai‘i. Since the first Polynesian travelers arrived, the forests of Hawai‘i have been a source of many exported products. Prior to the arrival of European colonizers in the late 1700s, the use of forest species was restricted to nonmarket uses, such as personal consumption and bartering. In general, harvests were limited to subsistence needs. This changed as outside influences rapidly transitioned demands on forests from sustenance to commercial gain. Sandalwood provides an exceptional example of the effects of this transition. Used primarily for medicine prior to outside market pressures, the supply declined rapidly as commercialization expanded (Merlin and VanRavenswaay 1990). This led to government actions (e.g., taxes) that directly affected local people who, in many cases, responded by destroying the resource base (Daehler 1989). Today, the sandalwood resource is severely limited, although forest landowners who recognize the market potential are beginning to reforest this species. This study indicated that other species, such as maile, could follow a similar path and provides insights into avoiding and mitigating the possible consequences.

Hawai‘i has a vibrant and diverse forest products industry that is based predominantly on products other than timber (i.e., furniture). The number of species used for nontimber purposes far exceeds those used for timber. Most NTFPs originate from plants other than trees, although trees do provide important nontimber products. The endemic species maile provides young vines with attached leaves used to make one of the most culturally significant lei. This study showed that the ‘ōhi‘a tree, which dominates most of the state’s native forests, supplies perhaps the most important nontimber forest product for foliage and cultural events. Koa logs are used for carving traditional canoes and bowls as well as lumber in the local furniture industry. Sandalwood is crafted into specialty wood products that command high prices, is sold in low volumes, and is also processed to produce a valuable oil. The diversity of species supporting personal, commercial, and cultural uses of NTFPs indicates that maintaining biodiversity of Hawai’i forests is important to ensuring the long-term viability of the state’s forest products economy as well as the health of its natural resources.

Land stewardship and management are ingrained in Hawaiian culture. Long before statehood, there was a well-established land stewardship system that provided formal and controlled access to natural resources, including NTFPs. In the mid-1800s, conversion of the local system resulted in three major divisions of land tenure. Through this transition, the rights to access lands by Native Hawaiians were protected and codified in the state’s constitution. Native people retain rights to pursue traditional activities, particularly harvesting plants. Today, much of the remaining ceded forest land base is held in trust and is managed by the DOFAW. Forest reserves and natural area reserves administered by the

DOFAW amount to about 20 percent of all lands on the main islands. As DOFAW-administered forests account for only a small portion of viable harvest areas, much more effort will be needed if management goals include the conservation of NTFPs throughout the state.

State Harvest Permits

The DOFAW-administered permit system for NTFP harvests provides the foundation for monitoring activities on forest reserves. It is possible to glean useful information from these permits about the species harvested, quantities permitted, and the island from which the plants were harvested. As with other agency permit systems (e.g., the USDA Forest Service and U.S. Department of the Interior Bureau of Land Management), the DOFAW system provides information on permitted harvest volumes and not actual harvest quantities and covers only DOFAW-administered lands. These constraints limit the usefulness of the data, although the available data are better than no data. They provide insight into ways to improve monitoring and reporting.

Similarly, the system relies on applicants to truthfully identify the reason for harvesting. Almost all permits were issued to harvest for personal use; less than 1 percent were reportedly for commercial gain. Over the 3-year period permits were examined, only two cultural permits were issued for culturally related harvest, although cultural use of NTFPs is predominant in the state. Interestingly, most of the commercial harvest permits were issued for O‘ahu and Maui, perhaps because these are more populated islands with larger markets for NTFPs. Most personal state harvest permits were issued on the island of Hawai‘i because the largest cultural event in the state is on this island, and it has the largest forested area. Modifications to the permit system could provide more refined reporting of the reasons for harvesting.

By applying knowledge of the diverse ethnic uses of plant materials, we inferred harvesters’ intended uses based on the common names they requested on the permits. For example, requests to harvest kakuma are assumed to refer to the traditional Japanese use of unfurled tree fern fronds. The term is used for the food item as well as the ornamental use of the plant material, though extensive processing is necessary for consumption. The Hawaiian word hāpu‘u refers to *Cibotium* sp. that is harvested for landscaping and typically implies harvesting the entire plant. The general use of pine as a product on permits describes boughs harvested for Christmas, but they might also be used for New Year’s kadomatsu arrangements. Better interpretation of permit data requires knowledge of the many cultural descriptive uses of NTFPs. Perhaps expanding the options that permit applicants can choose from to identify uses would benefit our understanding of NTFPs. Certainly, more dialogue with people who apply for these permits could elicit information about important changes to product uses.

The permits probably do not reflect total harvest activities. The results of our online survey indicated that fewer than one-third of the harvesters obtained

permits. Further, the number of permits issued declined significantly over the 3-year period. In 2015, there were 5,816 permits, and by 2017, this number had dropped by 3,000. The largest decline was observed on the island of Hawai‘i, and commercial harvest permits declined almost 50 percent over the period. Although the specific reasons for these declines are not clear, they may be of interest for future management objectives.

There is a diverse and large set of stakeholders that harvest NTFPs. Survey respondents identified themselves as belonging to several different ethnic and racial categories. An abundance of plant material was requested for hula, implying that hula groups are a large community of harvesters. Cultural permit applications were from lua martial arts practitioners and traditional house and canoe builders. The chosen ethnic/racial categories may not convey the cultural background of the permittees; however, they may offer some indication of the diversity of their beliefs and perspectives. Further identification of, and focused outreach to, these harvesters could improve understanding of harvester motives and improve monitoring.

The DOFAW standardized its permitting process, transitioning to a fully electronic statewide system in 2015. Prior to this, the use of paper permits created challenges to summarizing and analyzing data. Permit applications submitted before the transition showed that some species had not been requested post transition. Prior to the shift, product requests included evergreens, fungus, pepeiao (a variety of fungal species), silver moss, and greenery. Further refinement of the permit system could improve future analytical capabilities and provide additional transparency. This study provides a foundation for transitioning to a reporting system that involves NTFP stakeholders across cultural and economic boundaries.

Species and Harvested Plant Material

More than 140 forest plant species are harvested for their nontimber values. Most (62 percent) were post-Polynesian introductions. About 38 percent of the species harvested were native to the state, and 62 percent of these were endemic. Thirty percent of the 24 species most commonly harvested were endemic to the state. The most common endemic species were maile, kauna‘oa, pūkiawe, koa, wiliwili, ‘ōhi‘a, and ‘iliahi. Five native species (maile, ‘ōhi‘a, kakuma, Mokihana, and ‘ōhelo) and two nonnative invasive species (bamboo and strawberry guava) dominated the permits. Koa, maile, ‘a‘ali‘i, pūkiawe, wāwae‘iole, ‘ōhi‘a lehua, palapalai, and moa were the most common species identified through permits, surveys, cultural events, and market analysis. Maile and ‘ōhi‘a were the most used by performers at the Merrie Monarch Festival hula competition. The Polynesian-introduced ti leaf was the most used nonnative lei species and is a key substitute for maile in the market. As most maile is imported, this presents particular importance to future analysis of local sources. ‘Ōhi‘a is particularly important because of its applications across cultural practices and commercial markets, while being threatened by rapid ‘ōhi‘a death. Of course, koa was notable. The endemic species, wiliwili and palapalai,

also were common across the state and markets. Respondents to the online survey indicated that koa, maile, māmaki, hāpuʻu, sandalwood, and ʻōhelo (all endemic) were harvested to generate income. These valued species could represent a priority for collaborative management with forest harvest communities.

The most commonly harvested species also are relatively abundant. Like most native Hawaiian species, populations are under enormous pressures, and many have declined because of habitat loss, pests and disease, loss of pollinators and dispersers, and effects from nonnative invasive species. The conservation of native species emerged as a shared concern among harvesters and other stakeholders. Strong cultural bonds to these forest resources drive a conservation and management ethic to sustain NTFPs. This implies opportunities for cultural practitioners, forest managers, and other stakeholders to collaborate in the pursuit of the conservation of NTFPs. Additional research and education relative to motivations and perceptions of these stakeholders may reveal commonalities to advance conservation and sustainable management.

Primarily, NTFPs come from natural populations that are wild harvested with little or no formal management. Stewardship of natural resources is an important part of Hawaiian culture, but science-based management of NTFPs is lacking. Traditional and local ecological knowledge could provide a foundation for conservation, but this knowledge has not been fully assessed or considered as management options. Wild harvest of NTFPs has great potential to be unsustainable, depending on the plant parts gathered. The harvest of leaves, twigs, and fruits is more likely to be sustainable than the harvest of the entire plant or its vital organs (e.g., bark, roots). At this time, there is insufficient information to determine if harvests are having detrimental effects on populations; information is also lacking on whether harvests are sustainable. More research is needed to address these questions. Additional knowledge about the population biology of each species would help fill key information gaps. Documenting actual harvest rates instead of permitted harvest volumes and quantifying product recovery rates from harvest events could provide essential data. Fundamentally, product growth must exceed harvest and mortality for provisioning to be sustainable. More intense inventory sampling may be required to adequately assess the resource base. Ecological mapping of the island habitats may provide insights about where to focus conservation and management.

Cultivation has the potential to reduce pressures on the natural population and can provide opportunities for landowners to generate additional income. Farming māmaki is expanding, although its wild harvest is the predominant production method. Growing maile, which is primarily imported, on farms within Hawaiʻi could provide alternative income opportunities for local producers. It could also reduce the risk of importation of pests and disease. At the same time, cultivation could disenfranchise harvesters who have no land to farm. Cultivation in forests by landless harvesters could assuage this potential challenge. Small-scale forest

farming, an agroforestry approach, is widespread throughout the state. This group of agroforesters has experience and knowledge that could help supply much of the demand for cultivated NTFPs. Assessment of agroforestry production capacities and constraints could lead to approaches that advance conservation through cultivation of NTFPs.

Effects on the Resources

The ecological integrity of Hawai‘i’s forests is essential to the state’s culture and economy. Forest health and resilience is of utmost importance to the NTFP cultural economy, yet much of Hawai‘i’s original native forest has been converted to other land uses or altered by invasive plants, animals, and pests and diseases. The effects from these factors are likely to increase in magnitude if mitigation measures are not incorporated in natural resource management plans, policy, and regulations.

Invasive plant species dominate many Hawaiian forests and outcompete native species used for NTFPs. As an example, many moist ‘ōhi‘a forests are heavily invaded by strawberry guava, kahili ginger (*Hedychium gardnerianum*) and koster’s curse (*Clidemia hirta*), while drier forests are heavily invaded by Christmas berry, silky oak (*Grevillea robusta*), lantana (*Lantana camara*), and fountain grass (*Pennisetum setaceum*) (Owen et al. 2022). In both situations, invasive species form dense canopies that shade understory native vegetation and prevent regeneration. In many dryland forests, invasion by alien grasses has greatly increased the risk of wildfire (Trauernicht et al. 2015), which kills many native trees, including ‘ōhi‘a, sandalwood, kauila, and hala pepe.

Interviews, surveys, and market observations indicated that local populations of many NTFP species, such as maile, may be declining and are unable to meet demand. One reason for this may be the increase in gifting a maile lei across Hawai‘i’s diverse communities and the adoption of this practice by industries such as tourism. Another cause may be the rapid expansion of invasive species in lower elevation forests over the past century (Jacobi et al. 2017) coupled with pest and disease effects on NTFPs. Nonetheless, measures are needed if the goal is to meet the increasing demand for NTFPs. Increased effects from growing demand could be addressed through specific management of natural forests and cultivation of the desired products as well as consumer education. Awareness campaigns to inform market buyers about the conditions of the gathered resources as well as alternatives to them could lessen harvest pressure on some species. Alternatives include, for example, planting maile in a home garden or purchasing a lei that looks or smells like maile (ti leaf). Owing to the limitation of the native species for lei, the use of plastic or fabric lei are common. Rapid increase in invasive species in lower elevations could be eased through extraction of plants at lower elevation by local harvesters and others. Potential consequences from the introduction of maile pests and diseases to Hawai‘i by way of trade warrants more research before expanding market opportunities.

Two introduced pathogens—the fungi that cause rapid ʻōhiʻa death and the hala scale (*Thysanococcus pandani*)—are inflicting major effects on cultural and economic NTFPs. ʻŌhiʻa is valued by hula practitioners as a connection to the forest and by harvesters for economic gain through the sale of lei, house posts, fence posts, and general woodwork. Rapid ʻōhiʻa death, a disease caused by two newly discovered fungal pathogens (*Ceratocystis lukuohia* and *C. huliohia*) has killed more than 1 million trees since its discovery in 2014 (Fortini et al. 2019). Recognizing the severity of these pathogens, the state of Hawaiʻi and other vested stakeholders have taken actions.

In 2015, The Hawaiʻi Department of Agriculture quarantined ʻōhiʻa products on the island of Hawaiʻi, preventing their export unless they had been inspected and determined to be free of the fungal pathogens for rapid ʻōhiʻa death. As a result, the state's only inter-island freight company stopped shipping ʻōhiʻa unless its fungi-free status could be confirmed. In 2016, organizers of the Merrie Monarch Festival (CTAHR 2016) and the ʻōhiʻa working group, a collaboration of government and community members, launched an educational campaign for hula groups, lei makers, and consumers about rapid ʻōhiʻa death, sharing ways to mitigate effects on the forest and dispose of all lei to reduce the spread of the disease. As a result, the number of hula groups using ōhiʻa declined significantly (Kealiʻikanakaʻoleohaililani 2016). The DOFAW and Hawaiʻi Department of Agriculture at the Hilo and Kona airports have, since 2016, provided receptacles for travelers to deposit lei to be returned to the forest rather than take them to another island. These efforts have raised awareness of the importance of taking measures to alleviate the threat of pests and diseases to conserve natural habitats.

Lauhala weavers also are affected by, and gravely concerned about, the new hala scale insect. Hala leaves are of great cultural importance and provide significant economic opportunity for artisans. The Hawaiʻi Department of Agriculture issued a pest advisory in 2015 stating that the "hala scale can cause leaf deformities, discoloration, stunting, twisting, yellowing, and leaf blade length can be greatly reduced, all of which render leaves useless to weavers. The scale also attacks the tree's fruit, and can cause entire crowns of the plant to fall off and the premature death of trees" (HDOA 2015). These examples may illustrate the potential benefits for agencies and practitioners to work together on biosecurity planning and implementation if the goal is to conserve the ecological, cultural, and economic integrity of the NTFP resource. This could include collaboration between practitioners and agencies for effective management practices, preventing the movement of plants or plant parts (e.g., seeds) between forests or islands, and widespread adoption of rigorous biohygiene protocols, especially when there is potential for transporting pests or pathogens in clothing, equipment, or NTFPs themselves. Collaborative efforts by the community, nongovernmental organizations, and the government could support expanded monitoring and eradication efforts, where needed.

The combination of pests, pathogens, and invasive plants have severely affected native forests, yet local ecological knowledge, as evidenced by NTFP stewardship, including the removal of invasive species, can help mitigate those effects. Evidence indicates that in many cases harvesters are managing populations and have improved the status of some species (Ticktin et al. 2006, 2007). Knowledge from local harvesters about plant locations, habits, and harvest approaches can lead to better overall management of the resource. Combined with the empirical evidence of demonstrated conservation techniques, this knowledge can advance conservation efforts greatly. Working together, stakeholders and government agencies may stem the tide of these deleterious factors to ensure long-term sustainable sourcing of NTFPs.

Cultural Significance

NTFPs are embedded in the culture of Hawai‘i and are major economic contributors to the state. This study demonstrates that many economic contributors are tied to cultural events (e.g., Merrie Monarch arts fair, Japanese New Year’s customs, Christmas) and lifecycle milestones (e.g., graduation, birthdays, funerals, rites of passage). Many NTFPs are of such importance that associated species can be considered cultural keystone species, without which Hawaiian culture would suffer and decline (Girabaldi and Turner 2004).

Harvesting NTFPs fulfills many roles, and understanding their cultural importance can be improved through testimonies. Practitioners described the importance of these products as preserving Hawaiian traditions and lifestyle, Hawaiian rights, and responsibilities (“kuleana”), rites of passage, generational and family ties, and religious practices, as well as necessary for survival. For many people, gathering forest products provides a connection to the natural world, specific places, the land (“āina”), ancestors, the natural elements, family, and plants themselves. This relationship is epitomized by the response of one participant:

> We are one… the reciprocal love relationship circle. [I] cannot imagine my life without gathering. I am the gatherer for my ohana [family, from the] mauka [mountains] to makai [the ocean], all flora and fauna. Gatherers feel peace by gathering in nature; pride from the quality of the product collected; pride from providing for the ohana; accomplishment for executing something that was hard to do; accomplishment at being skillful… [It] is culturally significant, is spiritual, provides for extremely important cultural practices. [Also, it] provides for “rites of passage” for generations. It grounds me in Hawai‘i.

Interviews and surveys of cultural practitioners and vendors confirm the importance of spiritual connections, rights and responsibilities, and knowledge of the products being made. As one lauhala weaver explained, “There’s more mana [supernatural or divine power] in the end product.” Others emphasized the importance of exercising cultural rights. Another respondent described the

importance of gathering as, "I exercise my rights as a Hawaiian and I feel fulfilled and connected to the land and my ancestors when I do it." In sum, these testimonies provide evidence of the importance of NTFPs to the state and the need to improve management of the resources so that future ancestors can enjoy them in perpetuity.

Conclusion

This study is the first statewide assessment of nontimber forest products in the United States. The forethought of the state forestry department resulted in actions to assess the importance of NTFPs to Hawai'i. NTFPs provide significant cultural and economic value in many regions, and assessments of statewide NTFP resources may be of interest to other states (Frey et al. 2021). There is a dynamic and rich forest products industry in Hawai'i that is built on NTFPs.

The amazing forest biodiversity of Hawai'i is the foundation for the state's NTFP economy and related communities. It is the source of more than 140 plant species valued for their nontimber products. Most of this diversity resulted from introduced species, though native and endemic species also are collected. Indeed, half of the 24 most harvested species are native and endemic. Documenting the variety of plant organs harvested is important for understanding pressures on forest biodiversity, identifying high-risk species, and setting management priorities. The plant parts harvested have different effects on the resource base. Organs such as bark or stems, or whole plants, have the greatest potential to damage populations with irreversible consequences. Therefore, conservation efforts focused on these species may warrant higher priority than those harvested for fruit or leaves, although harvesting these organs also can have effects, thus these species could benefit from monitoring as well.

Hawai'i has a vibrant, diverse, and dynamic forest products industry that relies heavily on NTFPs. Cultural forest products gathered from forest plants for cultural activities define much of this industry. Floral products, made from leaves, seeds, twigs, and other foliage, are sourced from ecologically diverse forests. Koa and sandalwood have exceptional commercial value and are deeply embedded in the cultural economy. The vitality of the forest products industry depends on the culture, as without the culture there would be much less demand for the many products sourced from the forest. NTFPs are also usually processed locally. Maile and 'ōhi'a flowers are woven into lei for local sale, bamboo shoots are made into kadomatsu for New Year's celebrations, and oil is extracted from sandalwood in local distilling plants. Local processing increases the value of NTFPs to the local economy and creates employment opportunities. Recognizing the roles and contributions of NTFP species to the culture and economy is essential to the dynamics of the state. To fully assess the depth and breadth of the NTFPs requires investigation through multiple channels and expansion beyond traditional forest products market segments and product chains. The approach used here to assess

whether the NTFP industry can serve as a model for other states seeking to better understand the industry.

Twenty-four plant species provide most of Hawai‘i’s NTFPs (table 16). The most frequently collected nonwoody NTFP is the endemic plant maile, which is prized for its aromatics and used in lei. Local sources of this important NTFP are insufficient to meet demand so most of it is imported. This presents opportunities for nature-based economic development to encourage its cultivation for local sourcing. Koa and sandalwood are of sufficient economic value for landowners to invest in developing the resource to ensure a sustainable supply. Similar investments could be fruitful for the many nonwood forest products that may be at risk. Many NTFP species could be at risk of decline; this study offers insights that can help set priorities for management and cultural-economic development.

The permit system is the foundation for monitoring NTFP harvests in the state of Hawai‘i and is key to acquiring data on NTFP harvests on state land. It could develop over time with increased knowledge. The current system may need modification to adequately describe the forest products industry. A system that tracks actual harvest and integrates an intensive forest inventory would allow for volume estimations and improved analytics. An inclusive effort with all stakeholders to develop ways to monitor harvests across land ownership could provide more insight.

This study took an ethnobotanical approach to investigate and document Hawai‘i’s NTFP cultural economy. It focused on peoples’ interactions with, and strong cultural ties to, these plants. It highlighted the social and cultural values of NTFPs and revealed economic contributions at markets across the state. More investigation and infrastructure development are needed to integrate managing NTFPs into the overall management of Hawai‘i’s diverse forest resources, conserve

Table 16—Commonly used nontimber forest product species in both Hawaiian culture and markets

Endemic	Native	Polynesian introduction	Introduced
Hāpu‘u	‘A‘ali‘i	Ti	Laua‘e
Hinahina	‘Ilima	Hau	Strawberry guava
‘Iliahi	Kauna‘oa		Kīawe
Koa	Moa		
Māmaki	Palai		
Māmane	Hala		
Mokihana kūkae moa	Maile		
‘Ōhelo			
‘Ōhi‘a lehua			
‘Ōlapa			
Pūkiawe			
Wiliwili			

biodiversity, and sustain economic contributions. Market-based, focused research could provide the means to better quantify the economic contributions of NTFPs to the Hawaiian state and its islands. A monitoring system similar to the FIA timber product output assessments that tracks harvest volumes could provide long-term data and improve management decisions. Ecological modeling of suitable habitat for NTFP species could provide much needed knowledge to help prioritize conservation and management zones. Ecological modeling may determine a need for increasing the number of FIA inventory plots in select areas and expand monitoring to include an assessment of presence, condition, and extent of NTFP species to improve the state's ability to manage its resources. Models exist for other states where partners and land managers fund the collection of additional vegetation data or spatial intensifications to better understand the relationship of forest resources, biodiversity, and management (Hoover et al. 2020).

Hawai'i's NTFP-based cultural economy is vital to the resilience and vitality of Hawaiian society. Forest management, therefore, has a key role to play in sustaining Hawaiian society. NTFP species in the state face many threats. Ensuring their long-term sustainability likely requires proactive, intentional, and adaptive management strategies. Identifying desired future outcomes is a starting point that can inform current monitoring protocols and management decisions. Conserving NTFP species is an intentional endeavor that can ensure the capacity of the forests to support them in perpetuity for the people of Hawai'i.

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Metric Equivalents

When you know:	Multiply by:	To find:
Inches (in)	2.54	Centimeters (cm)
Feet (ft)	0.305	Meters (m)
Board feet (board ft)	0.0024	Cubic meters (m^3)
Miles (mi)	1.609	Kilometers (km)
Acres (ac)	0.405	Hectares (ha)
Square miles (mi^2)	2.589	Square kilometers
Pounds (lb)	454	Grams (g)
Pounds (lb)	0.454	Kilograms (kg)
Quarts (qt)	0.946	Liters (l)
Gallons (gal)	3.78	Liters (l)

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Appendix—Species List

Scientific names and authorities	Locally known common name	Citation for common name
Abrus precatorius L.	Black-eyed Susan	Wagner et al. 1999[a]
Abutilon menziesii Seem.	Ko‘oloa‘ula	Wagner et al. 1999
Acacia koa A. Gray	Koa	Wagner et al. 1999
Acacia koaia Hillebr.	Koai‘a	Wagner et al. 1999
Acacia mearnsii De Wild.	Black wattle	Wagner et al. 1999
Adenanthera pavonina L.	False wiliwili	Bishop Museum[b]
Aleurites moluccana (L.) Willd.	Kukui	Wagner et al. 1999
Alphitonia ponderosa Hillebr.	Kauila	Wagner et al. 1999
Alpinia purpurata (Vieill.) K. Schum.	Red ginger	Bishop Museum
Alyxia stellata (J.R. Forst. & G. Forst.) Roem. & Schult.	Maile	Wagner et al. 1999
Anthurium Schott	Anthurium	Bishop Museum
Araucaria columnaris (G. Forst.) Hook.	Cook pine	Bishop Museum
Araucaria heterophylla (Salisb.) Franco	Norfolk pine	Bishop Museum
Argyroxiphium DC.	Hawaiian silverswords	Bishop Museum
Argyroxiphium sandwicense DC.	Silversword	Bishop Museum
Artocarpus altilis (Parkinson ex Z) Fosberg	Breadfruit	Bishop Museum
Arundina graminifolia (D. Don) Hochr.	Bamboo orchids	Wagner et al. 1999
Astelia menziesiana Sm.	Kaluaha	Wagner et al. 1999
Bambusa Schreb.	Bamboo	NRCS PLANTS[c]
Bambusa vulgaris Schrad. ex J.C. Wendl.	Common bamboo	Bishop Museum
Begonia L.	Pīkōnia	Wagner et al. 1999
Bidens (L.) DC.	Ko‘oko‘olau	Wagner et al. 1999
Broussonetia papyrifera (L.) L’Hér. ex Vent.	Wauke	Wagner et al. 1999
Bruguiera gymnorrhiza (L.) Lam. ex Savigny	Kukunaokalā	Wagner et al. 1999
Calophyllum inophyllum L.	Kamani	Wagner et al. 1999
Calotropis gigantea (L.) W.T. Aiton	Pua kalaunu	Wagner et al. 1999
Cassytha filiformis L.	Kauna‘oa pehu	Wagner et al. 1999
Casuarina equisetifolia L.	Ironwood	Wagner et al. 1999
Cenchrus clandestinus (Hochst. ex Chiov.) Morrone	Kikuyu grass	Wagner et al. 1999
Cenchrus setaceus (Forssk.) Morrone	Fountain grass	Wagner et al. 1999
Cheirodendron trigynum (Gaudich.) A. Heller	‘Ōlapa	Wagner et al. 1999
Chenopodium oahuense (Meyen) Aellen	‘Āheahea, ‘āweoweo	Wagner et al. 1999
Cibotium Kaulf.	Hāpu‘u	Wagner et al. 1999
Cladium jamaicense Crantz	Uki grass	Bishop Museum
Clidemia hirta (L.) D. Don	Koster’s curse	Wagner et al. 1999
Cocos nucifera L.	Coconut, niu	Wagner et al. 1999
Coffea arabica L.	Coffee	Wagner et al. 1999
Coix lachryma-jobi L.	Pū‘ohe‘ohe	Wagner et al. 1999
Colocasia esculenta (L.) Schott	Taro	Wagner et al. 1999
Colubrina oppositifolia Brongn. ex H. Mann	Kauila	Wagner et al. 1999
Commelina diffusa Burm.f.	Honohono	Wagner et al. 1999
Coprosma ernodeoides A.Gray	‘Aiakanēnē	Wagner et al. 1999
Cordia subcordata Lam.	Kou	Wagner et al. 1999

Scientific names and authorities	Locally known common name	Citation for common name
Cordyline Comm. ex R. Br.	Cordyline	Bishop Museum
Cordyline fruticosa (L.) A. Chev.	Ti	Wagner et al. 1999
Curcuma longa L.	ʻŌlena	Wagner et al. 1999
Cuscuta campestris Yunck.	Kaunaʻoa pehu	Wagner et al. 1999
Cuscuta sandwichiana Choisy	Kaunaʻoa	Wagner et al. 1999
Cyathea australis (R.Br.) Domin.	Rough tree fern	NRCS PLANTS
Cyperus laevigatus L.	Makaloa	Wagner et al. 1999
Dianella sandwicensis Hook. & Arn.	ʻUki	Wagner et al. 1999
Dicranopteris linearis (Burm.f.) Underw.	Uluhe	Wagner et al. 1999
Digitaria pruriens (Fisch. ex Trin.) Büse	Kūkaepuaʻa	Wagner et al. 1999
Diospyros sandwicensis (A. DC.) Fosberg	Lama	Wagner et al. 1999
Diplazium Sw.	Hōʻiʻo	Wagner et al. 1999
Diplazium arnottii Brack	Hōʻiʻo	Wagner et al. 1999
Diplazium esculentum (Retz.) Sw.	Hōʻiʻo, warabi	Wagner et al. 1999
Diplazium sandwichianum (C. Presl) Diels	Hōʻiʻo	Wagner et al. 1999
Diplopterygium pinnatum (Kunze) Nakai	Uluhe lau nui	Bishop Museum
Dodonaea viscosa (L.) Jacq.	ʻAʻaliʻi	Wagner et al. 1999
Dracaena reflexa Lam.	Song of India	Plants of the World Online[d]
Elaeocarpus angustifolius Blume	Blue marble	Bishop Museum
Erythrina sandwicensis O. Deg.	Wiliwili	Wagner et al. 1999
Eucalyptus robusta Sm.	Swamp mahogany	Wagner et al. 1999
Eucalyptus saligna Sm.	Sydney blue gum	Wagner et al. 1999
Falcataria moluccana (Miq.) Barneby & J.W. Grimes	Albizia	Bishop Museum
Fragaria chiloensis (L.) Duchesne	ʻŌhelo papa	Wagner et al. 1999
Fraxinus uhdei (Wenz.) Lingelsh.	Tropical ash	Wagner et al. 1999
Freycinetia arborea Gaudich.	ʻIeʻie	Wagner et al. 1999
Gossypium tomentosum Nutt. ex Seem.	Maʻo	Wagner et al. 1999
Grevillea robusta A.Cunn. ex R.Br.	Silky oak	Bishop Museum
Hedychium flavescens Carey ex Roscoe	Yellow ginger	Wagner et al. 1999
Hedychium gardnerianum Shepard ex Ker Gawl.	Kahili ginger	Wagner et al. 1999
Heliconia L.	Heliconia	Bishop Museum
Heliotropium anomalum Hook. & Arn. var. *argenteum* A. Gray	Hinahina	Wagner et al. 1999
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	Pili grass	Wagner et al. 1999
Hibiscus tiliaceus L.	Hau	Wagner et al. 1999
Hydrangea L.	Hydrangea	NRCS PLANTS
Huperzia Bernh.	Huperzia, wāwaeʻiole	Bishop Museum
Ilex L.	Holly	Bishop Museum
Ilex anomala Hook. & Arn.	Kāwaʻu	Wagner et al. 1999
Ipomoea batatas (L.) Lam.	Sweet potato	Wagner et al. 1999
Jasminum sambac (L.) Aiton	Pīkake	Wagner et al. 1999
Juniperus L.	Juniper	Bishop Museum
Lantana camara L.	Lantana	Bishop Museum
Leptecophylla tameiameiae (Cham. & Schltdl.) C.M. Weiller	Pūkiawe	Wagner et al. 1999

Scientific names and authorities	Locally known common name	Citation for common name
Leucaena leucocephala (Lam.) de Wit	Koa haole	Wagner et al. 1999
Lobelia hypoleuca Hillebr.	Kuhi‘aikamo‘owahie	Wagner et al. 1999
Lonicera albiflora Torr. & A. Gray	White honeysuckle	Wagner et al. 1999
Lycopodiella Holub	Wāwae‘iole	wehewehe.org[e]
Lycopodiella cernua (L.) Pic. Serm	Wāwae‘iole	wehewehe.org
Lycopodium L.	Lycopodium	Bishop Museum
Macaranga Thouars	Bingabing	Wagner et al. 1999
Machaerina augustifolia (Gaudich.) T. Koyama	‘Uki	Wagner et al. 1999
Machaerina mariscoides (Gaudich.) J. Kern	‘Uki	Wagner et al. 1999
Majidea zanguebarica J. Kirk ex Oliv.	Mgambo, hua weleweka	Bishop Museum
Mangifera indica L.	Mango	Bishop Museum
Manihot carthagenensis (Jacq.) Müll. Arg. ssp. *glaziovii* (Müll. Arg.) Allem	Ceara rubber tree, turtleback	Bishop Musuem
Melicope anisata (H. Mann) T.G. Hartley & B.C. Stone	Mokihana	Bishop Museum
Melicope hawaiensis (Wawra) T.G. Hartley & B.C. Stone	Mokihana kūkae moa	Bishop Museum
Metrosideros polymorpha Gaudich.	‘Ōhi‘a lehua	Wagner et al. 1999
Mezoneuron kavaiense (H.Mann) Hillebr.	Uhiuhi	Wagner et al. 1999
Microlepia strigosa (Thunb.) C. Presl	Palapalai	Bishop Museum
Monstera deliciosa Liebm.	Swiss-cheese plant	Bishop Museum
Morinda citrifolia L.	Noni	Wagner et al. 1999
Mucuna gigantea (Willd.) DC. ssp. *gigantea*	Kā‘e‘e‘e	Wagner et al. 1999
Mucuna urens (L.) Medik.	Cow-itch plant	Wagner et al. 1999
Musa L.	Banana	Wagner et al. 1999
Myrsine sandwicensis A. DC.	Kōlea lau li‘i	Wagner et al. 1999
Nototrichium sandwicense (A. Gray) Hillebr.	Kulu‘ī	Wagner et al. 1999
Odontosoria chinensis (L.) J. Sm.	Pala‘ā	Bishop Museum
Olea europaea L.	‘Oliwa	Wagner et al. 1999
Osteomeles anthyllidifolia (Sm.) Lindl.	‘Ūlei	Wagner et al. 1999
Pandanus tectorius Parkinson ex Zucc.	Hala	Wagner et al. 1999
Passiflora edulis Sims	Liliko‘i	Wagner et al. 1999
Pennisetum ciliare (L.) Link	Buffelgrass	Wagner et al. 1999
Pennisetum setaceum (Forssk.) Chiov.	Fountain grass	Wagner et al. 1999
Persea americana Mill.	Avocado	Wagner et al. 1999
Phaseolus lathyroides L.	Uhiuhi	wehewehe.org
Phyllostachys Siebold & Zucc.	Bamboo	Wagner et al. 1999
Phymatosorus grossus (Langsd. & Fisch.) Brownlie	Laua‘e ferns	Bishop Museum
Pinus taeda L.	Loblolly pine	Bishop Museum
Piper methysticum G. Forst.	‘Awa	Wagner et al. 1999
Pipturus albidus (Hook. & Arn.)	Māmaki	Wagner et al. 1999
Pisonia umbellifera (J.R. Forst. & G. Forst.) Seem.	Pāpala kēpau	Wagner et al. 1999
Plantago major L.	Laukahi	Wagner et al. 1999
Pleomele Salisb.	Hala pepe	Wagner et al. 1999
Plumeria L.	Plumeria	Bishop Museum
Pritchardia Seem. & H. Wendl.	Loulu (Hawaiian fan palms)	Wagner et al. 1999
Pritchardia martii (Gaudich.) H. Wendl.	Loulu hiwa	Wagner et al. 1999

Scientific names and authorities	Locally known common name	Citation for common name
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	Kiawe	Wagner et al. 1999
Prunus mume (Siebold) Siebold & Zucc.	Ume	GBIF[f]
Prunus persica (L.) Batsch	Peach	Wagner et al. 1999
Psidium cattleianum Sabine	Strawberry guava	Wagner et al. 1999
Psidium guajava L.	Guava	Wagner et al. 1999
Psilotum Sw.	Moa	Bishop Museum
Psilotum nudum (L.) P. Beauv.	Moa	Bishop Museum
Psydrax odorata (G. Forst.) A.C. Sm. & S.P. Darwin	Alahe‘e	Wagner et al. 1999
Rhizophora mangle (Lour.) Poir.	Mangrove	Bishop Museum
Rosa x *damascena* Mill.	Lokelani (damask rose)	NRCS PLANTS
Rubus hawaiensis A. Gray	‘Ākala	Wagner et al. 1999
Rubus macraei A. Gray	‘Ākala	Wagner et al. 1999
Saccharum officinarum L.	Sugarcane	Wagner et al. 1999
Salix discolor Muhl.	Pussy willow	NRCS PLANTS
Samanea saman (Jacq.) Merr.	Monkeypod	Wagner et al. 1999
Santalum L.	‘Iliahi	Wagner et al. 1999
Santalum paniculatum Hook. & Arn.	‘Iliahi (sandalwood)	Wagner et al. 1999
Sapindus L.	Mānele	Wagner et al. 1999
Sapindus oahuensis Hillebr. ex Radlk.	Āulu	Wagner et al. 1999
Sapindus saponaria L.	Mānele, a‘e	Bishop Museum
Sasa Makino & Shib.	Bamboo	NRCS PLANTS
Scaevola L.	Naupaka	Wagner et al. 1999
Scaevola gaudichaudiana Cham.	Naupaka kauhiwi	Wagner et al. 1999
Scaevola sericea Vahl	Naupaka kahakai	Wagner et al. 1999
Scaevola taccada (Gaertn.) Roxb.	Naupaka	Wagner et al. 1999
Schefflera actinophylla (Endl.) Harms	Octopus tree	Wagner et al. 1999
Schinus terebinthifolius Raddi	Christmas berry	Wagner et al. 1999
Schizostachyum Nees	Bamboo	Wagner et al. 1999
Schizostachyum glaucifolium (Rupr.) Munro	Polynesian ‘ohe	Wagner et al. 1999
Sesbania tomentosa Hook. & Arn.	‘Ohai	Wagner et al. 1999
Sida fallax Walp.	‘Ilima	Wagner et al. 1999
Solanum americanum Mill.	Pōpolo	Wagner et al. 1999
Sophora chrysophylla (Salisb.) Seem.	Māmane	Wagner et al. 1999
Sphenomeris chinensis (L.) Maxon	Pala‘ā	hawaii.edu[g]
Sticherus owhyhensis (Hook.) Ching	Uluhe	Bishop Museum
Syzygium cumini (L.) Skeels	Java plum	Wagner et al. 1999
Syzygium malaccense (L.) Merr. & L.M. Perry	‘Ōhi‘a ‘ai	Wagner et al. 1999
Tamarindus indica L.	Tamarind	Bishop Museum
Telosma cordata (Burm. F.) Merr.	Pakalana	Bishop Museum
Terminalia catappa L.	False kamani	Wagner et al. 1999
Thespesia populnea (L.) Sol. ex Corrêa	Milo	Wagner et al. 1999
Tillandsia L.	Tillandsia	Bishop Museum
Tillandsia usneoides (L.) L.	Spanish moss	NRCS PLANTS
Toona ciliata M. Roem.	Australian red cedar	Wagner et al. 1999

Scientific names and authorities	Locally known common name	Citation for common name
Touchardia latifolia Gaudich.	Olonā	Bishop Museum
Uncaria tomentosa (Willd. ex Schult.) DC.	Cat’s claw	GBIF
Vaccinium L.	‘Ōhelo	Wagner et al. 1999
Vaccinium calycinum Sm.	‘Ōhelo	Bishop Museum
Vaccinium dentatum Sm.	‘Ōhelo	Wagner et al. 1999
Vaccinium reticulatum Sm.	‘Ōhelo	Wagner et al. 1999
Vitex L.	Chastetree	Wagner et al. 1999
Vitex rotundifolia L. f.	Kolokolo kahakai	Wagner et al. 1999
Waltheria indica L.	‘Uhaloa	Wagner et al. 1999
Wikstroemia Endl.	‘Ākia	Bishop Museum
Zingiber zerumbet (L.) Sm.	‘Awapuhi	Wagner et al. 1999

[a] Wagner et al. 1999: Wagner, W.L.; Herbst, D.R.; Sohmer, S.H. 1999. Manual of the flowering plants of Hawai‘i. Honolulu, HI: Bishop Museum Press. Vol. 1., rev. 1952 p.

[b] Bishop Museum Plants of Hawai‘i: https://plantsofhawaii.org.

[c] U.S. Department of Agriculture Natural Resource Conservation Service PLANTS database: https://plants.usda.gov/home.

[d] Royal Botanic Gardens Kew Plants of the World Online: https://powo.science.kew.org/results?q=Dracaena0reflexa.

[e] Ulukau’s wehewehe (Hawaiian dictionary books): https://wehewehe.org.

[f] GBIF (Global Biodiversity Information Facility): https://www.gbif.org.

[g] Native Plants Hawaii: http://nativeplants.hawaii.edu.

Glossary

The main objective of this glossary is to provide the reader with guidance on non-English words and to offer insight into place names, plants, and practices of Hawai‘i. Hawaiian is an official language of Hawai‘i and the original language of Hawaiians. Most definitions come from Mary Kawena Pukui and Samuel Elbert’s Hawaiian-language dictionary (1986) and Parker’s dictionary (Andrews and Parker 1922). Japanese, Maori (New Zealand), and Tagalog (Philippines) language resources also were used. If no known reference materials were available, accounts from permits were applied verbatim or interpreted by the lead author. Some definitions explain exactly what species are being discussed, while others provide insight into the reasoning behind plant names, uses, or relationships to their surroundings.

‘a‘ali‘i—Native hardwood shrub or tree (*Dodonaea viscosa*). Fruit and seed clusters are made into lei with their own leaves or ferns and worn by women in their hair.

ahupua‘a—Land division usually extending from the uplands to the sea, so called because historically the boundary was marked by a heap (ahu) of stones surmounted by an image of a pig (pua‘a), or because a pig or other tribute was laid on the altar as tax to the chief.

‘ā‘ī—Neck or collar.

ʻākala—Literally, pink. Two endemic raspberries (*Rubus hawaiensis* and *R. macraei*). Also ʻākalakala, ʻōlaʻa. Berries are commonly harvested for food. The ʻākala juice is used to make dye for tapa.

ʻauana—A contemporary hula and means to wander or drift.

hala—The pandanus or screwpine (*Pandanus tectorius*), a native of southern Asia and eastward to Hawaiʻi, growing at low altitudes. Cultivated and harvested wild, the tree has many branches tipped with spiral tufts of long, narrow, spine-edged leaves; its base is supported by a clump of slanting aerial roots. Leaves are used for mats, baskets, and hats; fruit sections are used for lei and brushes; male flowers are used to scent tapa; and bracts are used to plait mats (see hīnano). The aerial root tip is a good source of vitamin B and is cooked in ti leaves for medicinal use.

hala pepe—A small tree (*Pleomele* spp.) with soft whitish wood, emitting roots above ground, similar to pandanus.

hāliʻi—A covering, or spread, often covering food.

haole koa or ēkoa—(*Leucaena leucocephala*) An introduced tree species with many uses.

hāpuʻu—Endemic tree ferns (*Cibotium* spp.), common in many forests in Hawaiʻi. Frequently cultivated. These ferns grow to about 16 ft high and the trunks are crowned with large, triangular, lacy-looking fronds up to 9 ft long; their light brown stems rise from a mass of silky, golden pulu (wool). Young stems are used to make hats; the pulu is used to dress wounds, embalm bodies, and in recent times to stuff pillows and mattresses. Starch extracted from the trunk is used for cooking and laundry, and the outer fibrous part is used to line or form baskets for plants.

hau—(*Hibiscus tiliaceus*) A lowland tree found in many warm climates. Some spread horizontally over the ground forming impenetrable thickets or are trained to grow on trellises. The light, tough wood is used for canoe outriggers; the inner bark, or "bast fiber," is used for making cord; and the sap and flowers are used for medicine.

hinahina—Literally, shiny or silvery. Several plants with silvery leaves are called hinahina or ʻāhinahina, including silversword (*Argyroxiphium sandwicense*), Spanish moss (*Tillandsia usneoides*), and a native heliotrope (*Heliotropium anomalum*), which is a low, spreading beach plant with narrow, clustered, silvery leaves and small, white, fragrant flowers. As designated by the 1923 Territorial Legislature, it represents Kahoʻolawe in the lei of the islands; it is used for tea and medicine. *Tillandsia* is an epiphyte, growing on tree branches and hanging baskets, forming masses of gray, thread-like stems and leaves.

hīnano—The male blossom of *Pandanus tectorius*. Fine mats are made from the bracts of the flower.

hō‘i‘o—Two species of large native fern (*Diplazium arnottii* and *D. sandwichianum*) with subdivided fronds; however, nowadays hō‘i‘o may refer to the introduced, naturalized species, *D. esculentum,* also called warabi. The young fronds are both eaten raw and cooked.

hula—A type of Hawaiian dance.

‘ie‘ie—(*Freycinetia arborea*) A woody, branching climber endemic to forests at medium to high elevations. Traditionally, ‘ie‘ie is one of five plants used on the hula altar. Aerial roots were used to make baskets and fish traps. It is also called ‘ie‘.

‘iliahi—(*Santalum* spp.) Hawaiian species of sandalwood, shrubs and trees, with fragrant heartwood, small pale-green or gray-green leaves, small, dull-red or greenish flowers, and small purple fruits. **‘**Iliahi is pounded into new tapa cloth to improve the scent. Flowers were used in many different lei. Leaves were valued for traditional medicine. Wood is used to make an essential oil used in aromatherapy.

‘ilima—Small to large native shrubs (species of *Sida*, especially *S. fallax*), bearing yellow, orange, greenish, or dull-red flowers; some are strung for lei. The flowers last only a day and are so delicate that about 500 are needed for one lei. The 1923 Territorial Legislature designated the ‘ilima as the flower of O‘ahu.

imu—Traditional underground oven; food cooked in an imu. It is also called umu.

kadomatsu—Literally, gate pine in Japanese (門松). A traditional Japanese New Year’s decoration that is placed in pairs in front of homes to welcome ancestral spirits, or kami, of the harvest. Designs for kadomatsu vary depending on the region but are typically made of pine, bamboo, and sometimes plum tree sprigs to represent longevity, prosperity, and steadfastness, respectively.

kahikō—An ancient form of traditional hula and means old, ancient, antique.

kakuma—A local Japanese delicacy prepared from spineless, young, unfurled native Hawaiian tree fern (*Cibotium* spp.) shoots. Kakuma is sold in local markets and the Chinatown area in Honolulu. It is eaten pickled or panfried with pork. (See also hāpu‘u.)

kalo—(*Colocasia esculenta*) More commonly called taro, kalo spread widely from the tropics of the Old World and has been cultivated as a staple food crop in Hawai‘i since ancient times. Its use in Hawaiian culture has led to the development of more than 300 varieties. All parts of the plant are eaten; starchy roots cooked and pounded with water make an edible paste (poi), and its leaves are steamed, sometimes in coconut milk.

kauila or kauwila—A native tree (*Alphitonia ponderosa*) in the buckhorn family (Rhamnaceae) found on 6 of the 8 main Hawaiian Islands. The hard wood was historically used for spears and mallets. Also, kauila is the Hawaiian name for *Colubrina oppositifolia*, a native tree also in the buckhorn family (Rhamnaceae), found only on Oʻahu and Hawaiʻi, and also historically harvested its use in spears and tools. *Colubrina oppositifolia* is also called oʻa on Maui Island.

kaunaʻoa pehu—(*Cassytha filiformis* [native], *Cuscuta sandwichiana* [endemic], and *Cuscuta campestris* [introduced]). Parasitic vines belonging to the laurel family (Lauraceae) or the morning glory family (Convolvulaceae). These vines have no chlorophyll, are leafless, and grow densely on other plants. Numerous slender, orange stems are used to make an orange lei to represent the island of Lānaʻi.

kī, ti—(*Cordyline fruticosa*) A woody plant in the asparagus family (Asparagaceae) native to tropical Asia and Australia. The leaves were once used traditionally by Hawaiians for house thatch and are still used today for food wrappers, hula skirts, and sandals; thick, sweet roots were eaten baked or distilled for brandy. Many varieties are grown in gardens, having leaves wide to narrow, large to small; the colors include purple, crimson, scarlet, rust, pink, or green; patterns are striped or plain. Green ti leaves are still believed to afford protection from spirits and to purify menstruating women.

kiawe—Algaroba or mesquite (*Prosopis pallida*) was introduced from Peru in 1828 in Hawaiʻi; it has become one of most common and useful trees, especially for firewood. It is also valued as a honey plant. The sweet pods were once an important forage for cattle in dry regions.

kinolau—The many forms, according to traditional Native Hawaiian belief, that a supernatural being can assume. For example, it is said the deity Pele could at will become a flame of fire, a young girl, or a fierce and wise older woman.

koa—(*Acacia koa*) The largest native Hawaiian forest tree with light-gray bark, crescent-shaped leaves, and white flowers in small, round heads. A legume (Fabaceae) with fine, red wood and valuable lumber tree that is used for canoes, surfboards, calabashes, furniture, and ʻukuleles. A small koa was sometimes added to hula altars dedicated to Laka, goddess of the hula, to make the dancer fearless.

koʻokoʻolau—(*Bidens* spp.) Commonly referred to in other areas of the United States as beggarticks. Most species are native to Hawaiʻi; a few are introduced. Some species are used medicinally by Hawaiians as a tonic in tea. The plants are dried and used for tea, often in preference to tea available in stores.

kou—(*Cordia subcordata*) A tree found along shorelines from east Africa to Polynesia with large, ovate leaves and orange, short-stemmed clusters of tubular flowers that are 2.5 to 5 cm in diameter. The wood, considered attractive, soft, but lasting, was valuable to the early Hawaiians and was used for cups, dishes, and calabashes. Kou is also the old name for the Honolulu harbor and vicinity.

kukui—(*Aleurites moluccana*) A large tree in the spurge family (Euphorbiaceae), also called candlenut tree because its nuts contain white, oily kernels that were once used for lights. Hence the tree is a symbol of enlightenment. Native to Maluku in modern Indonesia, the tree was spread across the Pacific by the early Polynesians. The nuts are cooked for relish. The oil from the nut is used in many moisturizing products today and is extruded as an essential oil used in aromatherapy. The soft wood was once used for canoes, and gum from the bark was once used for painting tapa; black dye was obtained from nuts and roots; chewed nuts were spat into the sea by fishermen, which was believed to calm the sea. Polished nuts are strung in lei; the silvery leaves and small white flowers are strung in a lei to represent Moloka‘i Island. Kukui was named the official emblem for the state of Hawai‘i in 1959 because of its many uses and its symbolic value.

kuleana—A Hawaiian value that is broadly translated as responsibility. More narrowly it refers to a reciprocal relationship between who is responsible and the thing they are responsible for.

kupe‘e—Traditional wrist and ankle adornments.

lama—(*Diospyros* spp.) Also known as ēlama, lama refers to all endemic species of hardwood ebony trees with small flowers and fruits. Historically, Hawaiians used it for fishing traps and medicine. The fruit is eaten.

lei—A garland, wreath, or necklace of flowers, leaves, shells, ivory, feathers, or paper gifted as a symbol of affection; any ornament worn around the head or neck. The act of wearing a lei. A special song for presenting a lei; yoke, such as for joining draft animals, especially oxen. Figuratively, a beloved child, wife, husband, sweetheart, or younger sibling because a beloved child is carried on the shoulders with its legs draped over the neck like a lei.

lei po‘o—Lei worn on the head (po‘o).

liko—Leaf bud; newly opened leaf; budding; to put forth leaves.

lokelani—(*Rosa* × *damascena*) Native to Asia minor, this species is the official flower of Maui Island. Common name is also damask rose.

loulu—(*Pritchardia* spp.) All species of native Hawaiian fan palms in this genus. Hats are plaited from the bleached leaves.

lua—An ancient hand-to-hand Hawaiian martial art with techniques designed to break bones, dislocate joints, and inflict severe pain by pressing on nerve centers.

maile—(*Alyxia stellata*) A native twining liana. The maile vine has shiny fragrant leaves and is used for decorations and leis, especially on important occasions. It is a member of the periwinkle family (Apocynaceae). Traditional Native Hawaiian religion practitioners invoke Laka, goddess of the hula, and maile is one of five standard plants offered on altars dedicated to her.

māmaki—(*Pipturus albidus*) A small native tree with broad white-backed leaves and white, mulberry-like fruit; the bark yields a fiber used for a kind of traditional tapa, similar to that made from wauke (paper mulberry) but coarser. Currently, leaves are steeped in hot water to make a tea. Māmaki is commercially grown and harvested wild.

māmane—(*Sophora chrysophylla*) A native leguminous tree that thrives at high altitudes up to the tree line on Mauna Kea and Mauna Loa. Historically, Hawaiians used the hard wood for spades and sled runners. Currently, māmane seeds are used to make jewelry.

mana—Supernatural or divine power; miraculous power.

Mānele or a‘e or āulu—Hawaiian name for several native trees, including soapberries (*Sapindus oahuensis* and *S. saponaria*). Yellowish wood was historically used for digging sticks and spears; seeds (of which soapberry has the largest) are black, round, and used for leis today.

mokihana—A native tree (*Melicope anisata*), found only on Kaua‘i, belonging to the citrus family (Rutaceae). The small, leathery, cube-shaped, anise-scented fruits, which change from green to brown, are strung in leis that represent Kaua‘i. The large leaves are also fragrant.

moku—A term referring to a traditional division of land ownership referring to a district, island, islet, section, forest, grove, or clump.

‘ōhelo—(*Vaccinium calycinum*, *V. dentatum*, and *V. reticulatum*) Three species of small native shrubs in the cranberry family (Ericaceae) that bear round, red or yellow berries, which are edible raw or cooked for sauce. This species is considered sacred for the Native Hawaiian deity Pele, to whom offerings were once made by throwing fruiting branches into the fiery pit at Kīlauea volcano. Wind-dried leaves are used for tea.

‘ōhi‘a lehua (also commonly called ‘ōhi‘a or lehua)—(*Metrosideros polymorpha*) This Hawaiian name is used to define just the flower of the ‘ōhi‘a tree or the entire tree itself. The **‘ōhi‘a lehua** is the flower of the island of Hawai‘i. The flowers are red, rarely salmon, pink, yellow, or white. The wood is hard but unstable, used mainly for posts and flooring. In ancient times, it was used for spears and mallets. It was once believed that picking lehua blossoms would cause rain.

pakalana—Chinese violet (*Telosma cordata*). The yellowish-green flowers are also used as lei material.

palapalai or palai—(*Microlepia strigosa*) A native fern that is cultivated and harvested wild. Palapalai is a traditionally important plant placed on the hula altar dedicated to the Native Hawaiian goddess of hula, Laka.

po‘o—Lei worn on the head.

pūkiawe—Native shrub and small tree (Leptecophylla tameiameiae). The leaves were used medicinally for colds or headaches. Leaves are used for foliage in floral arrangements and lei. Also called ‘a‘ali‘i mahu, kānehoa, kāwa‘u, maiele, and pūpūkiawe.

tapa or kapa—Bark cloth made from wauke or māmaki bark.

‘uhaloa—(*Waltheria indica*) Also called American weed. Leaves and inner bark of root are very bitter and are used for tea or chewed to relieve a sore throat. In Native Hawaiian traditional belief, it is one of the plant forms of the pig demigod Kamapua‘a. Also called ‘ala‘ala pū loa, hala ‘uhaloa, hi‘a loa, and kanaka loa.

uhiuhi—(*Mezoneuron kavaiense*) An endemic legume tree. The hard and heavy wood was once used for sleds, spears, digging sticks, and house construction. Also called kawa‘u, kea, and kolomona. The weedy herb *Phaseolus lathyroides* is called uhiuhi on Ni‘ihau Island.

‘uki—(*Cladium jamaicense*, *Machaerina augustifolia, Dianella sandwicensis*, *M. mariscoides*) Coarse native sedges of several genera. Historically, ‘uki was used in traditional mask decorations worn by traditional canoe paddlers; today, this species is used in floral arrangements.

‘ulu—(*Artocarpus altilis*) Also called breadfruit, ‘ulu belongs to the fig family (Moraceae) and is grown for its edible fruits; sometimes it is grown for ornament.

uluhe—(*Dicranopteris linearis, Diplopterygium pinnatum* [uluhe lau nui], and *Sticherus owhyhensis*) All are native Hawaiian species of fern, sometimes called false staghorn ferns. They can be weedy, creeping, branching ferns, forming dense thickets. Historically, ‘ulu was used for medicine; today, this species is used as a lei material.

wāhine—A women or female.

wauke—(*Broussonetia papyrifera*) A small paper mulberry tree from eastern Asia, known throughout the Pacific for its usefulness. It belongs to the fig or mulberry family (Moraceae). In Hawai‘i, the bark was once made into tough tapa for clothing; it lasted longer than māmaki tapa.

wāwae‘iole—(*Lycopodiella* sp.) A far-creeping tropical club moss growing 1 to 5 ft high. Its stems and many branches are covered with short, narrow-pointed leaves and are made into Christmas wreaths. Eight other species of club mosses also bear this same Hawaiian name.

wiliwili—(*Erythrina sandwicensis*) A Hawaiian leguminous tree found on dry coral plains and lava flows. It is somewhat spiny with a short, thick trunk. Flowers are clustered near branch ends and are red, orange, yellow, or white; pods contain red, oblong seeds used for lei. The wood is very lightweight and is used for surfboards, canoe outriggers, and net floats.

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Publication requests	(503) 808-2138
FAX	(503) 808-2130
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