Why Start a Tropical Nursery for Native and Traditional Plants?

1

Kim M. Wilkinson and Brian F. Daley

Tropical ecosystems and agroecosystems are vital, life-giving landscapes and are home to diverse plants, animals, and people in a range of climatic, geologic, cultural, and environmental contexts. These systems provide services, such as cleaning air, improving water quality, stabilizing soil, and regulating the climate. The landscapes offer essential products including timber, food, fibers, and medicines.

During the past few centuries, waves of change have swept through tropical landscapes. These changes include obliterated native forests, drained wetlands, and decimated agroforests and indigenous management practices. Agricultural and industrial land uses, tourism, urbanization, climate change, and the introduction of problematic new plants, animals, pests, and pathogens have caused high rates of extinction (Carter and others 2001). Today, people are working to protect and regenerate tropical ecosystems and agroecosystems (Robotham and others 2004). Key tasks in revitalizing these systems are planting, protecting, and perpetuating native and traditional species, and sowing awareness of these plants among people. This is the work of the tropical nursery manager.

Nurseries in the tropics range in size from a single owner-operator growing a few plants for neighbors, to community organizations, universities, or cultural groups growing plants for certain goals, to large commercial nurseries, to governments founding native plant programs for their region. Without regard to scale, tropical nurseries are a key link in ecological restoration, sustainable agriculture, and cultural renewal (figure 1.1) by providing native and traditional plants.

Facing Page: *Nursery on Pohnpei, Federated States of Micronesia. Photo by Ronald Overton.*

Figure 1.1*—Nurseries in the tropics come in many shapes and sizes to serve diverse needs. Shown here are native tree seedlings in a nursery in Guam (A), a backyard nursery in Mexico (B), and a commercial nursery in Puerto Rico (C). Photo A by J.B. Friday, photo B by Thomas D. Landis, and photo C by Ronald Overton.*

Figure 1.2*—Nurseries play a key role in ecological restoration, cultural renewal, economic resilience, and sustainable agriculture by providing native and traditional plants. Nursery-grown plants are often used for planting native species in the U.S. Virgin Islands (A) and Hawai'i (B). Photo A by Brian F. Daley, and photo B by J.B. Friday.*

Examples of these links include—

- **Ecosystem Restoration and Biodiversity Protection—** Jump-starting or accelerating succession on disturbed sites; enriching species-poor secondary forests with rare or later successional species; partnering with farmers and agroforestry practitioners to facilitate tropical forest recovery; bringing native plants for native pollinators and wildlife into agricultural areas, urban landscapes, and backyard gardens; propagating threatened and endangered plants for their conservation and reintroduction to forests; and the full-scale restoration of native plant communities in conservation areas.
- **Sustainable Agriculture and Economic Resilience—** Enhancing farmer livelihoods and community food security with agroforestry practices; rediscovering diverse native and traditional species for timber, crafts, fibers, foods, and other uses; diversifying monoculture fields with traditional species of trees, shrubs, and vines; using native and traditional plants in conservation plantings, such as windbreaks, urban street trees, and erosion control installations.
- **Learning and Cultural Renewal—**Rekindling locally adapted practices and plant technologies; cultivating culturally significant plants in the forest understory for nontimber forest products; replacing exotic ornamentals with local species in landscapes; starting gardens of traditional species in schoolyards; revitalizing and sustaining human connections with local plants and ecosystems (figure 1.2).

The Environmental and Social Context in the U.S. Affiliated Tropical Islands

One of the greatest challenges of nursery management is choosing how to focus your efforts to be of most benefit to the land and the local people. Understanding your context requires integrating a "bird's-eye view" and a "worm's-eye view."A quick "bird's-eye view" of the context in the U.S. Affiliated Tropical Islands is shown in table 1.1; you are the only one who can describe your unique local context (the "worm's-eye view").

The U.S. Affiliated Tropical Islands house an immense diversity of native ecosystems, including mangrove swamps, wetlands, riparian areas, rainforests, dry forests, submontane forests, cloud forests, and more (table 1.2). These ecosystems are home to many unique, endemic plants found nowhere else on earth and are considered biodiversity hotspots of local and global significance in relatively small areas (figure 1.3). The health of the terrestrial areas affects diverse marine systems including estuaries, salt ponds, and coral reefs. These systems provide resources for a tremendous range of marine animals and critical breeding grounds for migratory and residential birds. The rich and unique biological diversity of these islands is an international heritage.

Islands are particularly susceptible to environmental changes and disturbances. The small populations of endemic plants and animals that evolved in isolation are unable to change locations or rapidly adapt when large changes occur. Changes facing island ecosystems include habitat destruction because of human development (urban expansion, agriculture, industrial use, and recreational use) and loss of habitat because of introductions of exotic invasive species (plants, animals, and diseases). Islands are extremely vulnerable to temperature shifts, altered or increased storm regimes, floods, and droughts associated with climate change. On islands, many native plants and animals are endangered; the islands are in an extinction crisis, experiencing the highest extinction rates anywhere in the United States (Carter and others 2001).

Throughout the tropics, native forests were cleared and converted to agriculture and then abandoned, leading to widespread creation of secondary forests. In the Caribbean, where land area is limited and human population density is

Table 1.1*—Characteristics of U.S.-Affiliated Tropical Islands. Adapted from USDA FS SPF Program Redesign Committee (2007), Carter and others (2001), U.S. Census Bureau (2014a, 2014b), and Brandeis and Oswalt (2007).*

Name	Status with United States	Geologic description	Total area (acres)	Forested area (acres)	Estimated human population (2010)
Commonwealth of Puerto Rico	Territory	One volcanic main island composed of uplifted sedimentary rocks and several smaller islands	2,199,901	710,156	3,721,208
U.S. Virgin Islands	Territory	Three volcanic main islands (St. Croix, St. John, and St. Thomas) composed of uplifted sedimentary rocks and several smaller islands and cays	85,587	52,477	106,267
Hawaiian Islands	State	Eight volcanic islands (Kaua'i, O'ahu, Moloka'i, Lana'i, Maui, Kaho'olawe, Ni'ihau, and Hawai'i) and several atolls	4,110,720	1,490,000	1,360,301
American Samoa	Territory	Five volcanic islands and two coral atolls (Ofu,Ta'u, Swains Island, Tutuila, Olosega, Rose Island, and Aunu'u)	49,280	28,686	55,467
Commonwealth of the Northern Mariana Islands	Territory	14 volcanic islands	113,280	40,000	53,517
Republic of the Marshall Islands	FAS*	5 low-lying volcanic islands and 29 coral atolls (each made up of many islets)	44,800	Not mapped	65,859
Republic of Palau	FAS*	Several hundred volcanic islands and a few coral atolls (eight islands inhabited)	114,560	77,241	20,879
Federated States of Micronesia	FAS*	607 small islands consisting of volcanic islands and coral atolls	149,804	76,527	107,154
Guam	Territory	One volcanic island composed of uplifted sedimentary rocks	135,680	65,005	159,434

* Freely Associated State in a Compact of Free Association with the United States.

Table 1.2*—Some ecosystems in the U.S.-Affiliated Tropical Islands, present or historically present. Adapted from US OTA (1987).*

									Federated States of Micronesia			
	Puerto Rico	U.S. Virgin Islands	American Samoa	Hawai'i*	Guam	Northern Marianas	Marshalls	Palau	Kosrae	Pohnpei	Yap	Truk
Cloud forest	✔	✔	✔	✔	✔	✔			✔	✔		
Submontane rainforest	✔		✔	✔					✔	✔		✔
Lowland rainforest	✔		✔	✔	✔	✔		✔	✔	✔	✔	✔
Riverine and swamp forest	✔		✔	✔	✔	✔		✔	✔	✔	✔	✔
Subtropical moist/ seasonal forest	✔	✔		✔								
Subtropical dry forest	✔	✔		✔								
Scrub	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Wetlands	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Mangrove forest	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔
Atoll/beach forest and scrub	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Lagoons/shallow bottoms	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

* Hawai'i also has subalpine and alpine ecosystems.

high, secondary forests on old agricultural land are already the most important and rapidly expanding forest cover type (Lugo and Helmer 2004). Secondary forests have novel species compositions, lower native species diversity, and higher influence of exotic species. In many areas in the Pacific Islands, secondary forests are composed exclusively of exotic species. Secondary forests will likely play an increasing role in conservation of forest biodiversity, especially in fragmented landscapes (Brown and Lugo 1990; Chazdon and others 2009).

Inextricably linked to these diverse ecosystems are diverse traditional cultures of the islands. A few examples include the Chamorro cultures of Guam and the Mariana Islands, the Samoan and Hawaiian cultures, the Boricua culture of Puerto Rico, and cultural groups who speak multiple languages and call the islands of the Federated States of Micronesia home (Carter and others 2001). Most of the islands have significant populations practicing traditional lifeways, including agricultural practices, hunting, fishing, gathering, and resource management. Agroforestry systems are, on some islands, a key forest type (figure 1.4). Traditional resource management in the islands espouses a ridge-to-reef perspective, the wisdom of which has lessons for watershed protection anywhere on earth (USDA FS SPF 2007).

Within the past few centuries, immigration and migration have added to the cultural diversity of the islands. Local culture is now infused with, for example, the influence of the Africans, Danish, French, and Spanish in the Caribbean; the Asians and Americans in Hawai'i; the Spanish in Guam; and countless others in other islands. Lifestyles in the islands range from densely populated urban areas to remote villages on outer islands (Carter and others 2001). Many islands have urban areas, agriculture, forest, and residential neighborhoods in close proximity to each other. Most of the islands currently experience a high level of dependency on mainland economies for food, energy, and other resources, but many also maintain a strong foundation and knowledge base of traditional subsistence agriculture and resource management.

Interconnections between social and ecological conditions are more evident to islanders than they are to people who live on large continents. Nurseries may provide native plants, traditional species, and other species to serve both humans and nature. Nurseries operate in urban, rural, and village settings, often integrating goals of economic resiliency, ecosystem protection and restoration, cultural renewal, and other community and ecosystem needs.

Why Grow Native Plants?

Native plants are the backbone of ecosystem function and integrity from soil nutrient cycling, clean water, and carbon sequestration to higher wildlife interactions. Individual species have evolved during the millennia to the

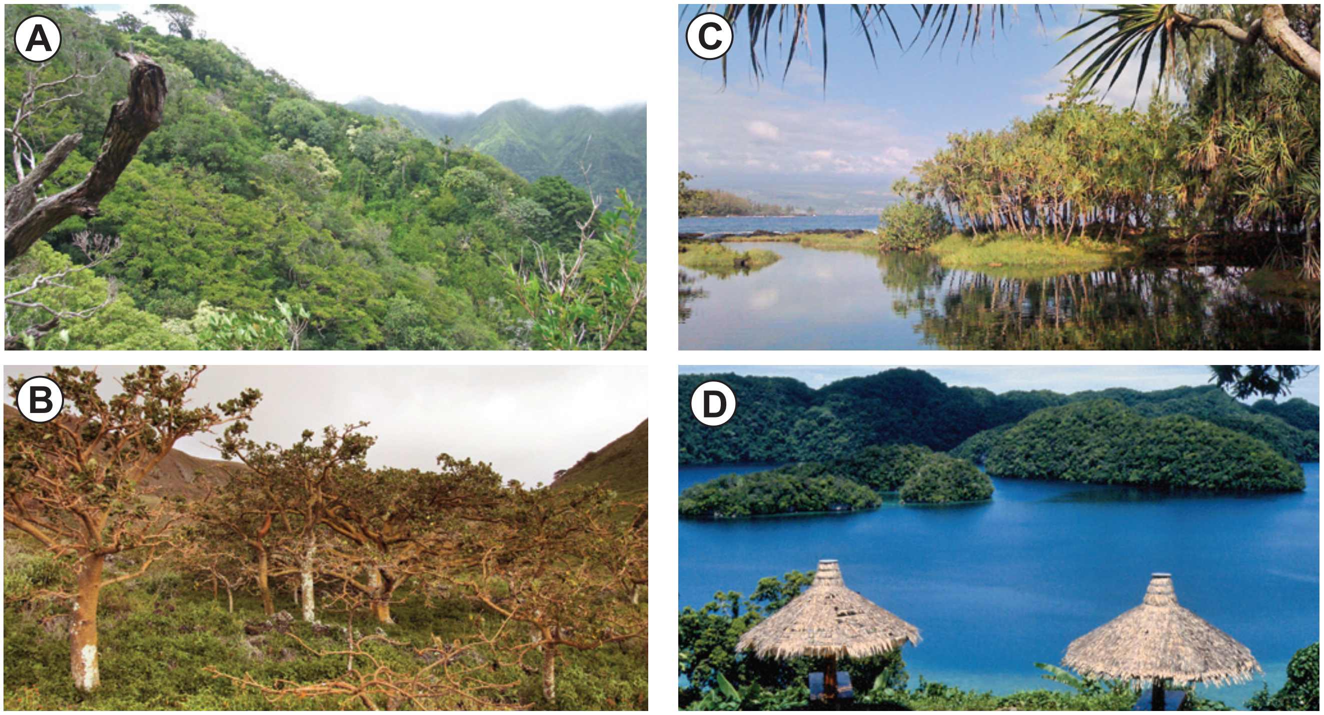

Figure 1.3*—The U.S.-Affiliated Tropical Islands house an immense diversity of ecosystems including mangrove swamps, wetlands, rainforests, dry forests, submontane forests, cloud forests, and more: mixed native and introduced forest on Oʻahu (A), dryland forest on Hawaiʻi (B), coastal pandanus (screw pine) forest in Hawaiʻi (C), and Rock Islands of Palau (D). Photos A, B, and C by J.B. Friday, and photo D by Thomas D. Landis.*

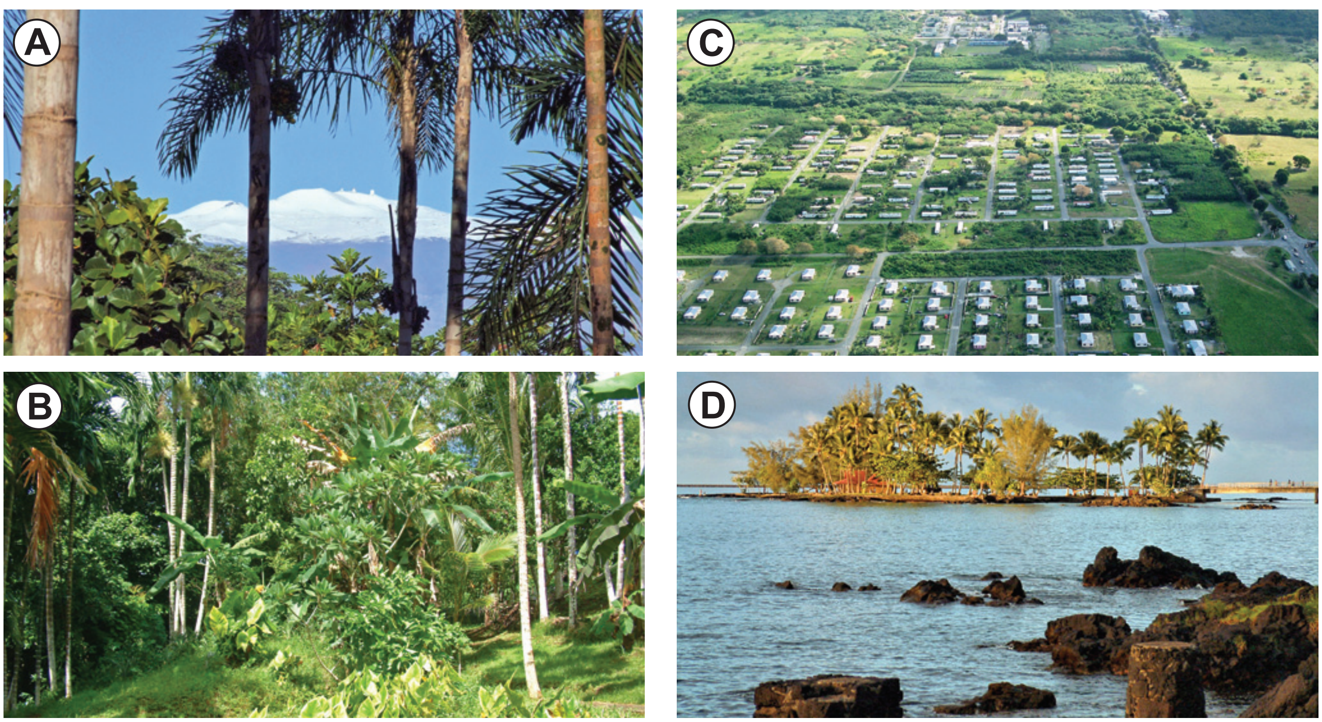

Figure 1.4*—Diverse agroecosystems such as agroforests are important to environmental health and human livelihood in the tropics. Snow on Mauna Kea (14,000-ft [4,600-m] elevation) framed by palm trees and breadfruit growing at 700-ft (215-m) elevation on the Big Island of Hawaiʻi (A); an agroforest in Palau with betel nut palm* (Areca catechu) *overstory, bamboo for building materials, bananas and avocados for fruit, and taro for starch (B); mixed land use in the U.S. Virgin Island with residential, pasture, forest, and commercial areas in close proximity (C); and Coconut Island in Hawaiʻi (D). Most visitors to the tropics do not realize that many of the landscapes they enjoy include plant species humans introduced and cultivated for centuries in the area. Photos A, B, and D by J.B. Friday, and photo C by Brian F. Daley.*

***Figure 1.5**—Deploying a diversity of locally adapted native plants helps support and regenerate ecosystems for local flora and fauna. Pictured is the ʻiʻiwi* (Vestiaria coccinea) *drinking nectar from an ʻōhiʻa lehua* (Metrosideros polymorpha) *blossom in Hawaiʻi. Photo ©Jack Jeffrey Photography.*

climatic and edaphic conditions where they now grow in association with a myriad of other species. The resulting assemblage of plants and animals is what makes each ecosystem unique and contributes to people's sense of place. When species associations are disrupted, local extinctions can occur (figure 1.5), leading to declining ecosystem function or even to ecosystem collapse (Hawkins and others 2008, USDI BLM SOS 2011). Restoring durable, self-sustaining, and resilient ecosystems depends on native plants to (Erickson 2008, 2010)—

- Recover natural vegetative composition, structure, and successional patterns.
- Protect biodiversity and plant genetic resources.
- Provide habitat connectivity.
- Maintain plant and pollinator interactions.
- Support wildlife populations.
- Increase system resilience to disturbances and stressors.
- Provide desired goods, services, and benefits.
- Provide economic benefit to rural communities.

In this handbook, native plants are defined as locally adapted, genetically appropriate native plant materials. Although that sounds simple, it is not a straightforward definition (see next section). The issue of plant nativity is hotly discussed in some areas; and this handbook does not intend to solve these debates, only to provide a working definition. In general, making a list of native plants for a region or an island may not be sufficient information because it does not indicate local adaptedness. Many widely distributed native species have local populations adapted to local conditions including climate, soils, elevation, precipitation, and environmental stresses, such as wind or drought. Local native plant materials, collected from the same or similar habitats as the outplanting site, have been shown to perform better than nonlocal sources. Using locally adapted seed sources is a key factor in ensuring the survival of native plants and of the native fauna that depend on these plants. In addition, deploying a diversity of locally adapted native plants creates communities and ecosystems that are more adaptable and resilient to climate change (Horning 2011, Erickson and others 2012). For some species, seed zones or transfer guidelines may have been defined (as discussed in Chapter 3, Defining the Target Plant), but establishment of seed zones is rare for most native tropical species. For most projects, growers must decide on a case-by-case basis what will be appropriate for their outplanting sites (Withrow-Robinson and Johnson 2006). The genetics guidelines provided in Chapter 8, Collecting, Processing, and Storing Seeds, detail essential elements of seed collection to ensure local adaptedness and genetic diversity.

Why Grow Traditional Plants?

This handbook recognizes that traditional plants are a sustainable and regenerative resource in the tropics, and that tropical nurseries work to serve those needs in addition to native plant conservation. Many people define "native" as those species present before any humans inhabited an area, but humans have resided in many parts of the tropics for millennia and have influenced the flora. Research is revealing that many tropical forests once thought to be undisturbed primary forests (such as in the Brazilian Amazon) are actually the result of ongoing human management and disturbances dating back, in some cases, for thousands of years (Berkes 1999) The first people to migrate to a new area brought many plants with them.

For example, in the Caribbean, Amerindians with cultural centers in Venezuela traveled by small boats northward, bringing with them important food crops, including trees such as the genip (*Melicoccus bijugatis*) and zapote (*Manilkara zapota*), which were then cherished for their fruit, much as they are today. Both species are now naturalized throughout the Caribbean Islands. When the first Polynesians arrived to the Hawaiian Islands, they found few edible native plants. The abundant agroecosystems of breadfruit, coconut, bananas, taro and other species that early Europeans thought to be native were in fact intentionally introduced species in Polynesian agroforestry systems. Islanders of the Pacific and Caribbean enjoyed a high level of food security and self-sufficiency before European contact (Thaman and others 2000). Their agroecosystems were built around a diverse base of native and introduced species (Elevitch and Wilkinson 2000). Many of these agroecosystems were displaced by colonial and later corporate entities, to convert land for development or to export crops such as sugar, coffee, or cattle. Today people are working to revitalize and reintroduce traditional species and agroecosystems for personal health and for economic, environmental, and political reasons (figure 1.6). For example, the U.S. Virgin Islands have seen a recent resurgence in Ital cooking that follows traditional Rastafarian practices of using locally grown herbs and vegetables without meat. Native Hawaiians are successfully overcoming nutrition-related disorders, such as obesity and diabetes, by reembracing traditional foods. The ancestral way of eating is cultivated in an interdisciplinary way involving cultural teachings and family support (Shintani and others 1994). On the islands, the general trend is toward locally grown foods in response to higher food prices, the desire to eat more organically and healthfully, to increase household food security, and to support food sovereignty movements. In the latter, local people claim the power to determine their own food systems as a basic human right, rather than allowing food systems to be controlled by global market forces (Whittman and others 2010). Growing traditional species in nurseries helps strengthen and renew sustainable agroecosystems (figure 1.7).

Helping to meet human needs using time-tested, traditional species also reduces pressure on more intact tropical ecosystems, without the risk of newly introduced and potentially invasive or noxious species. Traditional species can

Figure 1.6*—Traditional plant species sustain lifeways and livelihoods in tropical areas, providing food security, building materials, medicines, crafts, and more: a display of crops from an agroforestry system in the U.S. Virgin Islands, including a native passion fruit vine, medicinal neem tree leaves (originally introduced from India), and sweet potatoes (A); these food plants are part of traditional cooking and food security in the U.S. Virgin Islands (B). Traditional species also provide material for economic livelihoods, such as weaving materials for this traditional basket weaver on Yap (C). Specific native trees are used for building traditional fales in American Samoa (D and E). Photos A and B by Brian F. Daley, photo C by Thomas D. Landis, and photos D and E by Diane L. Haase.*

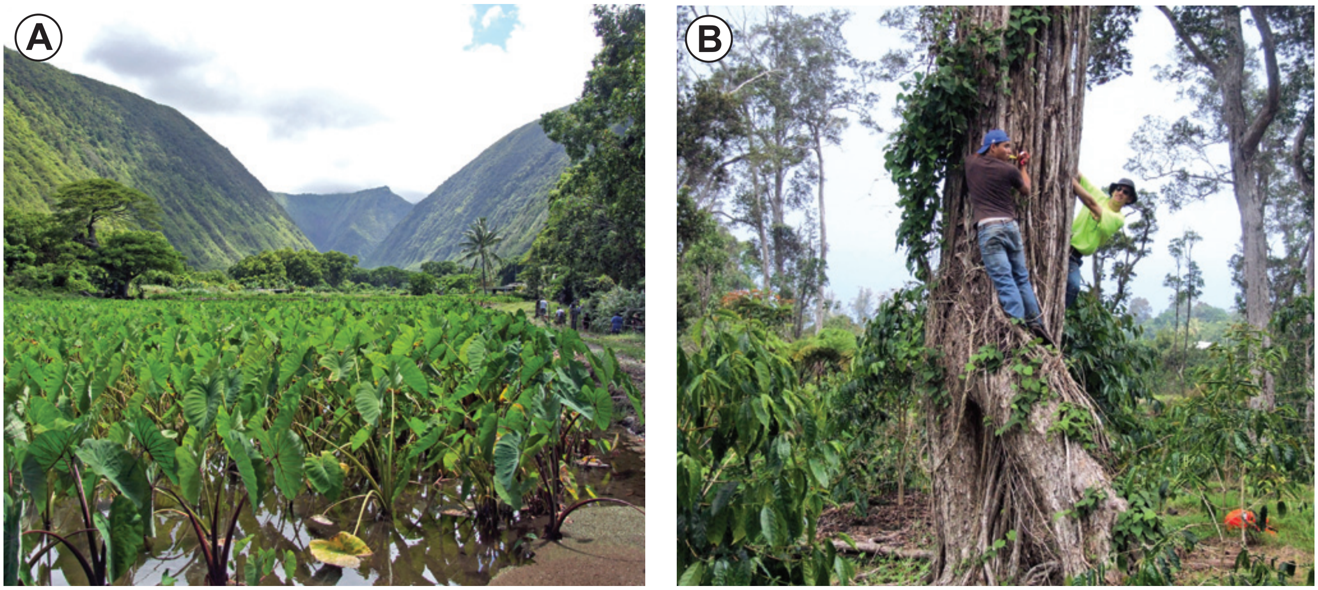

Figure 1.7*—Growing traditional species in nurseries helps strengthen and renew sustainable agroecosystems: taro paddy in Waipio Valley, Hawai'i (A), shade-grown coffee under native 'ōhi'a forest shade, Kona, Hawai'i (B). Photos by J.B. Friday.*

also be an integral part of tropical forest restoration using what is known as an agro-successional restoration approach (Vieira and others 2009, Holl and Aide 2010). In this approach, agroforestry and other agroecological practices are employed as a transition phase for forest restoration. Farmers share in restoration efforts to improve soil, establish trees, and exclude weeds while meeting their own needs for food security and livelihood (Vieira and others 2009). In this handbook terms including "traditional," "culturally significant," and "culturally important" are used interchangeably to refer to these kinds of plant species; some gray areas exist as to which species are in this category. Some culturally significant species are also native species; some are introduced species. Of the introduced species, some arrived with the first peoples of a place; others came with later waves of settlement. Some were adopted after European contact. For example, enslaved Africans arrived by ship to the Caribbean during the centuries of European colonization. Although most of the enslaved traveled without personal possessions, they somehow smuggled items that were culturally and spiritually important, including tree seeds. The native African baobab tree (*Adansonia* species) arrived in the Caribbean this way. Today in the U.S. Virgin Islands, the giant baobab trees (figure 1.8) serve as a tangible connection between modern Virgin Islanders and the first people who arrived from Africa and planted these tree seeds. A traditional species may not be of indigenous use, but may still be culturally significant. As a nursery manager, you will need to consider your scope to determine what species are appropriate to prioritize and perpetuate based on your area's unique environmental and cultural context.

Of course it is unwise to introduce to an island any species that is harmful (invasive, noxious, or untested in the area). In most cases, intentionally introducing new species is also unnecessary, given the diversity of time-tested plants already present.

Figure 1.8*—Seeds of the baobab tree (*Adansonia digitata*) were first brought to the Caribbean by Africans, who somehow managed to carry viable tree seeds through the ordeal of enslavement and travel on slave ships, and who planted their seeds upon arrival. Today the baobab is a culturally important tree in the Caribbean, linking today's islanders with centuries of African heritage in the region. Photo by Brian F. Daley.*

Figure 1.9*—Nurseries play a key role in conservation and restoration of species and ecosystems. This Department of Natural Resources nursery in Puerto Rico is growing threatened and endangered species. Photo by Ronald Overton.*

The Role of Nurseries in Ecosystem Restoration and Cultural Renewal

Nurseries Provide Quality Plant Materials to Facilitate Sustainable and Regenerative Practices

The nursery environment is a place to germinate, grow, and protect locally adapted seedlings until they are healthy, strong, and large enough to meet the challenges of outplanting sites and achieve project goals (Evans 1996). The work nurseries do to produce high-quality native and traditional plants helps perpetuate these species (figure 1.9). Nursery-grown native plants overcome barriers to natural recolonization, such as weed competition, animal predation, and lack of a natural seed bank. Nursery-grown traditional species ensure heritage varieties, and culturally important characteristics are passed on to the next generation. Good nursery work makes successfully establishing native and traditional plants more effective, affordable, and more likely to happen, whether nursery clients are farmers, gardeners, restoration ecologists, community groups, or others. Quality plants can mean the difference between people believing it is too hard to plant native and traditional species, and having an attitude that they can do this (figure 1.10).

Nurseries Serve as a Cornerstone of Ecological Restoration

Without human disruption to their health, tropical ecosystems regenerate naturally after disturbances through the process of succession. Forests can be degraded or damaged by humans to the point where they require some help, however, and that is where nurseries come in. Often, the intensity, duration, or extent of the disturbance results in a lack of native propagules (seedlings, seed bank in the soil, and so on) on the site or within a distance that they will naturally disperse to revegetate the disturbed site (Holl and Aide 2010). In addition, limiting factors on the site, such as takeover by highly competitive weeds, low soil fertility, excessively compacted soil, or nonnative animals that eat seeds and young plants can arrest natural succession until these conditions are overcome (Vieira and others 2009). In these scenarios, the planting of nursery stock is a cornerstone of ecological work.

Figure 1.10*—The work nurseries do to produce high-quality native and traditional plants helps break down barriers to planting and perpetuating these species. Good nursery work makes outplanting more effective and affordable for clients. Pictured: tree planters head out to plant native trees in Brazil (A) and Hawai'i (B). Photos by Douglass F. Jacobs.*

***Figure 1.11**—Nurseries can be wonderful places for working and learning about plants (A) and passing on knowledge and values to the next generation (B). Photo A by Brian F. Daley, and photo B by Megan Parker.*

Nursery plants may be used to (Holl and Aide 2010, Vieira and others 2009)—

- Jump-start succession (for example, planting trees to shade out aggressive weeds or improving soil with nitrogen-fixing pioneer native species).
- Stabilize highly disturbed areas and minimize further environmental damage, such as erosion.
- Enrich species-poor secondary forests or pioneered sites with rarer, more diverse, or later successional species.
- Serve as "islands" to act as dispersal points for propagules to adjacent land in need of restoration.
- Establish trees through an agro-successional approach.
- Complete full-scale restoration projects.

Nurseries Provide Livelihood and Learning Opportunities for People

Nurseries and nursery mangers are a bridge between the natural world and human needs. For example, perhaps an important cultural plant has become rare, and, because elders are unable to gather it, the children are not learning about this species and the local economy is no longer benefitting. The nursery can identify the species, learn how to propagate it, and help people to replant it, thus serving the local culture, economy, and ecology.

Some nurseries provide plants, employment, and knowledge to serve certain cultural groups, such as women, youth, or farmers. In many areas, nurseries tend to become centers and gathering places for people to connect with each other and learn about native and traditional species (PRAP 1999) (figure 1.11).

One of the most rewarding objectives for growing and outplanting native and traditional plants is the education of young people. Some native plant nurseries are operated by schools with a primary objective of environmental education, and other nurseries simply make themselves available to school groups. Young children can learn the names and uses of native and culturally important plants, and older children can enjoy the art and science involved in growing and outplanting different species. Gaining familiarity with species is a useful gateway to a deeper understanding of traditional ecological knowledge and resource management.

Nurseries Are a Key Link in Biodiversity Conservation

Loss of tropical biodiversity is a cause for serious concern. High levels of endemism in relatively small spaces mean that local habitat destruction can put already vulnerable species at greater risk of extinction. Nursery work to propagate and increase rare species is essential for conservation and reintroduction of these species (Prance 2005).

The restoration of disturbed sites is vital to conservation success, but so is the establishment of seed banks, including nurseries as living seed banks, to serve future needs. Conventional seed banks can conserve only species having "orthodox" seeds that can be dried and placed in long-term storage. Most tropical species, however, have

Time-Lapse Glimpses of the Tarzan River Savanna Area of the Cotal Reserve, Guam

Dr. Margie Cushing Falanruw recalls her ancestral knowledge that became a basis for a vegetation strategy for southern Guam. She writes (2002 p. 11):

"In the 1950s and early 1960s, the savanna above and along the trail leading to upper Tarzan falls in Guam was a child-friendly wonderland of shrubs. Some, such as the weird *Geniostoma micranthum* and lovely shiny-leaved *Decaspermum fruticosum,* grew to heights of about 7 feet and formed a dense maze through which children and adults could walk. 'Abas duendes' *Gloichidion* bushes with bright red tip leaves produced little 'guavas for elves.' The bonsai-like *Myrtella bennigseniana*, and the pink-flowered *Melastoma malabathricum* grew lower than a child and were interspersed with lavender, *Spathoglottis* ground orchids, yellow flowered *Curculigo orchioides,* and blue flowered *Dianella* lilies. The 'miniature iba tree,' *Phylannthus saffordi*, was present along with the 'out of focus wolf paw plant' *Lycopodium cernuum*, which was used to decorate nativity scenes in those days. We made garlands of *Cassytha*, *Lygodium*, or *Gleichenia* vines to shield our heads from the sun, soothed our eyes with isotonic drops of liquid from *Scaevola taccada* berries, and sipped nectar from *Stachytarpheta* flowers. We learned to stop bleeding with crushed *Glochidion* leaves and to heal bruises and sprains with *lada Morinda* leaves warmed on a campfire. We walked through soft *Dianella* grass, enjoyed the scent of wild mint and the 'chewing gum smell' of methyl salicicate-laced *Polygalla* roots. We rested below gagu, the 'singing tree' *Casuarina equisetifolia* and listened to the 'sound of silence' as wind blew through its needle branches.

Most of these species were present in the 1970s when my flora and fauna class compiled a list of species in the area on July 18, 1970. By the 1980s however, the area was invaded by invasive *Pennisetum* grass, which may have increased its vulnerability to wildfires that were reported to have swept through the area. The burned area had been subsequently planted to *Acacia* trees. I no longer lived on Guam at that time. When I visited The Tarzan river area with my grandchildren on Saturday, August 27th, 2002, most of the savanna species were no longer as abundant and do not grow as tall nor luxuriant as they did before the area was invaded by *Pennisetum* and fire.

The Tarzan river area of the Cotal Reserve has refreshed five generations of my family, and I hope that it can be restored to its former state so that my great grandchildren and their children may also experience this remnant bit of old Guam."

Using that ancestral knowledge, the restoration strategy in table 1.3 was developed.

***Table 1.3**—Revegetation strategy. Adapted from Bell and others (2002).*

Type of site	Problem	Restoration/stewardship objectives
Shaded fuelbreaks	Grass dominated watersheds are unbroken expanses that burn readily and at high intensity.	Compartmentalize contiguous fuels to reduce fire size and provide enhanced control opportunities. Establish shaded fuelbreaks of *Acacia* species in a strategically designed pattern to compartmentalize fuels.
Swordgrass grasslands	Swordgrass is highly flammable, fires tend to kill other vegetation and contribute to the spread of swordgrass.	Convert portions of swordgrass dominated grasslands to forests. Plant and maintain buffers of native trees. Underplant Acacia plantations with native trees. Plant nursery-grown natives *Callophyllum inophyllum, Intsia bijuga, Hibiscus tiliaceus, Neiosperma oppositifolia,* and *Pandanus tectorius* adjacent to existing ravine forests.
Native savanna shrub and ravine forest	Erosion of biodiversity as a result of fire, feral animals, and invasive species.	Protection and restoration. Weed out invasive plants, protect from fire. Assist or enhance regeneration of native trees, shrubs, and plants. Nursery propagation of native species to assist with natural regeneration of uncommon and rare species.

***Figure 1.12**—Laulima: "Many hands working together." The newly minted sign for Hakalau Forest National Wildlife Refuge's Native Plant Nursery, Hawai'i. Photo by J.B. Friday.*

"recalcitrant" seeds, meaning they cannot be dried and stored over extended periods (Kettle and others 2011). Thus, successful restoration and conservation of tropical forests requires that nurseries propagate and maintain genetically diverse living banks of recalcitrant species (Kettle and others 2011, Merritt and Dixon 2011).

Growing plants in the nursery is far more efficient than attempting to establish seeds through direct seeding in the field. Nurseries make the most efficient use of limited seeds by ensuring that each one receives the necessary care and attention to survive and develop into a mature plant. Also, nursery propagation does not deplete naturally regenerating areas because it does not involve uprooting wildings to transplant.

Good nursery management supports genetic and sexual diversity to ensure conservation of plants and all the other life forms that depend on them, from pollinators to primates. Genetic diversity is also essential for future adaptability and resilience in the face of climate change. Protecting local biodiversity and ecosystem resilience also protects local cultural diversity and economic resilience.

Challenge and Opportunity

Much needs to be done to restore tropical forests, recharge aquifers, regenerate wetlands, revitalize local economies, rekindle traditional practices, reclaim wastelands, and renew human connections to nature. The challenges may seem overwhelming. It is fortunate that even the loftiest goals can be reached with practical, persistent, everyday work (figure 1.12). Starting and operating a nursery for native and traditional species is a vital, positive endeavor full of challenge and opportunity. Good nursery work contributes to species conservation, ecosystem resiliency, cultural diversity, enhanced human livelihoods, and greater health and productivity of the land.

References

Bell, F.; Falanruw, M.; Lawrence, B.; Limtiaco, D.; Nelson, D. 2002. Vegetation strategy for southern Guam. Draft (September 2002). Honolulu, HI: U.S. Department of Agriculture, Forest Service and Natural Resources Conservation Service; Government of Guam Division of Forestry.

Berkes, F. 1999. Sacred ecology: traditional knowledge and resource management. London: Taylor and Francis. 209 p.

Brandeis, T.; Oswalt, S. 2007. The status of the U.S. Virgin Island's forests 2004. Resource Bulletin SRS-122. Ashville, NC, U.S. Department of Agriculture, Forest Service, Southern Research Station. 62 p.

Brown, S.; Lugo, A. 1990. Tropical secondary forests. Journal of Tropical Ecology. 6: 1–32.

Carter, L.M.; Shea, E.; Hamnett, M.; Anderson, C; Dolcemascolo, G; Guard, C; Taylor, M.; Barnston, T; He, Y; Larsen, M.; Loope, L.; Malone, L.; Meehl, G. 2001. Potential consequences of climate variability and change for the U.S.-affiliated islands of the Pacific and Caribbean. In: The potential consequences of climate variability and change: foundation report. Report by the National Assessment Synthesis Team for the U.S. Global Change Research Program. Cambridge, United Kingdom: Cambridge University Press: 315–349. Chapter 11. http://www.usgcrp.gov/usgcrp/Library/nationalassessment/11Islands.pdf. (December 2011).

Chazdon, R.L.; Peres, C.; Dent, D.; Shell, D.; Lugo, A.E.; Lamb, D.; Stork, N.E., Miller, S.E. 2009. The potential for species conservation in tropical secondary forests. Conservation Biology. 23: 1406–1417.

Elevitch, C.R.; Wilkinson, K.M., eds. 2000. Agroforestry guides for Pacific Islands. Holualoa, HI: Permanent Agriculture Resources. http://www.agroforestry.net/afg/book.html. (December 2011).

Erickson, V.J. 2008. Developing native plant germplasm for national forests and grasslands in the Pacific Northwest. Native Plants Journal. 9: 255–266.

Erickson, V.J. 2010. Personal communication. Pendleton, OR. Geneticist/Native Plant Program Manager, U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Erickson, V.J.; Aubry, C.; Berrang, P.; Blush, T.; Bower, A.; Crane, B.; DeSpain, T.; Gwaze, D.; Hamlin, J.; Horning, M.; Johnson, R.; Mahalovich, M.; Maldonado, M.; Sniezko, R.; St. Clair, B. 2012. Genetic resource management and climate change: genetic options for adapting national forests to climate change. Internal document. Washington, DC: U.S. Department of Agriculture, Forest Service. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5368468.pdf. (September 2012).

Evans, J. 1996. Plantation forestry in the Tropics. Oxford, United Kingdom: Clarendon Press. 403 p.

Falanruw, M. 2002. Appendix 3. Time-lapse glimpses of the Tarzan River savanna area of the Cotal Reserve. In: Bell, F.; Falanruw, M.; Lawrence, B.; Limtiaco, D.; Nelson, D. Vegetation strategy for southern Guam. Draft (September 2002). Honolulu, HI. U.S. Department of Agriculture, Forest Service and Natural Resources Conservation Service; Government of Guam Division of Forestry.

Hawkins, B.; Sharrock, S.; Havens, K. 2008. Plants and climate change: which future? Richmond, United Kingdom: Botanic Gardens Conservation International. 96 p.

Holl, K.D.; Aide, T.M. 2010. When and where to actively restore ecosystems? Forest Ecology and Management. 261(10): 1558–1563.

Horning, M. 2011. Personal communication. Bend, OR. Plant Geneticist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Kettle, C.J.; Burslem, D.F.R.P.; Ghazoul, J. 2011. An unorthodox approach to forest restoration. Science. 333: 36.

Lugo, A.; Helmer, E. 2004. Emerging forests on abandoned land: Puerto Rico's new forests. Forest Ecology and Management. 190: 145–161.

Merritt, D.J.; Dixon, K.W. 2011. An unorthodox approach to forest restoration—response. Science 333: 36–37.

Pacific Regional Agricultural Programme [PRAP]. 1999. Pacific agroforestry: an information kit. Suva, Fiji Islands: Pacific Regional Agricultural Programme.

Prance, G. 2005. Foreword. In: Lilleeng-Rosenberger, K.E. Growing Hawai'i's native plants. Honolulu, HI: Mutual Publishing.

Robotham, M.P.; Mas, E.; Lawrence, J.H.; Eswaran, H. 2004. The Tropical Natural Resources Technology Consortium: working together for tropical conservation. In: Raine, S.R.; Biggs, A.J.W.; Menzies, N.W.; Freebairn, D.M.: Tolmie, P.E. eds. Conserving soil and water for society: sharing solutions. ISCO International Soil Conservation Organisation Conference, July 2004, Brisbane, Australia: ASSSI/IECA. http://www.ttc.nrcs.usda.gov/news/TTC_paper_ISCO.pdf. (June 2011).

Shintani, T.; Beckham, S.; O'Connor, H.K.; Hughes, C.; Sato, A. 1994. The Waianae diet program: a culturally sensitive, community-based obesity and clinical intervention program for the native Hawaiian population. Hawai'i Medical Journal. 53: 136–147.

Thaman, R.R.; Elevitch, C.R.; Wilkinson, K.M. 2000. Multipurpose trees for agroforestry in the Pacific Islands. Agroforestry guides for Pacific Islands #2. Holualoa, HI: Permanent Agriculture Resources. http://www.agroforestry.net/afg/book.html. (December 2011).

U.S. Census Bureau. 2014a. International Programs, International Database. Midyear population and density: Puerto Rico, USVI, American Samoa, Commonwealth of the Northern Mariana Islands, Republic of the Marshall Islands, Republic of Palau, Federated States of Micronesia, Guam. http://www.census.gov/population/international/data/idb/region.php (March 2014)

U.S. Census Bureau. 2014b. State & County QuickFacts: Hawai'i. Population 2010. http://quickfacts.census.gov/qfd/states/15000.html (March 2014)

U.S. Congress, Office of Technology Assessment [US OTA]. 1987. Integrated renewable resource management for U.S. insular areas. OTA-F-325. Washington, DC: U.S. Government Printing Office. http://www.princeton.edu/~ota/disk2/1987/8712/871201.pdf. (November 2011).

U.S. Department of Agriculture, Forest Service, State and Private Forestry [USDA FS SPF], Program Redesign Committee. 2007. Tropical forests of the United States: applying U.S. Department of Agriculture, State and Private Forestry programs. http://www.hawaiistateassessment.info/library/tropicalforests-of-the-United-States-Final60607.pdf. (November 2011).

U.S. Department of the Interior, Bureau of Land Management, Seeds of Success [USDI BLM SOS]. 2011. Seeds of success training, module 1: introduction and overview, seed collection for restoration and conservation. Native Plant Materials Development Program. Internal document. Washington, DC: U.S. Department of the Interior, Bureau of Land Management. http://www.nps.gov/plants/sos/. (January 2014).

Vieira, D.L.M.; Holl, K.D.; Peneireiro, F.M. 2009. Agro-successional restoration as a strategy to facilitate tropical forest recovery. Restoration Ecology. 17: 451–459.

Withrow-Robinson, B.; Johnson, R. 2006. Selecting native plant materials for restoration projects: insuring local adaptation and maintaining genetic diversity. Corvallis, OR: Oregon State University Extension Service. http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20385/em8885-e.pdf. (August 2006).

Wittman, H.; Desmarais, A.; Weibe, N., eds. 2010. Food sovereignty: reconnecting food, nature and community. Oakland, CA: Food First Books. 232 p.