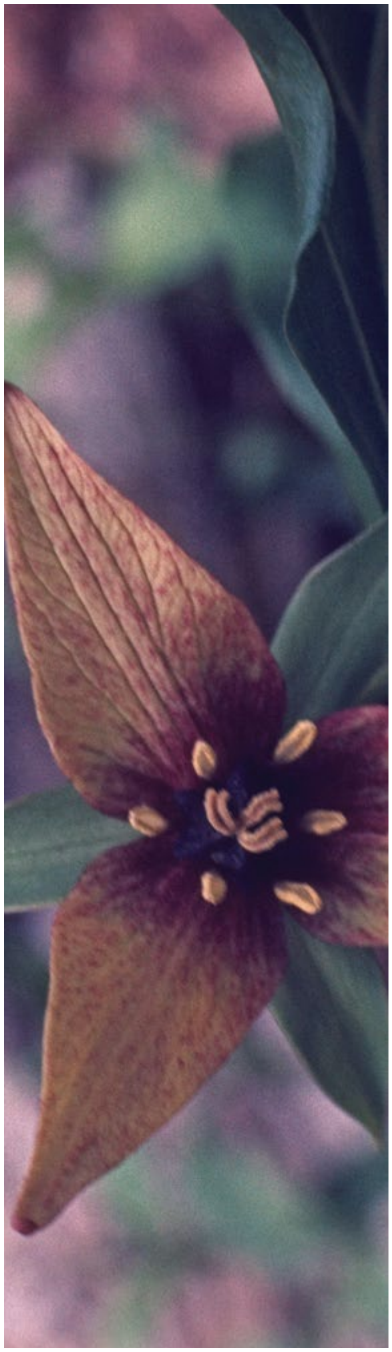

Appendixes

Appendix 1: Regional Summaries

Alaska

Nicole Grewe and Linda Kruger

Geography and Ownership

Alaska is a vast State covering 586,412 square miles, or approximately 375 million acres, an area roughly one-fifth the size of the contiguous United States. As the Nation's "Last Frontier," Alaska boasts its identity as the Nation's largest state with the lowest population density (1.2 persons per square mile) (U.S. Census Bureau 2014). An estimated one-third of Alaska is forested with 32 native tree species including coastal temperate and boreal rainforest, large expanses of subarctic forest or taiga, and riparian boreal forest located along river systems (Schroeder 2002). Of Alaska's total land base, about 44 million acres belongs to Alaska Natives by the 1971 Alaska Native Claims Settlement Act (ANCSA 1980). The act resolved aboriginal land claims and divided Alaska Native lands among 12 native regional corporations and over 200 village corporations. ANCSA left about 322 million acres under Federal, state, or local government ownership. Over one-half of Alaska's total land remains in Federal ownership and is managed by a variety of agencies including the National Park Service, USDA Forest Service, Fish and Wildlife Service, and Bureau of Land Management. Apart from native corporation lands, very little of Alaska is in private ownership.

Population and Demographics

Nearly two-thirds of Alaska's 2014 total population (735,601) is concentrated in the four urban communities of Anchorage, Fairbanks, Juneau, and Ketchikan (Alaska Department of Labor and Workforce Development 2015). Over three-quarters of Alaska communities are considered "rural" with populations less than 1,500 residents.[1] Approximately one-fifth of the population is Alaska Native including Yupik, Indian, and Aleut indigenous groups. There have been identified an additional 20 anthropologically distinct indigenous groups based on shared indigenous language and culture (Langdon 2002). In total, Alaska is home to 246 federally recognized tribes with governing structures similar to city governments. Tribal governments generally represent local indigenous groups that maintain ties to geographic areas that have been traditionally used for fish, wildlife, and plant harvesting.

Alaska's statewide racial composition continues to be dominated by Caucasian and Alaska Native. The Alaska Department of Labor and Workforce Development (2013) estimates approximately two-thirds of Alaskans are Caucasian (67 percent) and approximately one-fifth are Alaska Native (15 percent). The remaining 18 percent of the population is Asian (6 percent), African American (4 percent), Hawaiian or Pacific Islander (1 percent), or multiracial (7 percent). Alaskans of Hispanic origin comprise 7 percent of the total population. In 2011, the Anchorage School District reported 90 different languages were spoken in Anchorage area schools (Anchorage School District 2012).

Alaska Natives and Rural Residents

Alaska Natives have resided in the state for over 10,000 years. Many Alaska Natives participate in traditional hunting, fishing, and gathering activities. Tlingits, Haidas, Tsimshians, and Athabaskans are the primary cultural groups using temperate rainforest for nontimber forest products. Early settlers also depended on Alaska's fish, game, and forests for sustenance. Newer residents, especially those from outside the United States, have adopted the harvest and use of forest plants, animals, and fish as part of a natural resource-based lifestyle commonly referred to as "subsistence."

The term "subsistence" is used in a variety of ways (i.e., sustain, nourish, and give life), but remains a shared way of life for natives and nonnatives alike. Subsistence harvest activities are a cultural tradition with important economic implications for rural households and communities across Alaska (Thornton 1998). The harvest and use of traditional foods provides connections to place, belief, and history that are particularly critical to maintaining native culture and

[1] Grewe, N. 2009. Rural planning: the status of Alaska's rural and indigenous communities. Paper presented at the annual meeting of the Rural Sociological Society. Madison, WI: July 30–August 2.

identity. Historically, fish, marine and land mammals, and birds were main calorie sources for Alaska Natives; diets were supplemented with marine and terrestrial plants. Plants also provided medicines used to treat a normal range of human ailments and supported spiritual beliefs and practices (Garibaldi 1999, Thornton 1998). Over time, missionaries and colonists suppressed medicinal and spiritual practices and native cultures further lost faith in traditional practices and remedies after tragic epidemics. The transition from native language to English further fueled the loss of traditional knowledge and practices over time (Pilz et al. 2006).

Nontimber Forest Products

More than 75 forest plant species, with documented use as nontimber forest products, are utilized for edibles, medicinal products, arts and crafts materials, and other consumptive home uses (Garibaldi 1999). Nontimber forest products span seven primary product categories including: (1) arts, crafts, dyes, and floral greenery; (2) berries and wild fruits; (3) syrups, teas, and flavorings; (4) edible and medicinal plants; (5) native seeds; (6) edible mushrooms; and (7) medicinal fungi (Pilz et al. 2006; see also Garibaldi 1999).

A large quantity of arts and crafts products are produced with the wood and byproducts from trees including bark, limbs, roots, cones, berries, and boughs. Various plants provide leaves, berries, stems, and roots for display or dyes. Examples of artisan products include walking sticks, carvings, floral arrangements, wreaths, baskets, bowls, paintings, ornaments, (Chandonnet 1998) and high quality musical instruments and furniture. Yellow cedar (*Callitropsis nootkatensis* (D. Don) Oerst. ex D.P. Little), important for carving house poles and ceremonial masks and for weaving baskets, blankets, hats and other items is in decline (Hennon et al. 2012). Edibles, including fruits, mushrooms, and leaves, are harvested to make jams, jellies, syrups, sauces, teas, and toppings. The seeds of some plants, including fireweed and dwarf fireweed (*Epilobium angustifolium* (L.) Holub, *Epilobium latifolium* (L.) Holub), seashore and Nootka lupine (*Lupinus littoralis* Dougl., *Lupinus nootkatensis* Donn ex Simms), and wild geranium (*Geranium erianthum* DC.), are collected, cleaned, and stored for later germination (Pilz et al. 2006). Devil's club (*Oplopanax horridus* (Sm.) Miq.) and conks of wood have been historically used for medicinal purposes to treat a common range of human ailments (Pilz et al. 2006). Documentation of the economic value of nontimber forest products is, for the most part, unavailable, highlighting a significant research need.

Policies and Regulations

Alaska Natives, through their tribal governments, have agreements with the United States that reaffirm their access to and utilization of resources, for traditional, subsistence, and commercial uses. The Alaska National Interest Lands Conservation Act of 1980 (ANILCA 1980) establishes that all rural residents be given "reasonable access to subsistence resources on the public lands." Federal agencies and the state of Alaska have policies and manuals to facilitate collaboration, consultation, and planning to implement programs under this act (Alaska DNR 2010; Antypas et al. 2002; FWS 2012, 2014).

Federal legislation acknowledges nontimber forest product harvesting as an important physical, economic, traditional, and social activity for natives and nonnatives. ANILCA further defines subsistence use as: "The customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation: for the making and selling of handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade." In addition, ANILCA states "the continuation of the opportunity for subsistence uses by rural residents of Alaska, including Natives and non-Natives… is essential to Native physical, economic, traditional, and cultural existence and to non-Native physical, economic, traditional, and social existence." Federal agencies periodically review and update subsistence and other harvest, access, and use regulations. Review routinely includes consultation with federally recognized Alaska Native tribes.

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Hawai'i and the U.S.-Affiliated Tropical Islands of the Pacific

Katie Kamelamela and Kathleen S. Friday

The Hawaiian Archipelago was created from a volcanic hotspot starting millions of years ago, and now stretches over 1,500 miles (figure A1.1). Hawai'i is the southernmost State, the most isolated and one of the most populous places in the world (Juvik and Juvik 1998). From youngest to oldest, the inhabited islands are Hawai'i, Mãui, Kaho'olawe, Lãna'i, Moloka'i, O'ahu, Kaua'i and Ni'ihau. The uninhabited northwestern Hawaiian Islands are poetically referred to by Native Hawaiians as the "ancestral islands" which extend from

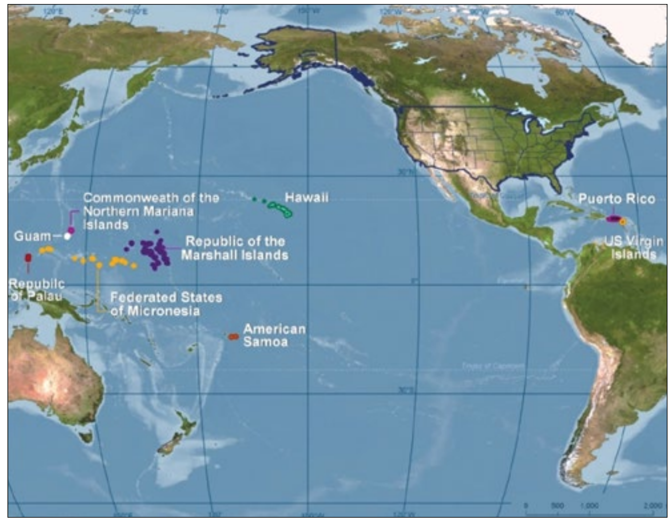

Figure A1.1—Map of Hawai'i and Pacific islands. (Source: Olga Ramos, U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry.)

Nihoa to Kure Atoll. The U.S.-affiliated islands of the Pacific include islands of Polynesia and Micronesia. Today, there is a continuum of subsistence to commercial gathering and management of NTFPs across these islands.

Pre-Western agroforestry practitioners and NTFP gatherers followed practices passed down to them over centuries and sometimes guarded as family secrets, as in the case of yams (*Dioscorea* spp.) in Pohnpei (Raynor and Fownes 1993). Many Pacific island residents now practice agroforestry with less benefit of traditional ecological knowledge and/or more concentration on recently introduced or cash crops. This includes younger generations, inter-island migrants now practicing on a different island (with different soils or climate), and migrants and contract laborers with their own cultural practices and crop preferences. Landowners grow fruit trees and other crops in home gardens or simpler plantation or orchard systems. NTFPs are primary forest products, for nutrition, cultural practices, cash income and practical everyday life in the islands.

Land Area in Nontimber Forest Product Production

Active management of NTFPs primarily takes place in private agroforestry systems, which comprise up to 85 percent of the forested areas of some islands (Table A1.1). Access to NTFPs harvested from public lands varies with who controls those lands.

In the state of Hawai'i people of diverse socioeconomic backgrounds gather forest products year round, from the mountain to the sea. The rights of Native Hawaiians, and

Table A1.1—Agroforest and forest ownership in Hawai'i and U.S.-affiliated Pacific Islands. Sources: ASCC 2010; Biza 2012; CNMI 2010; Cole et al. 1987, 1988; Donnegan et al. 2004a, 2004b, 2011a, 2011b, 2011c; Gon et al. 2006; Guam 2010; National Biodiversity Team 2000; Republic of Palau 2010.

State or U.S.-affiliated Pacific Island jurisdiction	Total area (acres)	Multistrata agroforest		Forest ownership by jurisdiction (% total forest area)			
		Acres	% of total forest	Private or communal	Local government	Jurisdiction	Federal (U.S.)
Hawai'i	4,127,337	n/a	n/a	47		44	9
American Samoa	49,280	15,510	35	≤ 96	n/a	≥ 4	0
Republic of the Marshall Islands	44,800	20,000	85	100	0	0	0
Federated States of Micronesia	149,804	35,655	25	27–100 (varies by State)	0–73 (varies by State)	0	0
Commonwealth of the Northern Mariana Islands	113,280	1,313	3	n/a		Almost 50	n/a
Guam	135,680	1,921	2	51	0	19	29
Republic of Palau	114,560	2,740	4	~ 30	~ 70	0	0

the general populace, to gather NTFPs are codified in the State Constitution (Article 12 Section 7; Hawai'i Revised Statutes sections 1-1 and 7-1 (1993)). To gather resources from State of Hawai'i forest reserves, citizens request personal, commercial or cultural use permits from the Department of Forestry and Wildlife. To gather resources on private property, permission is requested from the owner. Consent is also required for gathering where permitted by the military, National Parks, and other Federal lands. Factors that restrict NTFP productivity include ungulates, invasive species, water diversion, urbanization, national security, and climate change.

The situation in the affiliated-islands varies, greatly. The laws of Guam and the Commonwealth of the Northern Mariana Islands (CNMI) set aside some public land exclusively for Chamorros and people of Northern Marianas descent (Chamorros and Carolinians), and govern access to Territory-owned and Commonwealth-owned forest lands. Much of the Marianas' forest land is held by the United States military and access to NTFPs is restricted. Indigenous Pacific islanders still form majorities in American Samoa and the "Compact" nations, which have their own Constitutions, regulations, authorities and policies governing land tenure and access to and use of NTFPs. Forested land is generally privately owned, held under traditional land tenure systems or owned by local governments. The exceptions are Kwajelein military base (Marshall Islands) and the National Park in American Samoa, which is leased and allows "traditional" practices (ASCC 2010).

Nontimber Forest Product Practices and Species

People of the affialiated islands depend on NTFPs for food and medicine. The richness of Pacific island medicinal ethnobotanical tradition is illustrated by the 60 plant species used as medicine in just one Marshallese village. Even newly introduced plants are used medicinally by some people (National Biodiversity Team 2000). General information about such medicinal uses has been published through collaborations between researchers and Pohnpeian experts (Balick 2009, Kitalong et al. 2011), but detailed knowledge is held closely by traditional healers. Trees, such as breadfruits (*Artocarpus* species and hybrids), coconut (*Cocos nucifera* L.), *Citrus* spp., mango (*Mangifera indica* L.), avocado (*Persea americana* Mill.), and soursop (*Anonona muricata* L.) and other *Annona* spp. provide daily food items. Staple carbohydrates grown in agroforestry systems, includine yams, bananas (French plantain, *Musa* × *paradisiaca* L.), and the aroids (cocoyam, *Colocasia esculenta* L. Schott; giant taro, *Alocasia macrorrhiza* (L.) Schott; gallan, *Cyrtosperma merkusii* (Hassk.) Schott; and arrowleaf elephant's ear, *Xanthosoma sagittifolium* (L.) Schott). The leaves eaves of taro (*C. esculenta* L. Schott) and various shrubs are collected to eat, as well.

A single farm may have several dozen species, and the Pacific at large has dozens to hundreds of cultivars of important crops such as yams (Raynor et al. 1992), breadfruit (Zerega et al. 2004), and bananas (Englberger et al. 2006). Fiber is obtained from a wide variety of products including mats and basketry from *Pandanus* spp., textiles in Yap (bananas, *Musa* spp.; sea hibiscus, *Hibiscus tiliaceus* L.), cordage from coconut, and thatch from nipa palm, (*Nypa fruticans* (Wurmb)).

Native and introduced woods are closely tied to Pacific cultural lifestyles, primarily harvested and utilized on the same island. The traditional Samoan open fale (meetinghouse or guesthouse) is characterized by support posts (often simpleleaf bushweed, *Flueggea acidoton* (L.) G.L. Webster) arranged in an oval, roofed with a structure of poles and decorated with carving and woven sennit. Canoes, iconic for traditional fishing and historical navigation, are based on a hull fashioned from a large log. In Kosrae, the preferred wood comes from Terminalia (*Terminalia carolinensis* Kaneh.), while atoll islanders use planks made from breadfruit (*Artocarpus altilis* (Parkinson) Fosberg). Wood is used as fuel in large earthen pit ovens and meals from such ovens are integral to funerals, weddings, and other culturally significant gatherings. Artisans traditionally made a wide variety of tools, implements, and decorative architectural features from wood. Many such items are made today, such as ceremonial kava bowls made of matoa, *Pometia pinnata* (J.R.Forst. & G.Forst) from American Samoa; storyboards depicting legends from Palau carved from Honduras mahogany, *Swietenia macrophylla* (King); and sharks and other figures from Pohnpei carved from cedar mangrove, *Xylocarpus granatum* (K.D.Koenig).

Many people who live or manage resources in Hawai'i do so through an ahupua'a (figure A1.2) land management framework that is unique to Hawai'i. An ahupua'a is a traditional land and cultural resource management unit with a source of water, such as a stream or subsurface flow that physically connect the mountains to the sea. Each ahupua'a has a name that reflects characteristics of the place. The ahupua'a of *'Aiea* bears the common name (*'aiea*) of the endemic genus *Nothocestrum* (Pukui and Elbert 1986), and *Mokihana* valley and stream are named for the mokihana (*Pelea anisata*) tree that is only found on Kaua'i, where its flowers and seeds are strung into lei that represents Kaua'i (Pukui et al. 1976).

Subsistence gathering no longer meets all the needs of the Hawaiian community, although it continues to have significant economic, social, and cultural role (Kuokkanen 2011). Plant parts gathered include leaves, flowers, bark, inner bark, sap, seeds, fruit, stems, roots, fronds, timber and whole plants for the use of food, firewood, ceremony, *lei* (garlands), *lāau* (medicine), *mea kaua* (weapons), *hula* (traditional dance), baskets, crafts, for fishing, celebrations, adornment, and more. Within Hawai'i there are limited data related to Native Hawaiians who gather resources from the forest and even less is known of NTFPs gathered by people of other cultures who have adapted and made Hawai'i home (i.e., Japanese, Chinese, Korean, Tongan, Samoan, Vietnamese, Portuguese, Kosraean, Americans). In all, NTFP subsistence choices significantly and actively contribute to Hawai'i's shared economy and the cohesion of family traditions and values.

Data related to Hawai'i NTFP harvesting are focused nearly exclusively on hula plants (Blair-Stain 2010; Ticktin et al. 2006, 2007). The practice of hula is dependent on many NTFPs (Anderson-Fung and Maly 2009). Native NTFP resources are critical to the ceremony of the *kūahu*, or the hula altar, as well

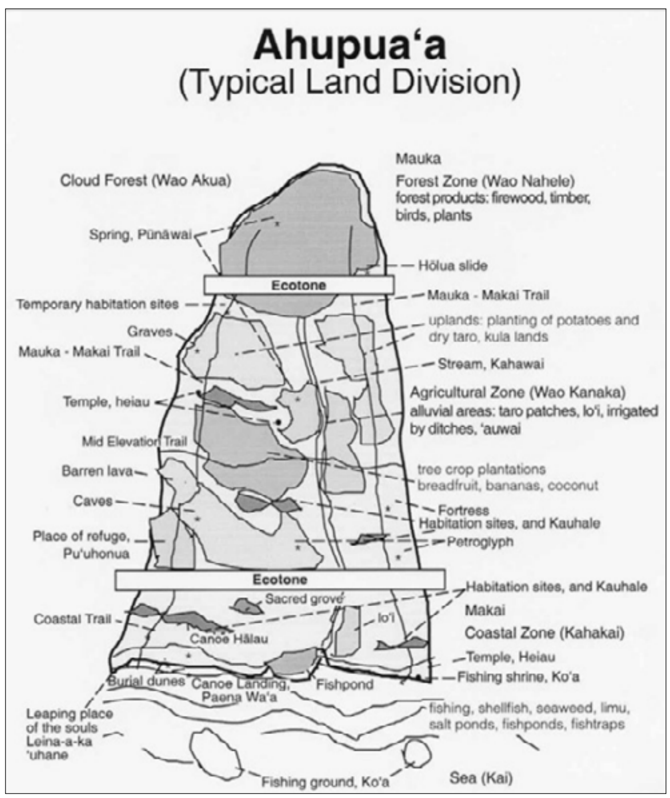

Figure A1.2—An ahupua'a, a patchwork of nontimber forest products management areas between mauka (mountain) and makai (ocean) resources (Minerbi 1999).

as to the ceremonial adornment of the dancer with ferns (palapalai, *Microlepia strigosa*; and Chinese creeping fern or pala'a, *Sphenomeris chinensis*), flowers ('ohi'a Lehua, *Metrosideros polymorpha*; and a'ali'i, *Dodonaea viscosa*), leaves ('ohi'a Lehua; koa, *Acacia koa*), and vines (maile, *Alyxia oliviformis*; and 'ie'ie, *Freycinetia arborea*) (Garcia 2002). Ticktin et al. (2006, 2007) have demonstrated that the removal of invasive species by hula practitioners benefits ecosystems.

Threats and Challenges Posed by Climate Change

Pacific weather and sea level conditions are characterized by high natural variability; it is difficult to measure and separate the effects of long-term climate change from the El Niño—Southern Oscillation (ENSO) (NOAA 2014) and decadal oscillations (Leong et al. 2014). ENSO-related precipitation variability is predicted to intensify with long-term global warming (IPCC 2014). Further, each island's topography affects its orographic rainfall, water storage capacity, and susceptibility to coastal flooding.

Nevertheless, measurable trends are being recorded, which may affect island NTFPs. A 15 percent decline in annual rainfall has been observed in the eastern islands of the subregion (the Marshall Islands, Kosrae, and Pohnpei), and slight increases in average rainfall have been observed in the western islands (the Marianas, Yap, and Palau). Models for the region predict increases in average rainfall and temperature by the end of the century (Leong et al. 2014). Extreme precipitation events are predicted to become more intense and more frequent, bringing wind, rain, and storm surges (IPCC 2014). In Hawai'i, average precipitation has been declining for nearly a century, but climate models generally predict average increases of up to 5 percent in the main Hawaiian islands and decreases of up to 10 percent in the northwestern islands (Leong et al. 2014).

Potential and Limitations to Nontimber Forest Products and Climatic Variability

Upland forests and agroforests—Increases in temperature and changes in average rainfall will change conditions for wild and cultivated NTFPs. The increased variability in rainfall is likely to favor adaptable and invasive species. Even where forest cover is intact or agroforest cover is complex and continuous, heavy rainfall can cause mass wasting events that devastate watersheds. For example, Typhoon Chata'an caused several hundred landslides in Chuuk, including many that carried away entire agroforests and soil from some plots and inundated other plots with debris and mud (USGS 2002). Droughts can lead to increases in wildfires, which hinder restoration of forests on the dry sides of Hawai'i's largest islands, and the western Pacific islands with dry seasons. High-elevation ecosystems in Hawai'i are beginning to show the effects of higher temperatures combined with drought (Leong et al. 2014).

Atolls—While Hawai'i's atolls are not inhabited, they are home of entire communities in Micronesia and the entire nation of the Marshall Islands. Atolls are particularly vulnerable to droughts because of their small freshwater lenses and lack of orographic rainfall. As sea level rises, saltwater intrusion during high water events will contaminate fresh groundwater. Increased groundwater salinity may reduce or eliminate the ability of low coral islands to support breadfruit and taro (Manner 2014). Storm surges and other high water events on top of the high sea levels recently experienced in the western Pacific have already led to salinization of coastal taro paddies (Keener et al. 2012).

Mangrove forests—Mangrove forests comprise 16 percent of forested acreage in the high islands of Palau and the Federated States of Micronesia (Cole et al. 1987, Falanruw et al. 1987a, 1987b; MacLean et al. 1986; Whitesell et al. 1986). Pacific islanders obtain NTFPs from mangrove forests including poles, fuelwood, and carving wood, as well as thatch from *N. fruticans* palms. Mangroves are vulnerable to current rates of global sea level rise (Keener et al. 2012). Mangroves at the seaward edge are expected to die off as sea levels rise because roots cannot get enough oxygen in consistently deeper waters. At the landward edge, mangroves might colonize new land where rising sea levels give them a competitive advantage over non-mangrove species, thus causing the landward edge of the mangrove forest to migrate inland. The substrates of mangrove ecosystems are very dynamic; rates of deposition and erosion of sediment change with every tide and every season, with human management of soils upslope, and with human impacts on nearshore currents. Gilman et al. (2007) predicted a 12-percent decrease in the extent of mangrove forests in the U.S.-affiliated Pacific islands by 2100, implying decreases in NTFP resources and ecosystem services.

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Northwest

Frank K. Lake

Land Area

The Northwest region of the United States encompasses Washington, Oregon, and Idaho (Melillo et al. 2014). Climatically, the southern area and western valleys of this region are more Mediterranean, with the coastal and Puget Sound areas having maritime influence. The interior areas, east of the Cascades, are continental climate-influenced zones (Kunkel et al. 2013). The region is geologically and topographically diverse, having soils of different sedimentary, metamorphic, volcanic, and ultramafic origin among others. The soils and climate affect potential vegetation. Across the Northwest, the diversity of ecoregions, ecosystems, and habitats support a wide variety of NTFPs harvested for various reasons and purposes. The associated disturbances of climate change, such as drought, wildfires, and insect outbreaks, are affecting the habitat quality and access to valued NTFPs in this region. These physical and biological conditions influence the condition and production of ecosystem services, such as NTFPs, utilized by public and other harvester communities across the Northwest.

Nontimber Forest Product Harvesters and Species

Human settlement in the region ranges from remote rural communities to densely populated cities with culturally diverse populations. Residents of the Northwest harvest hundreds of NTFPs for cultural, subsistence, recreational craft, and commercial purposes (Hansis et al. 2001). Many American Indians in the region harvest NTFPs for purposes associated with culture, spiritual, ceremonial, and subsistence practices on and off reservations in ceded ancestral territories (Flood and McAvoy 2007; Turner and Cocksedge 2001). Increased awareness of and opportunities for commercial harvesting of NTFPs has created conflict and competition among some harvester groups (Hansis et al. 2001).

The main basketry plants of use are California beaked hazel (*Corylus cornuta* subspec. *californica* (A. DC.) E. Murray), conifers (Sitka spruce, *Picea sitchensis* (Bong.) Carrière; cedars, western red, *Thuja plicata* Donn. *ex* D.Don and Alaskan Yellow- *Callitropsis nootkatensis* (D.Don); and pine, *Pinus* sp.), and common beargrass (*Xerophyllum tenax* (Pursh) Nutt.). A few species of lichens and berries are used as dyes for baskets. Poles or uniquely shaped branches from conifers and hardwoods are used in subsistence fishing and hunting activities for construction material for frames, scaffolds, traps or cages, and implements (e.g., clubs, adz handles). Iconic and well known from the tribes of this region are carvings (totem poles, masks, bowls, animal figures) and other ceremonial sacred or artisan craft items from Alaskan Yellow and redcedar wood and bark. Food resources of significance are huckleberries (*Vaccinium* spp.), other berries (salmon, thimble, black cap raspberry, and trailing), serviceberry (Saskatoon, *Amelanchier alnifolia* (Nutt.) Nutt.), chokecherry (*Prunus virginiana* L.), silver buffaloberry (*Shepherdia argentea* (Pursh) Nutt.), as well as roots (wild celeries, *Lomatium* spp.) and geophytes (small camas, *Camassia quamash* (Pursh) Greene), lilies (*Liliaceae* spp., *Calochortus* spp., *Lilium*, spp.), and onions, *Allium,* spp., and a few mosses and ferns (Lynn et al. 2013). Teas made from foliage, bark and roots of shrubs and trees also are medicinal importance. Collection of NTFPs (food and medicine) by tribal members was reported to be impacted by management operations on national forests (Flood and McAvoy 2007).

Ecological and Social Implications of Changing Climate

The Northwest climate is projected to increase in winter temperature, with warmer winters and hotter-drier summers. Precipitation regimes may shift, in response to global storm systems potentially bringing more precipitation to the region in some areas, but generally a trend of similar conditions is expected across the region until 2050 (Fettig et al. 2013, Kunkel et al. 2013, Littell 2012). Increased temperatures will shift the proportion of snow and rain delivery across the coastal to interior gradient, as well as an increase in total amount of precipitation falling as rain. Warmer and drier conditions will continue to increase wildfire activity resulting in larger and potentially higher severity fires across the forests found in the range of climatic zones. Fire regimes are anticipated to change across the coast range and Olympic peninsula, interior valleys (Bachelet et al. 2011), Cascades, and interior mountain ranges that will influence the recovery of vegetation in the areas burned. Increases in pests, diseases, and pathogens are anticipated. In particular, several conifer trees that dominate forests are expected to have increase insect outbreaks (e.g., defoliators and bark beetles) (Fettig et al. 2013, Little 2012). Douglas-fir and pines are expected to decrease across the Northwest (Littell 2012). A decline in the current climatically suitable range for many tree species is anticipated in the region by 2080 (see Coops and Waring 2011 in Littell 2012). In many cases, desired qualities, spatial distribution, and abundance of NTFP species are associated with a particular forest seral stage, time since disturbance, or severity of the disturbance. Challenges likely will arise around the temporal and spatial periodicity of NTFPs based on the type of disturbance and integrity of the habitats. Many of the ecological or climatic niches of valued NTFPs are anticipated to remain the same, but as the environment changes, so will the ranges of many species in response to disturbance (Fettig et al. 2013). The capacity of NTFP harvesters to anticipate when and where valued NTFPs will occur across the landscape in response to climate associated disturbances is an evolving adaptive social-ecological system.

In the Columbia Plateau, and across the coastal Northwest, tribes depend on NTFPs for food, materials, and medicines. Prolonged droughts and changing fire regimes are impacting NTFP resources important to tribes (Chief et al. 2014). The primary NTFP food resources of tribal significance at risk are huckleberries and other berry producing shrubs, perennial forbs that are harvested for their roots and greens, as well as mushrooms (Lynn et al. 2013). Many tribes are working with agencies and organizations to conduct climate assessments that identify risk and vulnerability to valued natural and cultural resources. From these assessments, managers are developing adaptation and mitigation strategies to identified threats and stressor and how best to plan and respond. NTFPs in tribal reservations and under tribal management are jurisdictionally constrained (Chief et al. 2014). Coordination and consultation with tribes to preserve access to NTFPs within their ancestral territory, but outside tribal reservations, will be particularly important.

Land and resource managers may have to consider how access and opportunities to harvest NTFPs for the general public change due to climate driven processes (von Hagen and Fight 1999). Given the size and importance of the commercial NTFP sector in the region, understanding the potential ecological and social impacts of climate on high value, high use NTFPs will be necessary to formulate mitigation and adaptation strategies (Lynn et al. 2013, Voggesser et al. 2013). As forest extraction and product industries change in response to climate and disturbance, many communities that rely on NTFPs for subsistence (e.g., food security) and commerce (e.g., economic security) may be affected (Carroll et al. 2010, Lal et al. 2011, Sohngen and Sedjo 2005).

Regulatory Context and Responses

As disturbance regimes change in response to extreme weather events, prolonged drought, and increased wildfire (Fettig et al. 2013, Littell 2012), NTFP resources will be impacted at the ecosystem, habitat, species and individual harvester scales (Turner and Clifton 2009). If climate change contributes to extreme weather events that effect pollination, plant vigor and development, or habitat quality impacts to high-valued NTFP resource as well as harvester communities, will have to be explored and understood by researchers and managers (Jones and Lynch 2007). Increasing the resilience of forest habitats to the threats of climate change to support NTFP harvesting will require adaptability and socioeconomic resilience of the harvesters (Carroll et al. 2010).

A variety of laws, policies, and regulations govern the access to and harvesting of NTFPs. Many American Indians in the region retain treaty rights for harvesting NTFPs for traditional cultural purposes on public and private lands (Cultural Heritage Cooperative Authority of 2008). Nonnative harvesters are subject to Federal or state regulatory and permitting requirements set at national, regional or local jurisdictions. There is a recognized need for NTFP harvesters and commercial buyers to participate more in understanding the impacts of current policies and with the development of additional policies and regulations (McLain and Jones 2001; see also chapter 7). Carroll et al. (2003) identify the need to improve the classification of NTFP harvesters beyond commercial versus recreational in policies and regulatory enforcement.

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Southwest

Frank K. Lake, Toral Patel-Weynand

Land Area

The Southwest region of the United States encompasses California, Nevada, Utah, Arizona, Colorado, and New Mexico and has unique climate change challenges compared to other areas of the United States (Garfin et al. 2013, Melillo et al. 2014). The diversity of ecoregions, ecosystems, and habitats in the region support a wide variety of NTFPs in habitat types ranging from grassland valley bottoms and desert lowland basins to mixed hardwood/chaparral foothill forests and montane conifer/meadow complexes. Climate varies from Mediterranean, to continental, to desert (Peterson 2012). Biogeophysical (e.g., soils and geology), topographic (i.e., landforms) and elevational diversity contribute to corresponding diversity of forest types, from coastal redwood to subalpine fir (Hurteau et al. 2014). Rain and snowfall levels, corresponding to elevation gradients and rain shadows across mountain ranges, further influence plant diversity in the region and production of ecosystem services, such as NTFPs.

Nontimber Forest Product Harvester Communities

The region's human population is distributed across densely populated urban environments and remote rural communities. Southwesterners with diverse and often multiple cultural heritages harvest NTFPs for traditional, cultural, subsistence, recreational, leisure, and commercial purposes (Gomez 2008). Ethnicity and socioeconomic status may influence their targeted species, manner, and reasons for harvesting (Alm et al. 2008). For example, southern California residents of Korean and Japanese heritage harvest bracken fern fiddleheads as a social activity that reinforces cultural identity and connections to nature (Alm et al. 2008, Anderson et al. 2000). Many California American Indians harvest and use NTFPs for traditional cultural purposes associated with spiritual, ceremonial, and subsistence practices. These include basketry and other arts, food, and medicinal uses (Anderson 1997, 1999; Anderson and Lake 2013; Bocek 1984). In the Great Basin and across the Southwest, tribes continue to depend on NTFPs such as pinyon (*Pinus edulis* Englem.) and sagebrush (*Artemesia tridentata* Nutt.) for food, materials, and medicines to support subsistence and ceremonial-religious activities (Ford 1985).

Threats/Challenges for Production

In the Southwestern United States, forest diversity is highly influenced by fires and drought. However, climate, fire suppression, land management, and urbanization have greatly altered historic fire regimes in many forest types (Liverman and Merideth 2002). Resulting changes in tree species composition and density have contributed to high fuel loading in habitats that contain valued NTFPs, placing these areas and the species in them at risk. (Hurteau et al. 2014). The legacy of fire exclusion and warming climate associated with drought is expected to result in continuing increases in fire severity over a lengthening fire season (Allen et al. 2015, Hurteau et al. 2014).

As disturbance regimes change in response to climate, especially extreme weather, prolonged drought, and increased fire events (Millar et al. 2007), NTFP resources will be impacted at the ecosystem, habitat, species, and individual harvester scales. Prolonged drought and changes in precipitation and temperature are particular threats. Across Nevada and other interior states, pinyon pine, a major NTFP food resource, has experienced severe die-offs. Pinyon pine is projected to replace ponderosa pine (*Pinus ponderosa* Douglas ex. C.Lawson), however. In mid-to-higher elevation mountain ranges, forests dominated by pine and conifer species such as lodgepole pine (*Pinus cortata* Douglas), Jeffery (*Pinus jeffreyi* Balff.), and ponderosa, are susceptible to insect outbreaks. Increasing extent and severity of wildfires coupled with insect induced mortality of conifer trees are impacting forests, and affecting the habitat of many NTFPs. Bark beetles are causing large-scale forest mortality, which in turn is increasing fire risk (Peterson 2012). In California, drought is reducing vigor and production of oak (*Quercus* spp.) acorns, reducing the quantity and quality of acorns from tribally preferred species. Loss of acorns is and will continue to impact tribal ceremonial and subsistence food security, as well as, tribal access to 67 wildlife species that also depend on abundant acorns (Lynn et al. 2013, Voggesser et al. 2013). In coastal northern California, the *Phytophtora ramorum* pathogen responsible for sudden oak death (SOD) is resulting in widespread mortality of oak-dominated forests. Loss of oak trees to SOD and sanitation treatments likely will result in reduced availability of acorns, nuts, berries, and other NTFPs vital to coastal tribes (Chief et al. 2014, Voggesser et al. 2013). Other threats include invasive species invading areas impacted by drought, insects, and fire. Invasive grasses, in particular, increase the potential for wildfire ignition and spread, out-competing native species and causing higher fire risk in a range of habitats (Peterson 2012). Challenges facing forest managers and cultures dependent on NTFPs involve coping with extensive tree mortality, managing forests to increase their resilience to climate-induced disturbances, and responding to and reacting to wildfires.

NTFP Practices to Address Threats/Challenges

Tribal NTFP resources are being impacted by climate change, primarily by prolonged droughts and changing fire regimes (Chief et al. 2014). The primary food resources of tribal significance at risk are pine nuts and other seed producing trees, shrubs, forbs, and grasses; berry producing trees and shrubs; and perennial forbs used as "greens," which emerge after winter and monsoonal rains (Bye 1985, Schauss 2009, Stoffle et al. 1992). Many plants are breaking dormancy, emerging or budding out earlier. In response, many NTFP harvesters will shift their harvesting schedule to correspond with plant phenological growth stage. For many cultures adapting to changing environmental conditions or plant developmental stage will require harvesting earlier or finding suitable conditions across the landscape at the "right time" when the NTFP resource is optimal for harvesting. The capacity of NTFP harvesters to anticipate when and where valued NTFPs will occur will require an evolving, adaptive process. Where subsistence, religious, or ceremonial practices rely on the timing of phenological stage, adaptation may be especially challenging and urgent (Chief et al. 2014).

Potential Limitations

Increasing resilience of forest habitats to environmental stressors in support of NTFP harvesting will require adaptability to ensure socioeconomic stability of the harvester communities. In some Southwestern localities, the high potential for complete reorganization or a major shift from forest to shrub or grassland will reduce or eliminate desired NTFPs. In some instances, tribal uses of particular climatically vulnerable tree species may require mitigation, such as reducing existing threats and stressors to habitats or point protection (i.e., wildfire management) for species, or adaptation actions as using surrogates or modifying cultural practices linked with specific species (Redsteer et al. 2013, Stumpff 2011).

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Midwest

Gregory Ormsby Mori, Badger Johnson, and Shibu Jose

Land Area

Agriculture is the dominant land use across the Midwest, home to some of the most agriculturally intensive areas in the world. The eight states of the region (Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois, Iowa, and Missouri) contain many rural areas with low population densities, but also hold 20 percent of the total United States population (61 million), the majority living in cities. A continental climate brings warm summers and cold winters. While not as extensively forested as other regions of the country, the Midwest's 87 million acres of forest (table A1.2) produce some of the Nation's most valuable timber species and account for about 30 percent of the land cover of the region. The distinct ecotypes of the region include the oak-hickory forests of Missouri, southern Illinois, Indiana, and Ohio; boreal and pine-aspen forests surrounding the northern and central Great Lakes; beech-maple forests of the upper Midwest; and the mesic mixed-hardwood forests of southeastern Ohio (figure A1.3).

Harvesting of nontimber forest products (NTFPs) occurs throughout the Midwest. Some NTFP practices, such as maple sugaring, gathering of morel mushrooms, collection of black walnuts and harvesting of medicinal herbs including American ginseng (*Panax quinquefolius*), are observed widely across the region. Others, such as the harvesting of forest mosses (*Thuidium delicatulum*, *Hypnum imponens,* and *H. curvifolium*) in Appalachian Ohio are local or subregional practices (McLain and Jones 2005). Upwards of 140 NTFPs are harvested in Michigan's Upper Peninsula by indigenous and nonindigenous people, for both commercial and noncommercial uses (Emery 1998, 2001). Annual production of maple syrup, during the period 1992 to 2010, averaged between $2.4 and $2.9 million each for Wisconsin, Michigan, and Ohio. Over 30 million pounds of black walnuts (*Juglans nigra*) were harvested in the region in 2013, from predominantly wild trees (Hammons Products 2014). Slippery elm (*Ulmus rubra*) is harvested for its mucilaginous inner bark and sold in herbal compounds (Rao et al. 2004). There is increasing market demand for ramps (*Allium tricoccum* Aiton) whose historical range includes most of the Midwest, but which has been extirpated in many areas.

In the northern Great Lakes region, a number of NTFP practices are observed. The bark of paper birch (*Betula papyifera*) is a traditional material used to construct baskets, decorations, shelters, and canoes. Black ash (*Fraxinus nigra*) is used in basket making and is highly prized by American Indian and other artisans (Diamond and Emery 2011). Boughs of balsam fir (*Abies balsamea*), arborvitae (*Thuja occidentalis*), and other conifer tree species are used to make wreaths, an industry with an estimated value greater than $75 million for the northern Great Lakes region in 2010 (Handler et al. 2012). Gathering of northern wild rice (*Zizania palustris*) by American Indian groups in the Great Lakes region has been practiced for centuries and is an integral part of these cultures.

Table A1.2—2007 total forest land acreage and percent for forest type group by State. Source: Shifley et al. 2012.

State	Forest land	Oak/ hickory	Maple/beech	Aspen/birch	Spruce/ fir	Elm/ash/ cottonwood	White/red/ jack pine	Oak/ pine
	thousand acres	*percent*						
MN	16,391	9	10	40	23	9	6	2
WI	16,275	23	26	20	9	9	9	4
MI	19,545	16	32	16	13	7	10	3
OH	7,894	62	23	1	0	8	1	2
IN	4,656	62	19	0	0	11	1	3
IL	4,525	67	5	0	0	22	1	1
IA	2,879	57	11	0	0	24	0	3
MO	15,078	80	2	0	0	7	0	7

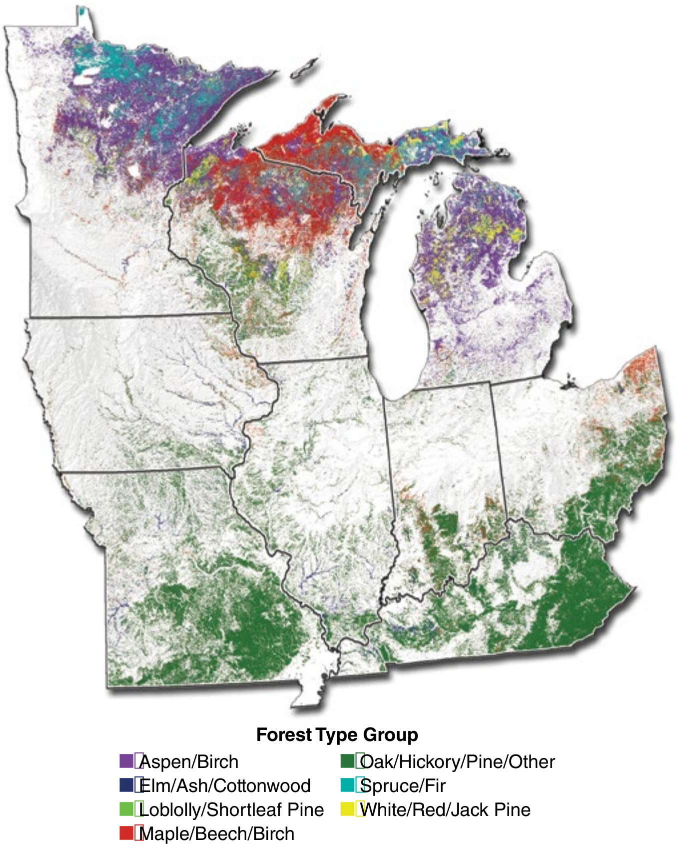

Figure A1.3—Forest type groups of the Midwest. (Source: Handler 2013.)

Threats and Challenges to Meeting the Production of Nontimber Forest Products

It is difficult to predict with precision how climate change-related phenomena, such as altered temperature and precipitation patterns and an increase in extreme weather events, will impact NTFPs in specific settings. Many NTFPs in the Midwest, however, will likely experience declines and life-cycle alterations that will threaten the sustainability of their future collection.

Longer growing seasons and shorter and warmer winters: American ginseng, despite its wide latitudinal distribution throughout the Midwest, is highly adapted to local climate conditions. Even small changes in mean temperatures can adversely affect this species. (Souther and McGraw 2011 2014). While longer growing seasons might benefit some species such as goldenseal (*Hydrastis canadensis* L.) by facilitating more root development, higher yields, and enhanced post-harvest recovery (Albrecht and McCarthy 2006, Davis and Greenfield 2002), in other species, particularly bloodroot (*Sanguinaria canadensis*) and ramps, shorter and warmer winters could interfere with seed stratification requirements (Albrecht and McCarthy 2011, Davis and Greenfield 2002). Higher spring temperatures may shift maple syrup production to earlier in the season and reduce the number of sap flow days, especially at the southern extent of its range. Production of maple syrup is predicted to decline over the next century by 15 to 22 percent (Duchesne et al. 2009, Skinner et al. 2010).

Loss of habitat—Altered temperature, precipitation and disturbance patterns along with changes in soil moisture and increased risk of drought and wildfires may lead to a reduction or elimination of NTFP habitat. Habitat for ramps and other NTFP herbs that prefer mesic habitat will likely be reduced with drier climate regimes and lower soil moisture (Bernatchez et al. 2013). Within the central hardwood region, black cohosh, considered critically imperiled in Illinois, is found in mesic upland forests dominated by ash, beech, and sugar maple, a community type thought to be highly vulnerable to climate change[2].

Amplification of existing stressors—The many stressors to which forest ecosystems are exposed—pests and pathogens, invasive species, disturbance—are likely to intensify with the effects of climate change. For many NTFPs, there may be increased pressure from undesirable pests and pathogens as ranges shift northward and as changing climatic conditions change disturbance and mortality patterns (Hatfield et al. 2015, Vose et al. 2012). Black ash, threatened by emerald ash borer (*Agrilus planipennis* Fairmaire; EAB), may be at increased risk with the combined effects of climate change as its ecological zone shifts northward and warmer winter temperatures expand the potential range of EAB (Iverson et al. 2016). Black walnut production in the central hardwood region may decline with the threat from thousand cankers disease and projected declines in habitat suitability[3]. Climate change effects could exacerbate the impacts of Dutch elm disease on slippery elm, which has shown increased mortality in recent years (Lin et al. 2004).

Ecosystem shifts and conversions—Major shifts and conversions of ecosystems will likely accompany changes

[2] NatureServe Explorer: an online encyclopedia of life. 2017. Available at: http://explorer.natureserve.org/. [Date accessed:: August 22, 2017].

[3] Forest Health Program, Missouri Department of Conservation. 2017. Thousand cankers disease of walnut: frequently asked questions. Available at: http://extension.missouri.edu/treepests/documents/tcdFAQ.pdf. [Date accessed: August 22, 2017].

in temperature and precipitation as some species decline and others migrate and reassemble into new communities. The boreal forests are considered to be highly vulnerable and are expected to disappear from the upper Midwest region by the end of the century, which will severely impact the livelihoods of thousands of seasonal workers who depend on the harvest of balsam fir branches (Vose et al. 2012). Similarly, birch and black ash may be increasingly at risk in the northern hardwood forests along with the culturally significant NTFP practices associated with them. Warmer temperatures combined with lower soil moisture may facilitate some oak and hickory species of the central hardwood region to extend their range northward into areas that were formerly dominated by a northern hardwoods vegetation community type. Black walnut could become less viable in Missouri but may expand further north.

Insufficient migration rates—A major concern is that NTFP species may not be able to keep pace with shifting climactic conditions (Souther and McGraw 2011) or be able to effectively colonize new areas with more favorable ecological conditions due to limited dispersal mechanisms (Bellemare et al. 2002) and seed predation (Furedi and McGraw 2004). Thus habitat loss and a high degree of fragmentation in the prairie parklands of the central Midwest will likely severely limit the ability of some NTFP species to migrate.

Practices That May Be Relevant to Address Threats and Challenges

Diversification and intensification through sustainable management of NTFPs may help offset some negative economic and ecological effects of climate change. These practices include:

Silvicultural and forest management: Silvicultural prescriptions might be tailored to encourage the growth of certain species (Zenner et al. 2006) and managing for NTFPs is a possible goal of such community composition manipulation. Single tree selection and group selection harvests have shown a positive effect on species richness compared to shelterwoods and clearcuts (Duguid and Ashton 2013). Studies of woodlot management in the upper Midwest indicate that active management of such woodlands can significantly increase productivity and biodiversity (Moser et al. 2009). Small diameter and low-value trees removed for timber stand improvement, particularly in oak-hickory forests, can be used in for the cultivation of mushrooms. Managing for understory plants may help to reduce risk of wildfires. Regular long-term silvicultural management for timber can be tailored to support goals of both maple syrup production and understory medicinal plants for additional income. An adaptation strategy for sugar maple might involve planting out germplasm that has been selected or bred for climate change adaptability.

Most private woodlands in the region are not actively managed. Of the 15 million acres of privately owned forest in Missouri, less than 10 percent are under management (NWOS 2015). Promotion of NTFPs in nonindustrial private forests provide incentives for landowners to manage their forests as healthy ecosystems. Well managed forests, can be more profitable and more resilient to potential impacts of climate change.

Forest farming—Forest farming has been suggested as a conservation strategy for wild-harvested NTFPs. Forest farming near canopy gaps may be more effective than growing NTFPs in more dense shade for some medicinal plants (Gillespie et al. 2006) which, while shade tolerant, can also make use of full sun (Vasseur and Gagnon 1994). The intentional cultivation of some vulnerable NTFPs may reduce pressure on native populations (Burkhart 2011) while potentially reintroducing species in areas where they have been extirpated (Boothroyd-Roberts et al. 2013).

Prescribed burning—Land managers may respond to the risk of increased wildfires by instituting prescribed fire plans. Prescribed fire may be useful to both forest health and the furnishing of ecosystem services, as well as production of NTFPs. The cessation of historic disturbance regimes, including fire (Farnsworth and Ogurcak 2006, Sinclair and Catling 2004, Van Sambeek et al. 1997), have likely contributed to the decline of certain NTFP species, especially in the Ozark region of Missouri. In oak-hickory forests, soil fertility and disturbance increase with long-term, low-severity fires (Scharenbroch et al. 2012). Generally, understory floristic diversity displays neutral or positive net effects from low residency time dormant season burns, as this can be significantly closer to historic fire regimes (Van Sambeek et al. 1997). Fire plans should be adapted to the regional context (Ray et al. 2012), and can be tailored to support particular populations of NTFP species (Storm and Shebitz 2006).

Assisted migration—In the case of valuable NTFP species with wide ranges throughout the Midwest such as American Ginseng, local populations are adapted to present local climatic conditions. If local climatic conditions change more rapidly than the species can adapt, lower fitness could be a result (Souther and McGraw 2014b). Assisted migration may be the best way to secure some species in the medium term (Svenning et al. 2009). Productive wild rice habitat is already available north of its current range in Saskatchewan, so production could shift (Weichel and Archibold 1989). Some NTFP species might be coplanted as crops in tree plantations, making use of favorable niche characteristics which can be created by plantations (Boothroyd-Roberts et al. 2013; Lugo 1997). Assisted migration of goldenseal and other NTFPs found throughout the Midwest region should aim to maintain genetic diversity within populations and promote gene flow between populations. Experimentation with assisted migration of some tree species is already occurring in parts of northern Minnesota with the pilot Adaptation Forestry Project[4].

Limitations

While there are opportunities for sustainable management of NTFPs there are many limitations, not least of which is the limited knowledge and research on the cultivation and management of these species. There are very few studies on the ecology of most NTFPs. Also, for many NTFPs there is also a lack of market maturity, incentives, and extension resources to support and promote effective management. Efforts to regulate and monitor harvesting would require legislative and enforcement coordination between Federal entities and across the many states of the region.

Further, just as the full potential impact of climate change-induced threats remains uncertain, other unknowns such the introduction of new or the expansion of existing invasive species and diseases or the possibility of increased future demand and harvest pressure, may also limit the potential to sustainably manage NTFPs in the region.

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Great Plains

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Description of Region

The Great Plains region lies in the central portion of the United States and stretches from Canada to northern Texas. However, there are no distinct regional boundaries for the Great Plains (Rossum and Lavin 2000). Boundaries defining the Great Plains typically are defined by physical characteristics, cultural characteristics, or some combination thereof. One of the more widely accepted regional delineations takes into account ecology, geology, history, and culture Wishart (2004) (figure A1.4). According to Wishart, the Great Plains includes the entire states of North Dakota, South Dakota, Nebraska and Kansas, as well as eastern portions of Montana, Wyoming, Colorado, and New Mexico. Western Oklahoma and northwestern Texas are also included.

The Great Plains region is vast, incorporating grasslands more than 1,800 miles north to south and 500 miles east to west (Center for Great Plains Studies 2016). At one time the region was considered a desert but now, more appropriately, it is thought to be a fertile, semi-arid grassland with great biodiversity. Altitude ranges from 2,000 feet above sea level (fasl) to about 5,000 fasl. Annual rainfall ranges from 10 to 20 inches, which contributes to a climate of harsh extremes with little topsoil.

Determining precise distribution of land ownership for the region is challenging as it does not strictly follow state or county borders. A rough estimate

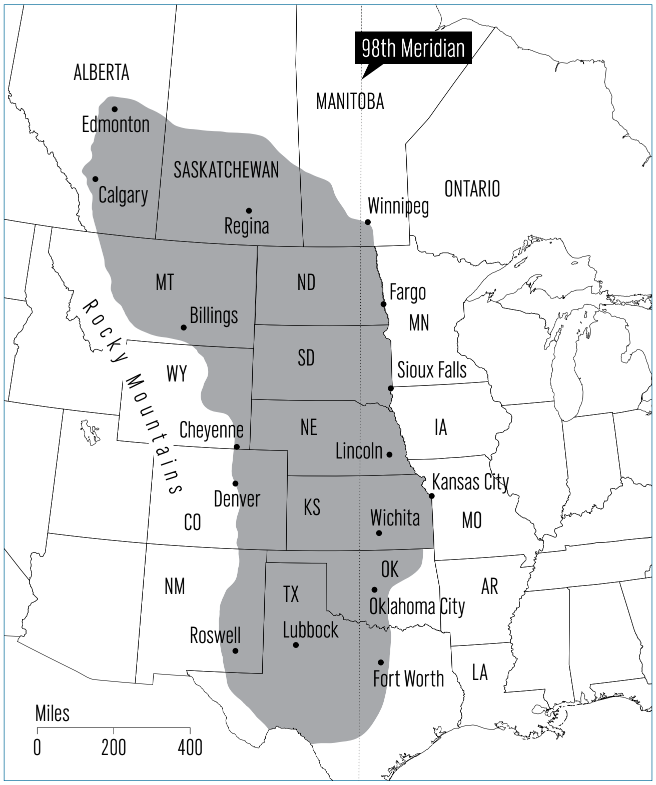

Figure A1.4—The Great Plains region (gray shading). (Source: Wishart 2004.)

can be obtained by overlaying a regional map on a nationwide map of nonprivate land ownership (U.S. Geological Survey 2012). About 85 percent of the land is in private ownership. The remaining land is split between Federal (7 percent), state or local government (~4 percent), and tribal lands (~ 4 percent).

Predominant Vegetation

The natural vegetation of the Great Plains is dominated by grasses. Tall and medium grass prairie dominates the eastern portion, while shortgrass and bunchgrass steppes are found in the west. In marginal areas larger plants such as yucca (*Yucca* spp.) and plains pricklypear (*Opuntia polyacantha* Haw.) are found. Shrubs, such as sagebrush (*Artemisia* spp.), western snowberry (*Symphoricarpos occidentalis* Hook), and rubber rabbitbrush (*Ericameria nauseosa* Pall. Ex Pursch) G.L. Nesom & Baird) can be found in marginal sites, as well. Also found in marginal sites are small trees (e.g., mesquite: *Prosopis* sp.). Riparian areas and other moist sites may have drought-tolerant trees such as box elder (*Acer negundo* L.), cottonwood (*Populus deltoids* (W. Bartram) ex Marshall), and green ash (*Fraxinus pennsylvanica* Marshall). Ponderosa pine (*Pinus ponderosa* Lawson & Lawson) can be found on mountains of the Black Hills.

The natural vegetation, though, has changed drastically because of agriculture and grazing. While hundreds of Great Plains species have documented ethnobotanical uses (Kindscher 1989, 1992; Kerry 2010), only a few are traded commercially in significant volume.

American Indian Use of Great Plains Plants

Humans likely have inhabited the Great Plains region for tens of thousands of years (Wishart 2004). More than 30 distinct tribes are known to have inhabited the region since European settlement in North America (Lowie 1954). A common practice shared by all tribes was the gathering of native plants for food, medicine, religious rites and/or material culture. Kindscher et al. (1998) identified more than 200 native prairie species that were used for medicine by North American tribes. Few of these are traded commercially. The Oglala Sioux tribe frequently used herbs such as sage (*Artemisia* spp.), sweet flag (*Acorus calamus* L.), and alpine sweetgrass (*Hierochloe odorata* (L.) P. Beauv.; not to be confused with *Muhlenbergia capillaris* (Lam.) Trin.) as medicine or for religious ceremonies (Morgan and Weedon 1990). The Blackfoot Indians utilized over 185 plant species, including small camas (*Camassia quamash* (Pursh) Greene) and prairie turnip (*Pediomelum esculentum* (Pursh) Rydb.), which comprised a large portion of their diet (Johnston 1970). The northern Cheyenne Indians recognized at least 138 wild plant species, 45 of which were used as a food source (Hart 1981). Some of the more important edibles used by the Cheyenne were chokecherry (*Prunus virginiana* L.), prairie turnip, milkweed (*Asclepias speciose* Torr.), and thistle (*Cirsium edule* Nutt.). Red baneberry (*Actaea rubra* (Aiton) Willd.) was frequently used in religious ceremonies. Like many of the other plains tribes, the Plains Apache diet included prairie turnips as well as groundnuts (*Apios Americana* Medik.) (Jordan 2014). The use of medicinal plants was also a very important part of the Apache culture and included such species as buffalo gourd (*Cucurbita foetidissima* Kunth), dodder (*Cuscuta foetidissima* Kunth.), purple coneflower (*Echinacea angustifolia* DC), bush morning-glory (*Ipomoea leptophylla* Torr.), puccoon (*Lithospermum incisum* Lehm.), star milkvine (*Matelea biflora* (Raf. Woodson), oaks (*Quercus* spp.), goldenrods (*Solidago* spp.), and American germander (*Teucrium canadense*). Various tree species were also used for fire and cultural materials. Blackjack oak (*Quercus marilandica* Münchh) was a favorite for cooking meat and the wood of Osage-orange (*Maclura pomifera* (Raf.) C.K. Schneid.) was preferred for making hunting bows.

For centuries, purple coneflower has been the most widely used medicinal plant of the Plains Indians in North America (Kindscher 1989, 1992). Tribes used this abundant prairie plant to treat many ailments. The Dakota used the root to treat hydrophobia (rabies), snakebites and putrefied wounds (Smith 1928). The Lakota used the root and green fruit as a painkiller for toothaches, tonsillitis, bellyache, pain in the bowels, or when they were thirsty or perspiring (Munson 1981, Rogers 1980). The Omaha used it for sore eyes and as a local anesthetic (Gilmore 1913). Both the Kiowa and the Cheyenne chewed on the root to relieve cold symptoms and sore throats (Grinnell 1962). The Kiowa also used the dried seedhead as a brush (Vestal and Schultes 1939). The Cheyenne used purple coneflower for sore mouth and gums, toothaches, and neck pain. They also made a tea to treat rheumatism, arthritis, mumps, and measles, as well as a salve for external treatment of these ailments (Grinnell 1962).

Prairie turnip was a staple food of the Plains tribes. The taproot of this perennial plant is harvested in June and July and consumed or stored for later. Groundnut produces an edible root, and is native to the prairie and Eastern woodlands. Although Jerusalem artichoke (*Helianthus tuberosus* L.) is cultivated around the world, the perennial sunflower produces an edible tuber that can be foraged from natural populations. Chokecherry (*Prunus virginiana*) was the most important edible wild fruit of the Plains, and is easily grown in home gardens. American plum (*Prunus Americana* Marshall) remains popular with residents of the Plains.

The taproot of purple coneflower is perhaps the most extensively commercialized Great Plains NTFP. Hayden (1859) first documented that the plant was found abundantly throughout the region and the root was effectively used by traders and Indians for the cure of rattlesnake bite. More recent research has shown that *E. angustifolia* has active medicinal constituents (Bonadeo et al. 1971, Moring 1984, Percival 2000, Stoll et al. 1950, Wagner and Proksch 1985).

Climate Change

The High Plains Regional Climate Center, based at the University of Nebraska, Lincoln campus, covers a six-state region that encompasses much of the Great Plains. The Center has access to climate records for the Great Plains that date back over 100 years that reveal variability and trends in climate (High Plains Regional Climate Center 2013). Over the last 118 years, the average annual temperature of the region has realized a warming trend of nearly 2 °F. The greatest increase in temperature has been in North Dakota (~ 2.9 °F), while the least was realized in Kansas and Nebraska (~1.3 °F). Precipitation trends are weaker, exhibiting only a 1.3-percent increase across the region.

Changes in temperature and rainfall regimes will have dramatic effects on crops as well as native plants. Changes in crop growth cycles have already been observed (Shafer et al. 2014) and provide insights into possible effects on native plants. Crops, as well as native plants, that leave dormancy earlier are susceptible to spring freezes (NOAA and USDA 2008). Dunnell and Travers (2011) examined flowering phenology patterns of 178 native plant species in North Dakota over 100 years and found significant shifts in more than 40 percent of the species. Species may be more or less sensitive to changes in temperature and precipitation, yet even small shifts in timing can disrupt ecological balance in natural systems.

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Northeast

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Nontimber forest products (NTFPs) are gathered throughout the Northeast region, for use as food, medicine, craft materials, and serve myriad cultural and spiritual purposes. No complete inventory of NTFPs exists for the Northeast, and the amount and types of NTFPs harvested vary across the region. Recent studies have documented the contemporary use of at least 173 vascular plants and 39 fungi in the Green Mountain and Finger Lakes National Forests of Vermont and New York (Emery and Ginger 2014), and 125 plants and fungi in northern Maine (Baumflek et al. 2010). Many of these species are gathered for multiple plant parts and multiple uses.

Forest Types and Land Ownership Characteristics

Three main forest types and their associated natural communities cover most of the region: spruce-fir forests thrive in the northern part of the region, as well as in higher altitudes further south; northern hardwood forests including sugar maple, American beech, and yellow birch, are prevalent in the central portion of the region; and oak-hickory forests are more common in the southern part of the region (figure A1.5). This diversity of forested landscapes provides varied habitat for different NTFPs.

Forest land ownership in the Northeast is predominantly private, which can impact access for NTFP gathering (Ginger et al. 2012). Most private forest land is owned by individuals and families, although Maine and West Virginia also support large industrial forestry operations (Nelson et al. 2010). Between 1993 and 2006, the region's nonindustrial private forests have become increasingly parcelized, as evidenced by a significant increase in forest landowners who own 1 to 9 acres of land, and a 20-percent decrease in family-forest landholding size from 25 to 20 acres (Butler and Ma 2011).

Diverse Nontimber Forest Product Users of the Northeast

The Northeast region is located on the homelands of many different native communities, including 18 federally recognized tribes that have distinct nation-to-nation relationships with the United States Government (Bureau of Indian Affairs 2014), 15 state-recognized tribes (National Conference of State Legislatures 2014),

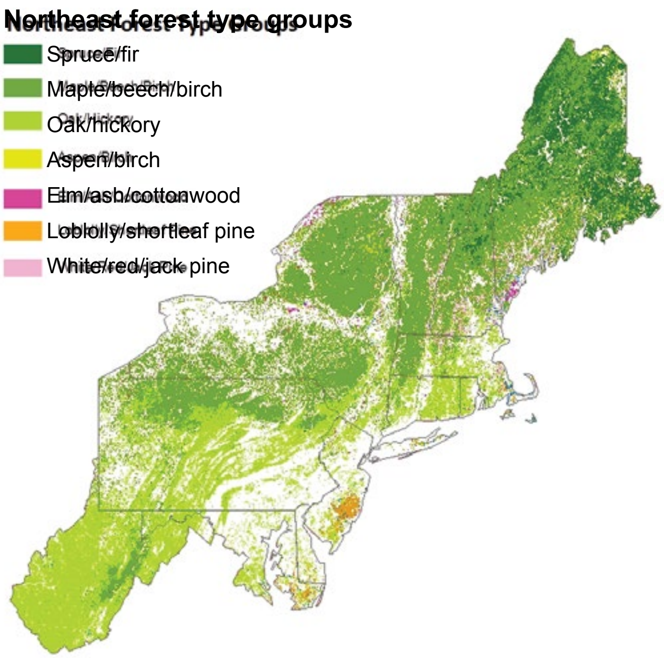

Figure A1.5—Forest type groups of the Northeast. The three dominant forest types of the region from north to south are the spruce-fir group, the maple-beech-birch group, and the oak-hickory group. (Map rendered by Michelle J. Baumflek, U.S. Department of Agriculture, Forest Service.)

and other communities that maintain a native identity despite lack of governmentally acknowledged status. NTFPs play important cultural and livelihood roles within these diverse communities. The traditional significance of hundreds of NTFPs as sources of medicine, food, spiritual importance, and livelihoods has been documented for many tribes in the region, including the Haudenosaunee, comprised of the Cayuga, Mohawk, Oneida, Onondaga, Seneca, and Tuscarora Nations (Herrick 1995, Parker 1910); the Mohegans (Tantaquidgeon 1928), the Wabanaki, the Maliseet, Mi'kmaq, Passamaquoddy, and Penobscot Nations (Prins and McBride 2007, Speck 1915), and the Shinnecock Indian Nation (Carr and Westey 1945). Furthermore, NTFPs contribute to tribal food and health sovereignty in the region (Baumflek 2015).

NTFP collection and use in the Northeast also is a widespread and popular activity that cuts across sociodemographic categories and rural to urban gradients (Robbins et al. 2008). A general population survey in New England states found that 25 percent of respondents had harvested some type of NTFP in the last 5 years. Most harvesters collect for personal use and are motivated by noncommercial reasons including home-consumption, recreation, spiritual, and familial traditions (Robbins et al. 2008). Qualitative research with plant gatherers in Maine, New York, and Vermont demonstrate similar findings (Baumflek et al. 2010, Emery and Ginger 2014). Furthermore, Bailey (1999) found that 25 percent of West Virginians surveyed reported gathering edible NTFPs, and 4 percent had gathered medicinal NTFPs.

An emerging body of research has begun to demonstrate the importance of NTFPs gathered in urban and suburban areas of the Northeast (Hurley et al. 2015, Jahnige 2002, McLain et al. 2014). These plants and fungi are mainly used for edible purposes, and are harvested in a variety of spaces including greenways, parks, vacant lots, and cemeteries. Ururban NTFPs play key roles for culturally-distinct user groups, including Chinese immigrants.[5]

Major Nontimber Forest Product Markets of the Northeast

While many NTFPs are gathered in small quantities for personal use, some enter formal and informal markets as raw materials or as value-added products, such as jams, tinctures, and wreaths. These products contribute to regional, household, and individual economies. NTFPs diversify household earnings by providing sources of income that supplement full-time jobs, deliver seasonal funds to fill gaps between other types of employment, and offer flexibility to people who have constraints on their time, including child and elder care (Baumflek et al. 2010, Emery et al. 2003).

Edible NTFPs in the region include maple syrup, fiddleheads from ostrich ferns (*Matteuccia struthiopteris* (L.) Todaro), wild leeks (*Allium tricoccum* Aiton), black walnuts (*Juglans nigra* L), berries and chanterelle mushrooms (*Cantherellus sp.*) (Alexander et al. 2011, Baumflek et al. 2010; Emery and Ginger 2014). These edible NTFPs enter local, regional, and national markets, and are commonly gathered for personal use. Freshly picked mushrooms such as chanterelles, oyster mushrooms, and morels appear seasonally in farmers' markets and restaurants (Emery and Ginger 2014). Fiddleheads are a welcome spring vegetable, and an important source of income in New England (Fuller 2012). As many as 100,000 pounds of fiddleheads may be harvested annually and appear for sale at roadside stands, grocery stores, and may be shipped across the

[5] Hurley, P.T.; Emery M.R. 2014. (Unpublished data). Forageable species and uses of New York City's urban forest.

country. The Northeast also leads the Nation in maple syrup production (Farrell and Chabot 2012). Vermont currently produces the greatest volume of syrup, while New York and Pennsylvania have the highest production potential (Farrell and Chabot 2012).

Medicinal plants such as American ginseng (*Panax quinquefolius* L.), goldenseal (*Hydrastis canadensis* L.), and black cohosh (*Actaea racemosa* L.) support significant national and international markets (AHPA 2006). Ginseng is one of the best understood NTFPs of northeastern forests due to its long history of harvest for export and considerable market value: between 2000 and 2007, primary buyers paid gatherers an average of $462 for a pound of dried roots. Harvest data for ginseng are available for the five northeastern states that are allowed to export the roots: Maryland, New York, Pennsylvania, Vermont, and West Virginia (Chamberlain et al. 2013). While ginseng has the potential for economic gains under a variety of forest farming scenarios (Davis and Persons 2014), Burkart and Jacobson (2009) found that it is only cost effective to harvest other popular medicinals from naturally occurring populations.

Craft plants include those used for basketry and wreaths. Black ash (*Fraxinus nigra* L.), alpine sweetgrass (*Hierochloe odorata* (L.) P. Beauv), and paper birch (*Betula papyrifera* Marshall) have special significance to American Indian gatherers as well as other artisans in the region who use these plants to construct baskets and other items that support their cultures and livelihoods (McBride 1990, Mundell et al. 2008), variety of conifers, clubmoss species, red osier dogwood (*Cornus sericea)*, and grape vines (*Vitis* spp.) are commonly harvested for wreaths. Balsam fir (*Abies balsamea*) harvests support local cottage industries as well as regional demand for boughs (Baumflek et al. 2010).

Ecological and Stewardship Considerations

As in many other regions, systematic data on the ecology and harvest volumes for most NTFPs are scarce in the Northeast (Alexander et al. 2011, McLain and Jones 2005). The most detailed information likely exists for American ginseng, wild blueberries, and maple syrup. With the exception of several wild-simulated medicinal plants such as American ginseng, and a burgeoning shitake mushroom market, most NTFPs in the region are gathered from populations of wild plants. Systematic studies on plant range and ecological sustainability of harvest are lacking for some of the most widely collected species, including wild leeks and fiddleheads. Paucity of information, combined with harvests that include plant parts known to reduce population fitness if not done appropriately (including bulbs and fronds), have caused Emery and Ginger (2014) to identify wild leeks, fiddleheads, alpine sweetgrass, and black ash as northeastern NTFPs in specific need of future research to determine if active management is appropriate.

Gathering NTFPs often involves respectful stewardship practices, developed over time, involving acknowledgment of reciprocal relations with plants and fungi, and based on traditional knowledge (Kimmerer 2011). American Indian NTFP gatherers in the Northeast currently implement a wide variety of stewardship practices that often are grounded in cultural norms (Baumflek 2015). Similar stewardship practices are also evident among other cultural and ethnic groups within the region (Baumflek et al. 2010, Emery and Ginger 2014). Systematically collected data on stewardship of ginseng (Burkhart et al. 2012), and wild mushrooms (Barron and Emery 2012) have also been obtained for the region. Because local NTFP gatherers have detailed knowledge about NTFP phenologies, ecologies, and habitat characteristics, their knowledge can and should contribute to participatory management planning for NTFPs.

Several major forest health threats with implications for NTFPs exist in the Northeast. Of primary concern to American Indian and other basketmakers in the region is the spread of the emerald ash borer (EAB; *Agrilus planipennis* Fairmaire), an introduced beetle that causes mortality in all ash species (Herms and McCullough 2014). Insect and disease outbreaks, such as hemlock woolly adelgid (*Adelges tsugae* Annand), and beech bark disease (fungi of the genus *Neonectria* in combination with the beech scale insect, [*Cryptococcus fagisuga* Lindinger]) threaten major tree species of northeastern forests. In these examples the eastern hemlock and American beech not only generate important NTFPs including beechnuts, but their loss may result in dramatically altered canopies and increases in forest light availability, which could be detrimental to certain NTFP species that thrive in low-light understories (Roberts and Gilliam 2003). Forest stressors including invasive earthworm species, and white-tailed deer (*Odocoileus virginianus* Zimmermann) overbrowsing may also impact the ability of certain NTFP species to establish or regenerate in many Northeastern forests (Dobson and Blossey 2015, Frelich et al. 2006).

Effects of Climate Change on Northeastern Nontimber Forest Products

Existing social and ecological stressors to NTFP availability in the Northeast may be exacerbated by climate change. Average annual temperatures in the region have risen by 2 °F since 1970; average winter temperatures have risen by 4 °F. Warming has already led to changes including a reduced snowpack, earlier breakup of winter ice, and earlier spring snowmelt resulting in earlier peak river flows (Rustad et al. 2009). These shifts may affect the phenology and availability of NTFP species such as fiddleheads that respond to water conditions. Furthermore, spread of forest pests, including EAB, may be accelerated due to warmer winter temperatures that are predicted in the region (Crosthwaite et al. 2011). Warming temperatures also may be detrimental to locally adapted NTFPs with limited seed-dispersal ranges, such as ginseng (Souther and McGraw 2011, 2014). Climate change impacts are also predicted to reduce suitable habitat for spruce-fir forests, as well as some northern hardwood species, including sugar maple (Iverson et al. 2008, Skinner et al. 2010, Vose et al. 2012). By limiting access to NTFPs used as traditional foods, climate change is predicted to have significant negative impacts on American Indian communities in the Northeast (Lynn et al. 2013).

Access and Management of Nontimber Forest Products on Public and Private Lands of the Northeast

Opportunities to gather NTFPs on public lands exist in national forests, state forests, and other state-owned lands. Many of these activities, such as gathering berries, are allowed on a limited basis, although monitoring and enforcement are challenges. Permitting is used to regulate the harvest of commercially important or vulnerable species. For example, the Monongahela National Forest in West Virginia is the only Federal land in the Northeast that permits ginseng harvesting (USDA Forest Service 2016). State entities, such as the Pennsylvania Bureau of Forestry, also enforce a moratorium on ginseng harvests, and district foresters issue limited permits for goldenseal, and rare clubmoss (*Lycopodium obscurum* L) (Pennsylvania Bureau of Forestry 2003). Several major cities in the region, including Boston and New York have bans on harvesting NTFPs in urban parks (City of Boston Park 2014, Foderaro 2011, NYC Administrative Code 2014), while other cities like Philadelphia promote fruit picking from trees in public spaces (McLain et al. 2014).

Specific considerations for access to NTFPs on Federal lands exist for American Indians in the region, who have established nation-to-nation relationships with the U.S. Government. This applies to national forests in the region that must honor treaty obligations related to NTFP regulations and permits (Emery and Ginger 2014). In some instances, the American Indian Religious Freedom Act (1978) may also apply to NTFPs used for religious purposes. The National Park Service recently proposed a regulation change to Title 36 of the Code of Federal Regulations (see chapter 7) that would allow American Indians to gather plants in the national parks they are historically associated with (Federal Register 2015). In the Northeast, this means that members of the four Wabanaki tribes of Maine may be allowed to gather plants in Acadia National Park for noncommercial purposes. The state of Maine also issues permits to Wabanaki gatherers to harvest black ash logs (Ginger et al. 2012).

Gathering on private lands are negotiated by formal and informal agreements (Ginger et al. 2012). Industrial forest managers in Maine revealed that NTFPs are not typically included in forest planning, with the exceptions of maple syrup and balsam fir permitting (Ginger et al. 2012). However, certain industrial forest products corporations are interested in allowing American Indians access to harvest culturally significant species as part of Forest Stewardship Certification compliance, which requires establishing relationships with local indigenous communities (Ginger et al. 2012).

Many Northeastern family-forest landowners cite reasons of aesthetics and privacy for owning forest land, although Butler and Ma (2011) found an increase in people choosing to own forests as financial investments. The relatively small size of average forest land holdings in the region, from 6 acres in Massachusetts to 36 acres in Vermont (Butler and Ma 2011), accompanied by the idea that private forest landowners adopt forest farming as a way to generate income without having to rely on timber sales (Chamberlain et al. 2009), suggests that these landowners may be interested in some form of NTFP management on their lands. For example, Strong and Jacobson (2006) found that 36 percent of the respondents in a survey of Pennsylvania landowners reported an interest in forest farming.

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Southeast

James L. Chamberlain

Introduction

The forests of the Southeast (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia) are biologically diverse and the source of many nontimber forest products (NTFPs) that are embedded in the region's culture and economy. The significant lack of data on most NTFPs does not reflect the tremendous number and diversity of products. There are a few NTFPs that demonstrate the importance of these products to the Southeast. To fully understand the social, ecological, and economic value of NTFPs it is important to examine them through various lenses. An ecoregional perspective portrays a cornucopia of biological diversity that interweaves to support diverse landscapes from coastal plains to high peaks. The forests of the region are vulnerable to changes in climate and other anthropogenic stressors, but the most immediate limitation to realizing the tremendous potential of these resources and products is the lack of recognition that they are natural resources and require relative management actions.

Land Area in Nontimber Forest Product Production

Forests and products—The forest lands of the Southeast United States are expansive and diverse. The Southeast has nine ecoregions (figure A1.6) that encompass five geopolitical subregions (Bailey 1995, Wear et al. 2009). Examining the makeup of the forests provides insights into the diversity of nontimber forest products of the region. The Southeast has five major forest management types (Wear et al. 2009), and about 80 percent of this is in private ownership. About 20 percent of the total forest area is planted pine, while about 15 percent is considered natural pine forests. About 40 percent of the forests are upland hardwoods, which are the predominant forest type in the Southeast. Lowland hardwood forests account for about 16 percent of the total, while the oak-pine group accounts for about 4 percent.

The Appalachian-Cumberland subregion may the most biologically diverse area, represented by three distinct ecoregions that define the forests. The Central Appalachian Broadleaf Forest—Coniferous Forest—

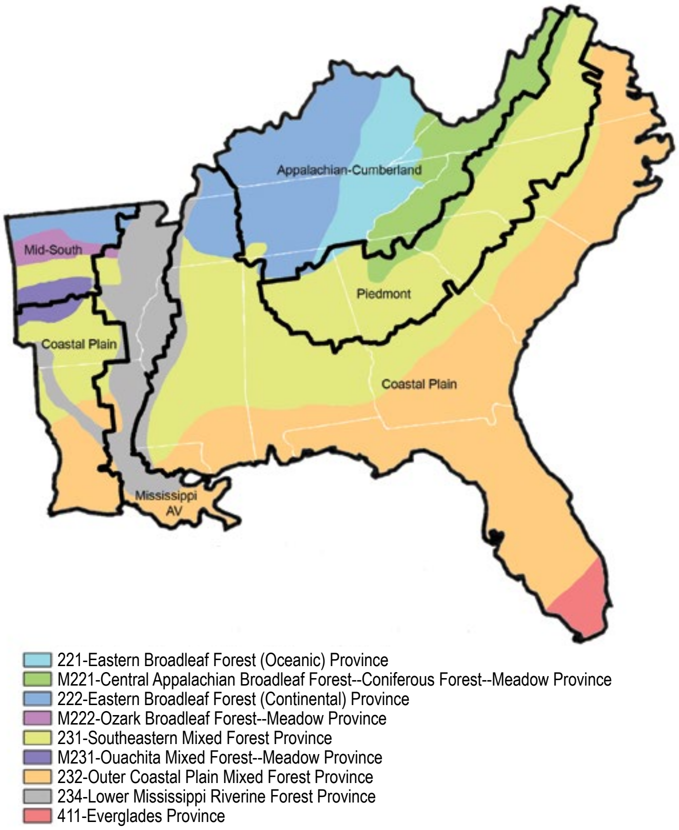

Figure A1.6—Ecoregions of the Southeast. (Source: Adapted from Bailey 1995 and Wear et al. 2009)

Meadow Province extends along the mountain ranges to the west of the Piedmont, from north Georgia north and east through North Carolina and Virginia. To the west of this ecoregion is the Eastern Broadleaf Forest (Oceanic) Province, which extends through eastern Kentucky, the tip of southwestern Virginia, eastern Tennessee and small portions of Georgia, and Alabama. The Eastern Broadleaf Forest (Continental) Province covers much of the western portion of the Appalachian-Cumberland subregion, through central and western Kentucky, Tennessee, and into northern Alabama and Arkansas.

The Cumberland Mountains in this subregion are known for high biological diversity and are considered the center of the mixed mesophytic vegetation type (Keyser et al. 2014). The mixed mesophytic forests are the sources of American ginseng (*Panax quinquefolius* L) and many other medicinal forest products that are in commerce (table A1.3). More than 469,000 pounds of dried American ginseng root were harvested from the forests of seven southeastern states, from 2000 through 2013 (figure 2.2). The national forests in Georgia, Kentucky, North Carolina, and Tennessee accounted for 31 to 35 percent of the total value of American ginseng harvest reported from those states, from 2009 to 2013.

There are many other nontimber forest products from these forests that are ecologically and economically important to the region. For example, galax (*Galax urceolata* (Poir) Brummitt), is an herbaceous groundcover with glossy green leathery, heart-shaped leaves that are harvested for the floral industry (Predny and Chamberlain 2005). Most of the harvest occurs on Federal lands (Greenfield and Davis 2003), and as national forest and national park lands adjoin, management and controlling poaching are challenging. Ramps (*Allium tricoccum* Aiton) are spring ephemeral herbs native to mixed-mesophytic forests with rich moist soils most often found on north-facing slopes. Most harvesting was for personal use until the mid-20th century when community groups started organizing ramp festivals as a source of revenue to support local needs. By the end of that century commercial demand had grown enough to draw concerns for the long-term conservation of the plant. Ramps are a cultural icon for many rural people of the Appalachian-Cumberland region. Other edible forest products of this subregion include wild-harvested black walnuts, mushrooms, and maple syrup.

The Piedmont section of the Southeast is predominantly the Southern Mixed Forest Province and stretches from northern Virginia through North and South Carolina, Georgia, Alabama, Mississippi, northern Louisiana, and southern Arkansas (Bailey 1995, Rummer and Haffer 2014, Wear et al. 2009). Naval stores and other pine products were, at one time, major products from Piedmont forests. The Piedmont forests are sources of native NTFP species such as black cohosh (*Actaea racemose*), bloodroot (*Sanguinaria canadensis*), jack in the pulpit (*Arisaema triphyllum* L.), joe pye weed (*Eutrochium* spp. Raf.), mayapple (*Podophyllum peltatum* L.), and wild ginger (*Asarum canadense* L.), although they are probably not harvested in this region. Tree species native to the Piedmont and valued for their nontimber products, include pawpaw (*Asimina triloba* (L.) Dunal), sassafras (*Sassafras albidum* (Nutt.) Nees), sugar maple (*Acer saccharum*), sweetgum (*Liquidambar styraciflua* L.), and tulip poplar (*Liriodendron tulipifera*; also commonly known as yellow-poplar). Many of these are found throughout the region as well as other subregions.

Table A1.3—Average annual harvest of medicinal forest products tracked by American Herbal Products Association and found in southeastern forests. Sources: AHPA 2012, Chamberlain et al. 2013.

Latin name	Common name	Plant part	Average annual harvest[a] 2001–2005	Average annual harvest[a] 2006–2010	Percent change
Actaea racemosa	Black cohosh	Root	224,072	284,162	26.8
Aletris farinosa	White colicroot	Root	1,012	690	-31.9
Aristolochia serpentaria	Virginia snakeroot	Root	121	43	-64.2
Caulophyllum thalictroides	Blue cohosh	Root	6,651	5,169	-22.3
Chamaelirium luteum	Fairywand	Root	4,688	4,541	-3.1
Cypripedium spp.	Lady's slipper	Whole plant	51	48	-4.3
Dioscorea villosa	Wild yam	Tuber	33,422	37,692	12.8
Hydrastis canadensis	Goldenseal	Root and leaf	73,619	74,708	1.5
Panax quinquefolius	American ginseng	Root	62,294	63,461	2.0
Sanguinaria canadensis	Bloodroot	Root	24,823	5,056	-79.6
Serenoa repens	Saw palmetto	Fruit	3,293,377	2,432,841	-26.1
Trillium erectum	Red trillium	Whole plant	1,099	1,445	31.5
Ulmus rubra	Slippery elm	Bark	182,435	304,207	66.7

[a] Average annual wild harvest (pounds dry weight) for 5-year periods.

The Coastal Plains subregion of the Southeast is defined by Outer Coastal Plains Mixed Province and extends from tidewater of Virginia through North and South Carolina, Georgia, most of Florida, the southern portion of Alabama and Mississippi, and into Louisiana (Bailey 1995, Klepzig et al. 2014). Sparse open canopied pine stands with dense understory of herbaceous plants cover much of the Coastal Plains. Prior to European settlement, the pine forests of the Coastal Plains were made up of a few species, most notably longleaf pine. In much of the North and South Carolina region, there is a long history of using sweetgrass (*Muhlenbergia filipes, M. sericea* or *M. capillaris*) for baskets.

By the early 20th century, the longleaf pine forest ecosystem was basically extirpated. Two centuries earlier, there was a vibrant economy based on the nontimber values of longleaf pine. In the late 1700s, naval stores from naturally regenerated longleaf pine forests were the colony's most important industry (Walbert 2015). North Carolina was producing more than 70 percent of the pine tar exported from North America, and half of the turpentine, by the 1770s. Today, other NTFPs from pines, particularly pine straw, which is a major nursery and landscape forest product, are prominent. The long slender needles of longleaf pine are preferred, though "straw" is harvested from other pine trees as well. Production figures on pine straw suggest that it is of significant importance to some states (Harper et al. 2009), though data are not readily available making assertions for the entire region challenging.

Saw palmetto (*Serenoa repens*) is the other major NTFP of the Coastal Plains. The fruit of saw palmetto, a short palm with sawlike teeth, and ubiquitous to low pine and savanna forests is harvested for its medicinal properties. The palm is endemic to the Coastal Plains region, from South Carolina to southeastern Louisiana, including most of Florida. The palm is a common understory shrub in coastal stands and oak-pine communities (Duever 2011). Total estimated harvest volume of saw palmetto for 1997 through 2010 was 38.3 million dried pounds (AHPA 2012), or an average annual harvest of 2.7 million pounds.

The Coastal Plains forests are the sources of other NTFPs, though much less is known about them. For example, Spanish moss (*Tillandsia usneoides* (L) L), harvested from forests of Coastal Plains states, is readily available over the Internet. There are ready and vibrant markets for cones (green and dry) for forest regeneration and for fine arts and crafts. Other ferns and plant parts, such as shrub branches from crooked-wood (*Lyonia ferruginea* (Walter) Nutt), are harvested for use in the floral industry.

The Lower Mississippi Riverine Forest Province, as defined by Bailey (1995) and that once covered most of the Mississippi Alluvial Valley subregion, has changed so much that only remnants of the Province can be found. Prior to most of it being converted to agricultural lands, this was a vast forest of bottom-land deciduous trees. A few species identified that are harvested for their nontimber values include giant cane (*Arundo donax* L.), pawpaw, common persimmon (*Diospyros virginiana* L.), eastern redcedar (*Juniperus virginiana* L.), sweetgum, red mulberry (*Morus rubra* L.), and sassafras. Muscadine grapes (*Vitis rotundifolia* Michx.), blackberries (*Rubus* spp.), and other edible forest products are found in forests of the Mississippi Alluvial Valley. Spanish moss grows in the canopy and may be collected for its decorative properties.

The Mid-South subregion is comprised of three ecoregions in Arkansas. Parts of this subregion, especially the northern third, are the source of American ginseng and other medicinal forest products. As biological diversity of this region declines the number of NTFPs are fewer.

National forests of the Southeast—Federal ownership controls less than 20 percent of the forest lands in the Southeast, and these forests are the sources and refugia of many NTFPs. The national parks and other protected areas are the last refuge for many of the plants and fungi harvested for nontimber values. They harbor the genepool that ensures the resiliency of NTFP resources. The national forests have multiple roles in the protection and conservation of NTFPs. The management of NTFPs on national forests is guided by recent legislation (DOI appropriations 2000, 2004, 2008). The permitted harvest records from national forests of the Southeast provide another perspective of the importance of NTFPs in the region.

The units of measure for permitted NTFP harvests are not convertible to those used for timber, and as such comparing the two types of products is not possible (USDA Forest Service 2015). Over a 5-year period (table A1.4), ending in 2014, the national forests of the Southeast permitted the harvest of 800 cubic feet, 2.1 million pounds, 108,000 pieces, and 2,000 bushels of nontimber forest products. The national forests of Alabama reported the most "cubic feet" of "nonconvertible product", which were pine needles. The Ouachita National Forest in Arkansas reported tons of "other plant" products, which was converted to "pounds" for this summary and may distort those figures. The National Forests of North Carolina reported about 600,000 pounds of NTFPs that included foliage, herbs, roots, and vines. The leaves of galax are a major portion of the products reported as harvested for foliage. The Cherokee National Forest in Tennessee issued harvest permits for 24,000 "pieces" that were transplants (live plants dug from the forests for nursery and landscaping).

Revenues generated from NTFP harvest permits by the national forests (table A1.5) may be indicative of the total market value, but extrapolating total market value from these figures is problematic. Nonetheless, the national forests in the Southeast generated about $470,000 from issuance of harvest permits for NTFPs for the 5-year period ending in 2014. The National Forests of North Carolina were responsible for 70 percent of the total, while the National Forests of Florida accounted for about 12 percent. Most of the value realized by the National Forests of North Carolina came from the sale of foliage (e.g., galax leaves) and roots (e.g., American ginseng). About 80 percent of the value realized by National Forests of Florida was from the sale of limbs/boughs and foliage.

Other national forests generated revenues from the sale of NTFPs, though they did not add significantly, to the overall total. Even though, some national forests realized significant revenues from specific products. For example, the National Forests of Alabama generated nearly all of its NTFP revenues from the sale of needles. The Kisatchie National Forest in Louisiana generated nearly all of its NTFP revenues in 2010 from the sale of cones. The Daniel Boone National Forest (KY) and the Chattahoochee/Oconee (GA) have consistently generated about 80 percent of their NTFP revenues from the sale of roots over the last 5 years.

Threats and Challenges to Meeting Production

The production of NTFPs from the region's forests is vulnerable to changes caused by climate and other anthropogenic stressors. Urbanization, parcelization, and other development may lead to lose of critical habitats. Unmanaged harvesting pressures can lead to species extirpation, loss of genetic resources, and a decline in forest resiliency.

Table A1.4—Permitted harvest volumes of NTFPs from national forests (NFs) of the Southeast. Source: USDA Forest Service 2015.

State	National forest	Unit of measure	2010	2011	2012	2013	2014	Total
AL	NFs in Alabama	Cubic feet	80	220	83	344	63	**790**
		Pounds	2	2				**4**
KY	Daniel Boone	Pounds	554	1,060	443	515	452	**3,024**
GA	Chattahoochee/Oconee	Pieces	2,139	2,531	1,261	1,420	880	**8,231**
		Pounds	6,200	1,829	4,021	2,623	1,817	**16,490**
TN	Cherokee	Pieces	3,622	6,572	4,732	3,985	5,090	**24,001**
		Pounds	4,845	3,196	3,757	3,310	6,155	**21,263**
FL	NFs in Florida	Pieces	133	138				**271**
		pounds	138,698	135,711	95,610	59,399	85,795	**515,213**
LA	Kisatchie	Cubic feet	10					**10**
		Bushels	2,000	4	28	28		**2,060**
MS	NFs in Mississippi	Bushels	500	500	200	100	40	**1,340**
VA	GW & Jefferson	Pounds			20	20	8	**48**
AR	Ouachita	Pounds	230,000	230,000	282,000	90,000	50,000	**882,000**
AR	Ozark St. Francis[a]							
NC	NFs in N orth Carolina	Pieces	10,592	16,327	16,594	20,572	11,955	**76,040**
		Cubic feet					1	**1**
		Bushels		35				**35**
		Pounds	101,521	112,938	129,061	120,538	141,596	**605,654**
SC	Francis Marion	Pounds	12,000	6,000	14,000	8,000	14,000	**54,000**
TN/KY	Land Between the Lakes[a]							
	Totals	Cubic feet	90	220	83	344	64	**801**
		Pounds	493,820	490,736	528,912	284,405	299,823	**2,097,696**
		Pieces	16,486	25,568	22,587	25,977	17,925	**108,543**
		Bushels	2,000	39	28	28		**2,095**

[a] No permit harvest reports issued by these national forests.

The forests of Florida and other low lying areas in the Coastal Plains that dominate much of the Southeast, are especially vulnerable to changes in sea levels. This will reduce the habitat for important NTFPs such as saw palmetto that supplies the raw materials for herbal medicines used to treat prostate issues. Sweetgrass that grows in coastal forests of South Carolina would be directly affected by changes in sea levels, which will impact ethnic artisans that use the grass to make traditional baskets. Encroachment of sea levels into other low lying forests also could impact other habitats that are valuable for production of NTFPs.

Changes in climate will affect understory NTFPs in more biodiverse upland forests in the Southeast. Some temperate hardwood forests in the mountainous regions are high in biological diversity and many of the plants are sensitive to climate change. In particular, spring ephemeral herbs, such as ramps (a culinary onion), that grow on the forest floor are affected by small changes in temperature and moisture. Changes in soil dynamics may affect NTFPs that are harvested for their roots, such as American ginseng, and many other medicinal forest products. Changes in the understory composition and complexity will impact the biodiversity of the region, as well as forest health and resiliency.

The most immediate challenge to production of NTFPs is recognizing that these are natural resources of ecological and economic value, and require action to manage them like other natural resources. Many NTFPs are harvested for their roots, rhizomes, and the entire plant,

Table A1.5—Revenues from the permitted harvest of NTFPs from southeastern national forests (NFs). Source: USDA Forest Service 2015.

State	National forest	2010	2011	2012	2013	2014	Total	Total
		U.S. dollars						*percent*
AL	NFs in Alabama	880	1,840	830	830	630	5,010	1.1
KY	Daniel Boone	1,900	2,540	1,740	2,700	1,890	10,770	2.3
GA	Chattahoochee/ Oconee	2,043	1,275	2,610	4,105	855	10,888	2.3
TN	Cherokee	7,519	8,569	9,765	9,170	7,245	42,268	8.9
FL	NFs in Florida	15,226	14,350	9,258	9,056	9,818	57,706	12.2
LA	Kisatchie	10,100	20	182	182		10,484	2.2
MS	NFs in Mississippi	250	250	100	50	20	670	0.1
VA	GW & Jefferson			20	20	8	48	0.0
AR	Ouachita	115	115	141	180	125	676	0.1
AR	Ozark St. Francis[a]							
NC	NFs in North. Carolina	58,768	61,979	71,618	75,000	67,453	334,817	70.6
SC	Francis Marion	150	75	155	100	175	655	0.1
TN/KY	Land Between the Lakes[a]							
	Total	**96,950**	**91,013**	**96,418**	**101,393**	**88,219**	**473,992**	

[a] No permit revenues reported by these national forests.

which has direct impact on the populations' abilities to sustain and regenerate. This can have deleterious impacts on natural populations if done with disregard to the long-term effects. There is little information about the long-term impacts of harvesting NTFPs and how to manage them without detriment to natural populations. Sustainable management of NTFP resources requires more knowledge and the integration of that knowledge into forest management. The management of forests to include NTFPs is essential for health of the forests and the communities that depend on them for these products.

Potential and Limitations

The Southeast is referred to as the "wood basket" for the forest products industry, as the region is the source for most of the timber for the industry. Those same forests are the source of many other forest products, and many of those forests produce "green gold," a term of endearment for American ginseng because of the tremendous economic potential of this understory NTFP. The incredible biological diversity of the Southeast's forests means that there is great potential for them to be the source of many products for many uses. To realize this potential, we must address the greatest limitation, which is the lack of management of these resources, relative to their social, cultural, ecological, and economic importance.

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Caribbean

Sarah Workman

Introduction

As part of the Lesser Antillean archipelago, the U.S. Caribbean islands consist primarily of Puerto Rico and the U.S. Virgin Islands (USVI). There are six subtropical Holdridge Life Zones on the island of Puerto Rico (Ewel and Witmore 1973), representative of the USVI also (Woodbury and Weaver 2007), with diverse terrestrial, wetland, coastal, and marine ecosystems as well as agroforest and urban systems (Miller and Lugo 2009). The other U.S. Caribbean islands share a tropical maritime climate that has little annual variation in temperature and distinct seasonal rainfall, with a rugged topography in short distances from ocean to mountaintops. The predominant forest types are subtropical moist forest and dry forest with some lowland montane rainforest on Puerto Rico (Holdridge 1967). Natural vegetation in the Puerto Rico Province (M411) ecoregion includes orchids, vines, and grasses. South-facing xeric sites support thorn scrub (e.g., acacia), royal palm (*Roystonea regia* (Kunth) O.F.Cook), agave (*Agave* spp.), and cacti (Bailey 1995).

Puerto Rico is the largest island of a group of cays and islands that includes Mona, Monito, and Desecheo to the west and Culebra and Vieques to the east. Fifty-three percent of the island of Puerto Rico is mountainous (three ranges) with nearly 12 percent of the landscape in ridges, 25 percent in plains, and 20 percent hilly. Dry climatic conditions prevail on nearly 30 percent of the island and, of the 57 landscape units of the islands of Puerto Rico, the most abundant landforms are moist and wet slopes, primarily on volcanic soils (Puerto Rico DNER 2009, Gould et al. 2008, Martinuzzi et al. 2007). Puerto Rico consists of 49 percent forest, 33 percent agriculture/pasture, and 14 percent developed land. Private ownership comprises 82 percent of forests on Puerto Rico (Puerto Rico DNER 2009).

The USVI has three large islands, St. Croix, St. John, and St. Thomas, and includes nearby Water Island along with 68 smaller islands and cays. Most of the forested land is privately owned on the two larger islands (89 percent St. Croix, 94 percent St. Thomas) while 74 percent of St. John's forest is managed as the VI National Park. The topography is characterized by central mountain ranges and small coastal plains. The uplands are rocky, rugged slopes; 50 percent of St. Croix's land area contains slopes of 25 percent to 35 percent. Natural influences such as landslides, hurricanes-tropical storms, and fire are key to shaping the environment and the marine and terrestrial communities of the islands (Chakroff 2010).

Cultural Perspective

Understanding nontimber forest products (NTFPs), their uses, markets, and most importantly their ecology for their conservation and continued viability, is an important aspect of forest management (Chamberlain 2014, FAO 2010, IFCAE 1998, USDA Forest Service 2014). NTFPs are valued by people as resources for their health and well-being. As testament to their role in the economy and culture of the islands, over 500 native and introduced tree species are recognized as materials for arts, crafts, building components, or charcoal (FAO 2010, Kicliter 1997). Stewardship of NTFPs and awareness of needs for conservation of native plants harvested for commercial and personal use is important since island ecosystems, with limited biological buffering capacity, are especially vulnerable to change (Ewel et al. 2013). More than 165 commercial species of NTFPs are listed in the United States NTFP species database (IFCAE 1998) for Puerto Rico.

Most of the NTFPs collected or cultivated have traditions based on inherited knowledge and cultural identity from the many peoples who have immigrated to the islands. NTFPs are part of the region's history and have a long tradition of local and commercial benefits that include development of medicinal plants, arts and crafts materials, food, fibers, animal forage, resins, and oils (Acevedo-Rodriquez 1985; Robinson et al. 2014). Some local artisans are using native and other locally grown wood to produce musical instruments (Kicliter 1997) and materials for artisanal woodworking are important nontimber forest products.

Kicliter (1997) found a large variety of NTFPs used by artisans to make crafted items from forest materials (table A1.6). Wood carving, especially of native bird and animal species, has a rich history in Puerto Rico. Carved figures of saints or *santeros*, primarily from Spanish cedar and mahogany (*Swietenia* L. spp.), are renowned as folkart and traditional artistry. Kicliter (1997) noted that local artisans on Puerto Rico express concern about availability of the most commonly used species and note some problems of scarcity.

Across the islands, many NTFPs are valued for fibers and as components of crafts. Seeds, bark and other tree parts are used for items that vary from jewelry, nursery stock, and medicines (Jones 1995, Kicliter 1997, Petersen 1990, Thomas et al. 1997, van Andel 2006). Trees and woody plants in forest and woodland habitats important for bee-keeping and honey production help maintain pollinator populations and other ecosystem services, and provide material for value-added products such as mead, a novel product flavored with infusions of tropical fruits.

A number of trees and shrubs yield edible fruits (Aleman et al. 2005, Birdsey and Weaver 1982, Kicliter 1997, Little and Wadsworth 1999, Vila-Ruiz et al. 2014). Traditional varieties of fruits (e.g., indigenous fruits like guavaberry [*Myrciaria floribunda* (West ex Willd.) Berg] or avocado [*Persea americana* Mill. var. *americana*]) or mixtures of culinary crops under tree shade have cultural antecedents. Guamo (*Inga laurina* (Sw.) Willd.) or river koko (*Inga vera* Willd.) have provided shade for coffee plantings in Puerto Rico (Morgan and Zimmerman 2014, Birdsey and Weaver 1982). Many others, such as mango (*Mangifera indica* L.), coconut (*Cocos nucifera* L.), bananas and plantains (*Musa* spp.), sea or tropical almond (*Terminalia catappa* L.), tamarind (*Tamarindus indica* L.), and baobab trees (*Adansonia digitate* L.), were introduced from the Old World. Others were introduced from South America, such as the mamee apple (*Mammea Americana* L.), stinkingtoe or West Indian locust (*Hymenaea courbaril* L.), and Spanish lime (*Melicoccus bijugatus* Jacq.). References for the silvics (Francis et al. 2000), forest inventory (Brandeis and Turner 2013, FAO 2010), and flora of the islands (Acevedo-Rodriquez 1996, Little and Wadsworth 1999, Little et al. 1988) help clarify native, naturalized, and exotic status of species.

Seeds from more than 30 tree species (Kicliter 1997) are used for rosary beads and jewelry or other crafts. Other species are of note for charcoal or fence posts or fuelwood (Birdsey and Weaver 1982, Kicliter 1997). Harvesting bayrum (*Pimenta racemose* (Mill. J.W. Moore) leaves and berries to make perfume and cosmetics was a big industry on the island of St. John,

Table A1.6—Categories of items crafted from nontimber wood in Puerto Rico. Adapted from Kicliter 1997, p. 23.

Carving—general	
Carved saints	
Musical instruments	Wooden barrels for drums, bamboo, calabash, rods
Wood models and replicas	Boats, houses, toys, trays, facades, brooms, etc.
Images and scenes	Painted, wood relief
Turned wood	Balustrades, vases, bowls, cups, pens, etc.
Coconut	Sculpted heads, cups, flower planters, piggy banks, masks, earrings, bracelets, etc.
Calabash	Utensils, bowls ,etc.
Basket weaving	Vines
Other weaving	Palms, potato, hammocks, figures, hats, etc.
Jewelry	From wood, seeds
Other crafts from forest products	Stone sculptures, forest clay, wooden handles

USVI, from 1880 to 1950 (Weaver 2009). Fibers are used for hats, baskets, mats, brooms, and as thatch or Mauritius hemp (*Furcraea foetida* (L.) Haw.) for traditional hammocks (Kicliter 1997, van Andel 2006).

Medicinal plants play an important role in rural and traditional household life and are widely used in the islands (Kicliter 1997, Liogier 1990, Palada et al. 2005, Petersen 1990, Thomas et al. 1997). There are dozens if not hundreds of plants utilized traditionally for their curative properties. Examples include lignum-vitae (*Guaiacum officinale* L.) used to treat yaws, achiote (*Bixa orellana* L.) to treat headaches, chaneyroot (*Smilax coriacea* Spreng.) used as a tonic and stimulant, the plant of many applications worrywine (*Stachytarpheta jamaicensis* (L.) Vahl) as an anti-inflammatory, congo-root (*Petiveria alliacea* L.) for sinus congestion, and bayrum for essential oil and as a fragrance plant. Useful medicinal products are sought from the soursop (*Annona muricata* L.), the turpentine tree (*Bursera simaruba* (L.) Sarg.), the bloodwood or campeche (*Haematoxylum campechianum* L.), and many others. From bush tea herbs to stimulants and curatives, local plants and botanical products from forests may be cultivated and have both formal and informal markets.

The tropical islands are home to some of the world's most biologically diverse forest ecosystems—sources of a large variety of NTFPs. These forests have changed drastically since first contact with nonnative inhabitants. The potential impacts to tropical NTFPs from climate change and other stressors are tremendous. Increased catastrophic weather events may result in extirpation of habitats and species. Changes in temperature regimes may result in irreversible alterations in forest habitat that eliminate species. Livelihoods related to the tourist industry, a foundation for the economy, could suffer with loss of raw materials for fine arts and crafts.

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Appendix 2: Assessment of Risk Due to Climate Change

A variety of nontimber forest product (NTFP) species were selected to represent a range of taxa (e.g., tree, shrub) from different U.S. regions. Species that are presented in this appendix reflect an effort to compile and synthesize available information to construct risk matrices identifying the climate related stressors, threats, and vulnerability to the species as understood within the predictive capacity for different climate models.

Paper Birch (*Betula papyrifera* Marsh.)

Marla R. Emery and Louis Iverson

Nontimber Forest Products and Values

Paper birch bark is used by peoples from Alaska to Maine for personal, commercial, and traditional cultural purposes. Paper birch is a cultural keystone species for *Anishinaabe* (also referred to as Ojibwe or Chippewa) peoples of the Upper Midwest, for whom the tree plays a central role in cultural teachings and practices (Emery et al. 2014). Birch bark also is an important part of the cultural traditions of Americans with roots in Scandinavia and Russia (North House Folk School 2007, Yarrish et al. 2009). The many current and historical uses of paper birch bark include canoes, baskets, sheeting to cover structures, and writing media (Emery et al. 2014, Turner et al. 2009). These uses take advantage of the unique mechanical and chemical properties of birch bark, which is flexible but tough, has many separable layers, and contains compounds such as suberine and betuline, which make it highly flammable yet waterproof and retard decay of the bark and items stored in it (Krasutsky 2006). Unlike most tree species, the bark of paper birch can be harvested around the entire circumference of a tree without killing it, provided the cambium layer remains intact (Turner et al. 2009).

Ecology

In 1990, Safford et al. stated that the native range of paper birch:

> "closely follows the northern limit of tree growth from New Foundland and Labrador west across the continent into northwest Alaska; Southeast from Kodiak Island in Alaska to British Columbia and Washington; east in the mountains of Northeast Oregon, northern Idaho, and western Montana with scattered outliers in the northern Great Plains of Canada, Montana, North Dakota, the Black Hills of South Dakota, Wyoming, Nebraska, and the Front Range of Colorado; east in Minnesota and Iowa, through the Great Lakes region into New England. Paper birch also extends down the Appalachian Mountains from central New York to western North Carolina." (figure A2.1)

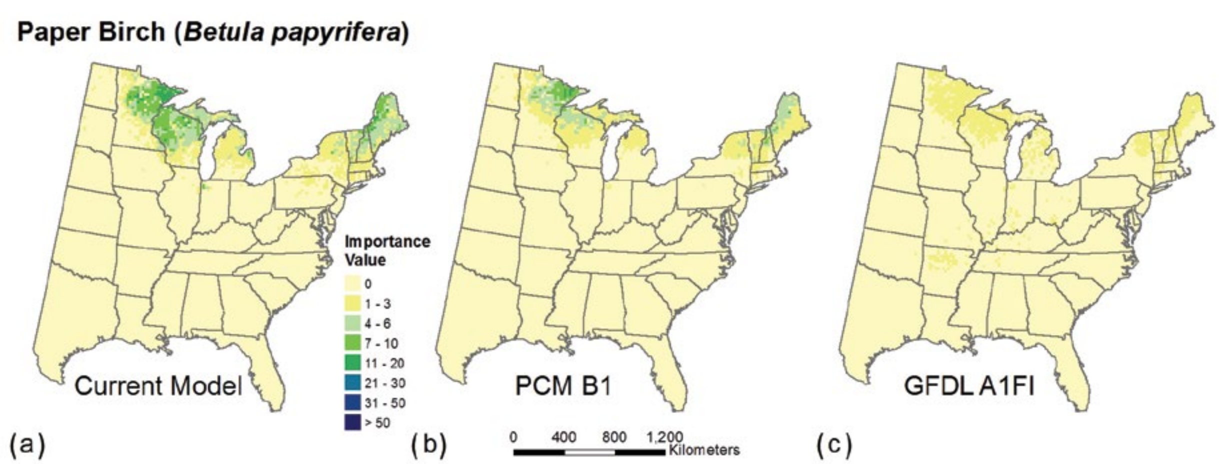

Figure A2.1—Suitable habitat (Iverson and Prasad 2002) for paper birch across the eastern United States according to (a) current USDA Forest Service, Forest Inventory and Analysis data, (b) projected future habitat for the year ~2100 under a mild scenario of climate change (PCM B1), and (c) a harsh scenario (GFDL A1FI).

Throughout its range, paper birch occurs in both pure stands and as a component of mixed forests, including other hardwood and softwood tree species (Moser et al. 2015). It commonly occurs with a variety of shrubs with NTFP values. In the east, these include beaked hazel (*Corylus cornuta* Marshall), bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.), wintergreen (*Gaultheria procumbens* L.), sarsaparilla (*Aralia nudicaulis* L.), blueberries (*Vaccinium* spp.), raspberries and blackberries (*Rubus* spp.), elderberry (*Sambucus canadensis* L.), and hobblebush (*Viburnum lantanoides* Michx.). Among common woody companion NTFPs in the Alaskan interior are high bush cranberry (*Viburnum edule* (Michx.) Raf.), Labrador tea (*Ledum groenlandicum* Oeder), and roses (*Rosa* spp.). While tolerant of a wide range of precipitation patterns and volumes, paper birch does not readily tolerate high temperatures and rarely grows naturally where average July temperatures exceed 70 °F (Safford et al. 1990).

Climate Change-Related Risks

In the United States, paper birch and NTFP uses of its bark appear to be particularly vulnerable to climate change effects (Iverson and Prasad 2002). Paper birch is on the International Union for Conservation of Nature (IUCN) List of Threatened Species, or Red List[6] with the note that "Climate change will extirpate paper birch at its southernmost distribution, especially in the mid- to southern Appalachian Mountains," although the northern extent of its range in eastern Canada may increase (Stritch 2014).

A complex of interacting climate change-related factors are likely to adversely affect paper birch populations in eastern North American and, consequently, the availability of birch bark. Among these factors are rising temperatures (Ashraf et al. 2015) and tropospheric ozone levels (Karnosky et al. 2005), as well as increased winter temperature variability (Man et al. 2014). Further, among eastern hardwood species, paper birch is especially susceptible to ice damage and subsequent mortality, making it vulnerable to projected increases in frequency and severity of ice storms (Bruederle and Stearns 1985, Duguay et al. 2001, Hopkin et al. 2003, Rustad and Campbell 2012). In an analysis of vulnerabilities to climate change among forest communities in northern Wisconsin and western Upper Peninsula Michigan, aspen-birch, upland spruce-fir, lowland conifers, lowland-riparian hardwoods, and red pine forests were determined to be the most vulnerable ecosystems by a panel of experts reviewing ecological and model information (Janowiak et al. 2014).

We used the "Climate Change Tree Atlas" (Iverson et al. 2008) and methods developed for the National Climate Assessment (Iverson et al. 2012) to generate a risk matrix for paper birch in the northeastern United States (northern Wisconsin and northern New York to western Maine) for three future periods: 2010 to 2014, 2040 to 2070, and 2070 to 2100. Two scenarios of climate change by century end were evaluated according to Intergovernmental Panel on Climate Change scenarios (Nakicenovic et al. 2000): mild (Parallel Climate Model [PCM] B1; Washington et al. 2000) and harsh (Geophysical Fluid Dynamic Laboratory [GFDL]; Delworth et al. 2006).

When we evaluate the risk matrix for the two locations, both show increasing risk with time as habitat is projected to move north (figure A2.2). Northern Wisconsin is poised to lose substantially more suitable habitat by 2070 as compared to northern New York and western Maine under either high or low emissions scenarios. Both locations are in the "develop strategies" zone, the highest level of risk, by 2070 under the harsh GFDL scenario and northern Wisconsin hits this level of risk even under the mild PCM scenario by 2070. The species is also low in its overall level of adaptability to increased disturbances from climate change, especially by century's end (figure A2.2)

Conclusions

It appears likely the 21st century will be challenging for paper birch in the United States and those who depend on its bark for livelihood and culture. Potential ecological adaptation strategies will include silvicultural approaches to assist the resistance and resilience of the species *in situ*, and potentially northward assisted migration of southern genotypes. Social adaptation strategies may include development of trade networks that make northern paper birch bark available to peoples in southern regions where the species has become scarce to absent. The longer-term outlook for the species is tenuous but there may be room for optimism that through concerted effort it may be possible to maintain stands for those who need a supply of birch bark (Huang et al. 2013).

[6] The report also provides technical input to the 2017 National Climate Assessment (NCA) Given the global perspective of the IUCN and projected expansion of the paper birch range in eastern Canada, the species is rated "Least Concern" on the Red List.

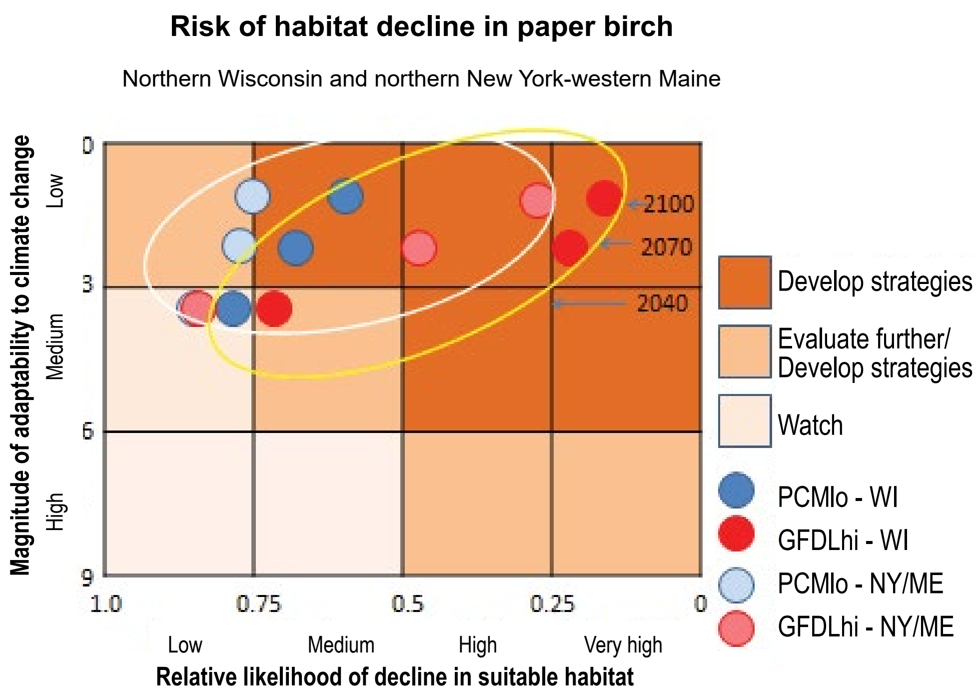

Figure A2.2—Risk of habitat decline in paper birch in northern Wisconsin and northern New York to western Maine. Northern Wisconsin (yellow ellipse) is poised to lose substantially more suitable habitat by 2070 as compared to New England (white ellipse), under either high or low emissions scenarios. Both locations are in the "develop strategies" zone by 2070 under GFDL scenario, and northern Wisconsin hits this level of risk even under the mild PCM scenario by 2070.

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Thinleaf (*Vaccinium membranaceum* Doublas ex Torr.) and Evergreen (*V. ovatum* Pursh) Huckleberries

Frank K. Lake

NTFP Uses and Values

Huckleberries are valued as sources of food and medicine, as well as inputs to the floral and nursery industries by diverse peoples from the coastal Pacific Northwest and Cascades Mountains of northern California to the interior mountain ranges of Idaho and Montana. An important food with many nutritional and health benefits (Hummer 2013, Lee et al. 2004, Tirmenstein 1990), the fruits of thinleaf (also known as black) and evergreen huckleberry (*Vaccinium membranaceum* Doublas ex Torr. and *V. ovatum* Pursh, respectively) are used for personal consumption, local commerce, and value-added markets (i.e., jams, syrups, pies; Alderman 1979, Kerns et al. 2004). Historically, American Indians in the region utilized thinleaf and evergreen huckleberry for a variety of cultural and culinary purposes and continue to do so today (Hummer 2013, Kerns et al. 2004, Minore et al. 1979). Leaves of both species are recognized as having medicinal properties associated with improving human health (Hummer 2013).

While there are some overlaps, the predominant uses of thinleaf and evergreen huckleberry differ. Thinleaf huckleberry is the primary source of highly sought-after fruits. Commercial sale of thinleaf huckleberry fruit is a multimillion dollar industry for the states of Washington, Oregon, Idaho, and Montana (Kerns et al. 2004). Evergreen huckleberry fruits also are sold or used for personal consumption. However, this species is valued especially for decorative and landscaping purposes. Evergreen huckleberry branches are used as greens in floral arrangements, with older branches providing a dark green, glossy background, while the reddish leaves and open branching of younger growth offer colorful texture (Kerns et al. 2004). Commodity chains for evergreen huckleberry branches often involve small groups of harvesters who sort and bundle the two branch types separately and sell them to regional buyers, who then transport and sell them to larger floral distributors (Vasquez and Buttolph 2010). In addition, evergreen huckleberry plants are sold as a garden and landscaping species (Kerns et al. 2004, Wender et al. 2004).

Ecology

Like the hundreds of other species in the genus *Vaccinium* found across the northern hemisphere (Ballington 2000, Hummer 2013), thinleaf and evergreen huckleberry are understory shrubs. However, each occupies distinct habitats and exhibits differing reproductive strategies and morphologies (i.e., physical forms or appearances). Thinleaf huckleberry is associated with mid-to-high elevation subalpine forests located predominantly in the Pacific West, but with broad distribution from Alaska to Arizona and a limited presence in the Northeast (Gorzelak et al. 2012). Reproducing primarily through vegetative production from rhizomes and root crowns (Simonin 2000), new leaves and flowers emerge in the spring, with the fruit developing over the summer, ripening in late summer to early fall. Habitat dominance or site abundance tends to be greatest in mature and old growth forests. However, thinleaf berry production declines under closed-canopy conditions (Kerns et al. 2004) and is most abundant in montane forest gaps and meadow habitats, where increased sunlight, soil moisture, and nutrients are available (Kerns et al. 2004, Minore et al. 1979).

Evergreen huckleberry grows primarily in coastal forests and mountains of the Pacific Northwest and northern California. The species lacks or has reduced rhizomatous vegetation growth (Kerns et al. 2004). New leaves and flowers emerge in the spring, with fruit developing through summer and ripening in late summer through fall. Several variants occur across the species' range, resulting in differences in fruit size and a range of colors from dark purple to light blue. Most have a bloom on the fruit skin that contributes to differences in taste, color, time of ripeness (Alderman 1979), and nutrient values (Taruscio et al. 2004). A shade tolerant species that expands or colonizes slowly, evergreen huckleberry is most abundant under closed forests with high canopy cover. However, as with thinleaf,

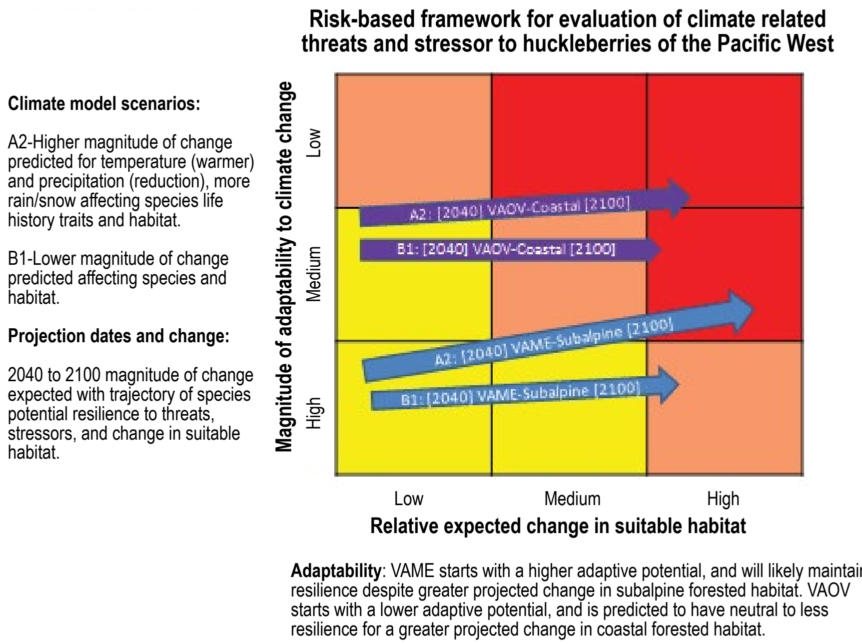

Figure A2.3—Adaptive capacity of thinleaf huckleberry (*Vaccinium membranaceum*) and evergreen huckleberry (*Vaccinium ovatum*) under projected low, medium, and high magnitude changes in their respective habitats.

evergreen huckleberry flowering and berry production appear to increase in forest gaps (Vance et al. 2001).

Both thinleaf and evergreen huckleberry are adapted to a variety of natural (e.g., fire, drought, and browsing) and human disturbances (e.g., berry and foliage harvesting) and can colonize or regain dominance in forest patches following fire, timber harvest, landslides, or windstorms that open gaps (Simonin 2000, Tirmenstein 1990). However, recovery of evergreen huckleberry may be slower (Kerns et al. 2004). In addition to their value to humans, huckleberries are important sources of food for wildlife (Holden et al. 2012, Kerns et al. 2004).

Climate-change Related Risks

Thinleaf and evergreen huckleberries are adaptive, disturbance-tolerant species capable of surviving a range of stressful circumstances. However, their adaptability is not limitless and the two species likely will respond differently to the effects of climate change (figure A2.3). Among risk factors relevant to both species, significant changes in the extent and timing of snow cover and air and soil temperatures may lead to plant-pollinator asynchronies with impaired fruit and seed set resulting (Straka and Starzomski 2015). Drought and fires are likely to affect soil nutrient, temperature, and moisture levels, which also can affect seed viability and longevity (Hill and Vander Kloet 2005). The adaptability of huckleberries to changing soil conditions are linked to and mediated in part by mycorrhizal relationships, which are strongly affected by soil moisture and temperature regimes (Gorzelak et al. 2012). Some models suggest likely reductions in the area of montane-subalpine ecosystems and maritime conifer forests, which could reduce habitat for thinleaf and evergreen huckleberry, respectively (Bachelet et al. 2011). However, the same analysis projects potential increases in the temperate shrubland vegetation type, which potentially could benefit huckleberries if stressors do not impact other growth or reproductive processes.

In the specific case of thinleaf huckleberry, persistence and berry production may be differentially affected by climate change related stressors. Projected increases in drought, which heightens potential for more extensive fires, may reduce tree and other vegetation, allowing populations of thinleaf huckleberry to regain site dominance following this disturbance (Minore et al. 1979, Simonin 2000). Conversely, soil moisture stress resulting from reduced snow and precipitation may reduce plant vigor and berry production and increase mortality. Extreme weather events such as late spring snow or freezing during flowering can damage stem tissue and hinder pollinators, compromising flower development and fruit set. In the Olympic Mountains of western Washington, upward movement of firs (e.g., *Abies amabilis* Douglas ex J.Forbes) on southwestern slopes with climate change is expected to supplant subalpine meadows and mountain hemlock forests that currently provide thinleaf huckleberry habitat (Zolbrod and Peterson 1999).

Evergreen huckleberry ecology and social values may be similarly affected. Increased drought may compromise leaf quality required by floral markets and reduce berry production for human and wildlife consumption. Sudden oak death (SOD; *Phytophthora ramorum*), which reduces evergreen huckleberry plant vigor and increases its mortality rates (Rizzo and Garbelotto 2003), demonstrates the potential impacts of climate-related increases in pathogens.

Conclusions

Thinleaf and evergreen huckleberry are culturally, economically, and ecologically important NTFPs of the coastal to interior mountains of the Pacific West. As forests change in response to tree mortality from drought stress and fire, huckleberries may maintain or expand their site dominance. However, evergreen huckleberry is potentially less resilient than thinleaf huckleberry. Climate related stressors, such as temperature and type and amount of precipitation likely will have different effects on the two huckleberry species and their respective habitats with particular implications for berry production and leaf characteristics.

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Whitebark Pine (*Pinus albicaulis* Engelm)

MARY MAHALOVICH

American Indian tribes in the Pacific Northwest have strong cultural ties to whitebark pine that date back to their first encounter with this high elevation tree. They traditionally used the 'nuts' and cambium to nourish their bodies, and the sap to heal ailments (Augare-Estey 2011, Blankinship 1905, Johnston 1970, Turner 1988). Consumption for food and medicine was foundational for the cultural value bestowed to this tree. From 1860 to 1940 the whitebark pine was extensively cut for timber to feed the Montana mining industry for mine supports and fuel for smelters and home heating (figure A2.4) (Arno and Hoff 1990). The habitat for this culturally important tree has declined with an associated reduction in availability for food and medicine (Martinez 2003). Although consumption for nutrition and healing has decreased, the cultural value to the American Indians has remained strong.

In an effort to ensure the sustainability of the cultural value of this tree, the Confederated Salish and Kootenai Tribes, and others are cooperating with the U.S. Department of Agriculture, Forest Service, U.S. Department of the Interior, National Park Service and Bureau of Land Management to reestablish whitebark pine populations. This cooperation is merging traditional ecological knowledge with science-based knowledge for the health and viability of a tree species that is invaluable for the cultural wellbeing of the people who first inhabited the region. This collaboration could benefit other American Indian tribes with access to whitebark pine in the northern Rockies such as the Coeur d'Alene, Colville, Nez Perce, Shoshone-Bannock, Crow, and Blackfoot. All these tribes traditionally gathered the nutrient-rich seeds of whitebark pine in the autumn and harvested the cambium as a food supplement in springtime, a period when food sources were relatively scarce (Augare-Estey 2011, Blankinship 1905, Johnston 1970).

Whitebark pine, a keystone species, maintains subalpine biodiversity and provides a nutritional source of food for several important wildlife species (Lorenz et al. 2008). The stability and long-term persistence of the species is jeopardized by a nonnative pathogen white pine blister rust (*Cronartium ribicola* A.Dietr.),

Figure A2.4—Whitebark pine (*Pinus albicaulis* Engelm.) exhibits three growth habits from single-stem erect (shown), multiple-stem erect, and wind-swept krummholz common at tree line. Huson Peak Research Natural Area, Kootenai National Forest. (Photo credit: Mary Mahalovich, U.S. Department of Agriculture, Forest Service).

mountain pine beetle (*Dendroctonus ponderosae* Hopkins), altered fire regimes resulting in successional replacement in mixed-conifer stands, and changes in climatic conditions (Federal Register 2011, Keane et al. 2012). The species occurs from 37° to 55° N latitude, 107° to 128° W longitude, from subalpine to tree line and elevations from 2,952 to 12,000 feet. As a foundation species, whitebark pine protects watersheds and promotes post-fire regeneration (Keane et al. 2012).

The species could become extinct due to small habitat shifts. From 1901 to 2009, temperatures in the Pacific and Inland Northwest increased 1.3 °F (Rupp et al. 2013), while precipitation patterns did not change consistently. East of the Continental Divide, particularly in the Greater Yellowstone ecosystem, precipitation has decreased in the high elevation ecosystems and the overall patterns have changed from largely snowpack to rainfall (Tercek et al. 2015). Research projecting future habitat for whitebark pine indicate declining habitat above tree line (Bartlein et al. 1997, Chang et al. 2014, Crookston et al. 2010, Rehfeldt et al. 2012, Schrag et al.

2008). By the end of the 21st century, dramatic decreases are anticipated in suitable habitat for whitebark pine.

As more than 90 percent of whitebark pine grows on public lands, the USDA Forest Service and U.S. Department of the Interior (DOI) are collaborating on science to assess the current and future vulnerability of the species. The Northern Rockies Adaptation Partnership (NRAP), with Forest Service leadership, is a science-management collaboration with the goals of assessing vulnerability of natural resources and ecosystem services, and developing science-based strategies for land managers to understand and mitigate the negative effects of climate change (http://adaptationpartners.org/nrap/).

The NRAP process has classed whitebark pine with one of the highest vulnerability scores in the northern Rockies (Keane et al. 2017). The broad-scale climate change effects impacting whitebark pine are characterized as increased warming temperatures combined with a limited ability to compete with encroaching conifers. Natural regeneration is anticipated to be reduced by warming temperatures and low seed availability. Negative impacts may be favorably modified by attributes of its adaptive capacity, as whitebark pine exhibits a generalist adaptive strategy (Mahalovich et al., 2016) and, coupled with increased wildland fire, seed dispersal by Clark's nutcracker may allow rapid colonization of burned areas. Management recommendations for restoration actions and prioritizing areas to promote resilience are ongoing.

The companion vulnerability assessment with DOI leadership, using Landscape Conservation Cooperatives as a focal point, is tasked with developing strategies for managing climate-change impacts across all Federal lands (DOI 2009). Common to both is a synthesis of climate science and research on whitebark pine. Where data are lacking, the sensitivity and exposure components are supplemented with expert opinion. Following selection of scale for analysis and models emphasizing IPCC CMIP5 RCP8.5 (equivalent to "business as usual" A2 emission scenario) and the RCP4.5 (equivalent to B1 global reduction in greenhouse gas emissions), data are combined in a linear index (NRAP) or metadata analysis (DOI) to assign a vulnerability score for whitebark pine.

Hansen and Philipps (2015) through a metadata analysis of bioclimatic suitability models and land-use patterns, noted that significant studies (Coops and Waring 2011, Crookston et al. 2010) demonstrated one of the highest vulnerability scores among conifers. Results suggest that less than 10 percent of the species distribution will remain in the northern Rockies by the end of the century (figure A2.5). The authors concluded that managers are unable to influence climate over large landscapes, but they can manipulate many other factors that influence tree population viability. Reforestation using genetically appropriate blister rust resistant and drought tolerant seedlings may prove viable approach to reestablishing populations of whitebark pine. Furthermore, knowledge of whitebark pine's climate suitability is a critical filter for deciding where to use management actions to protect, restore, or establish tree populations under changing climates.

Interpretation of the studies were represented for a generalist (whitebark pine) and specialist (lodgepole pine, *P. contorta* var. *latifolia*) in upper subalpine ecosystems using Lake's relative risk matrix (Lake, this volume). Mountain pine beetle and altered fire regimes for climate models A2 and B1 were contrasted for active and no active management. A moderate change in suitable habitat is indicated for both species with active management (figure A2.6). Changes for lodgepole pine are offset with planting and high potential for natural regeneration. However, whitebark pine with the added stressor of blister rust, exhibits a higher relative change in suitable habitat, tempered by planting rust resistant seedlings (longer arrows). In the case of no active management (figure A2.7), the trajectory for lodgepole pine is similar to active management due to its high natural regeneration potential. An upward shift in the relative change of suitable habitat for whitebark pine is evident, as it relies solely on bird-dispersed seed to support natural regeneration.

The collaborative research to reestablish populations of whitebark pine demonstrates the recognition of Federal agencies to the cultural value of the species. Cooperation with American Indian tribes helps to ensure that efforts address appropriate concerns. The integration of traditional ecological knowledge with science could serve as an invaluable model for restoration of other cultural nontimber species. Integrative research opportunities abound for many nontimber forest species that are of significant cultural value.

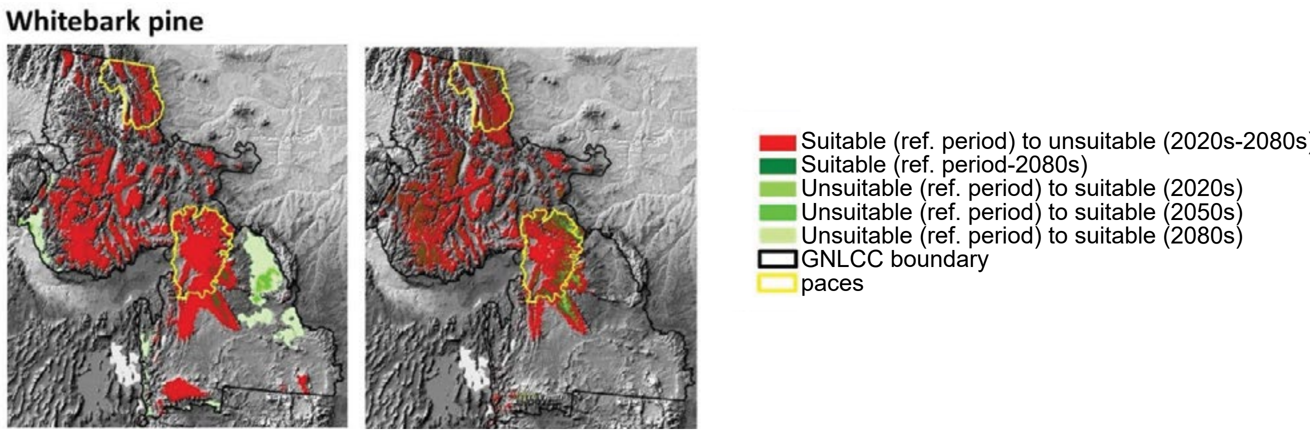

Figure A2.5—Metadata analysis of projected change in modeled spatial distribution of climate suitable areas for whitebark pine (*Pinus albicaulis* Engelm.) in Idaho, Montana, and northwestern Wyoming across the reference and three future time periods (2020, 2050, 2080), under the A2 emission scenario based on (a) Coops and Waring (2011) and (b) Crookston et al. (2010). Whitebark pine is projected to have one of the largest losses of climate suitable areas and the least area of newly suitable areas, with only 0.5 percent (b) to 7 percent (a) of suitable habitat remaining by 2080. The Great Northern Landscape Conservation Cooperative (GNLCC) boundary is noted in black, and areas considered essential to maintaining natural processes within a national park or a protected-area centered ecosystem (PACE) are shown in yellow. (From Hansen and Philipps 2015, used with permission.)

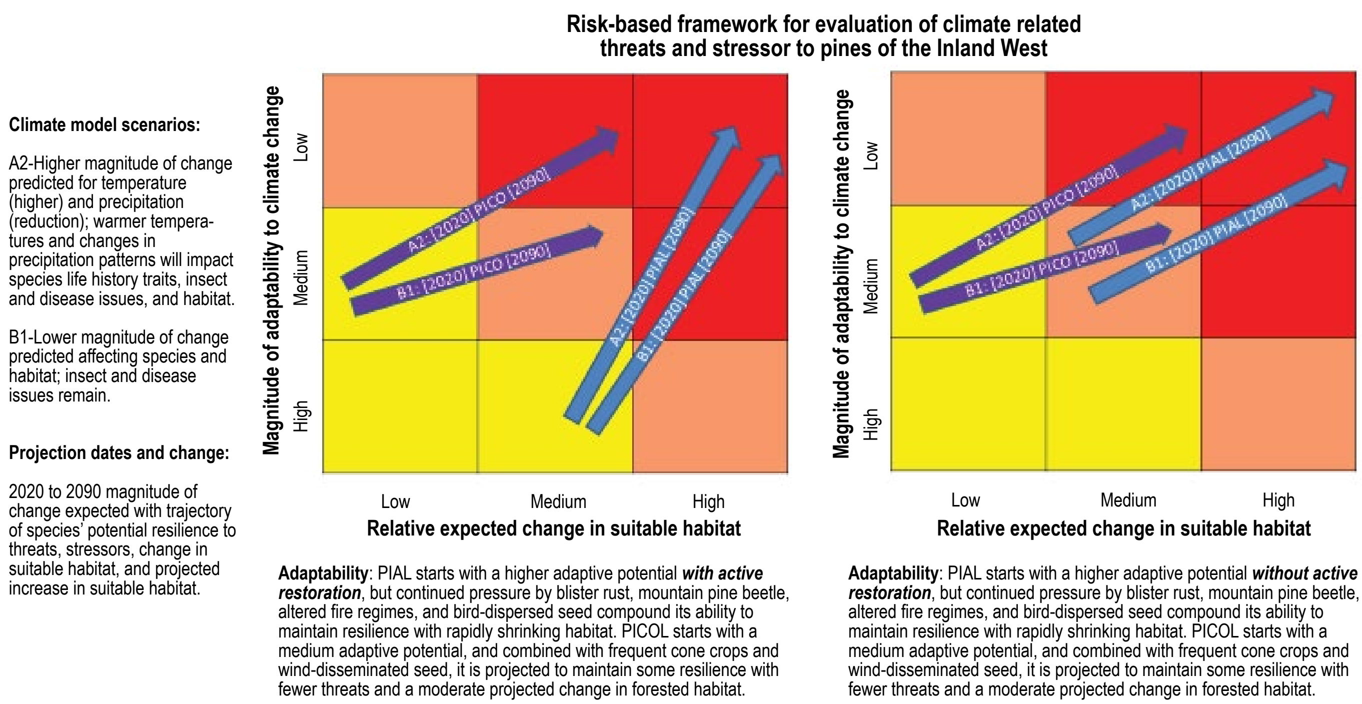

Figure A2.6—(left) Risk matrix for whitebark pine (a generalist) and lodgepole pine (a specialist) under climate model scenarios A2 and B1 *with active restoration*. Under conditions of mountain pine beetle predation, altered fire regimes, and climate change tempered by reforestation and high natural regeneration potential, suitable habitat for lodgepole pine (dark blue arrows) can be expected to exhibit moderate change. With the added stressor of blister rust, tempered by planting rust-resistant seedlings, whitebark pine habitat change (light blue arrows) likely would show greater change.

Figure A2.7— (right) Risk matrix for whitebark pine (a generalist) and lodgepole pine (a specialist) under climate model scenarios A2 and B1 *without active restoration*. Under conditions of mountain pine beetle predation, altered fire regimes, and climate change offset by natural regeneration potential through wind dispersal of seeds, suitable habitat for lodgepole pine (dark blue arrows) is expected to exhibit moderate change. With the added stressor of blister rust, in the absence of active human management, whitebark pine habitat (light blue arrows) likely would show greater change.

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Saw Palmetto (*Serenoa repens* W. Bartram Small)

Christine Mitchell

Saw palmetto is the most common palm found in Florida (Bennett and Hicklin 1998), growing wild throughout the state. Its name derives from the sharp needle-like growths (petioles) found along the edges of its leaves (Tanner et al. 1996). Tanner et al. (1996) estimate that some saw palmetto plants could be 500 to 700 years old, and note that though it is little studied, it is an ecologically and economically important native palm in Florida. Abrahamson and Abrahamson (2009) highlighted that though saw palmetto is common in the landscape, showing "extraordinary persistence and tolerance" in its environment, it does so at "a cost of exceptionally slow growth rates" (Abrahamson and Abrahamson 2009, p. 123). Abrahamson and Abrahamson found that seedling reproduction can take multiple decades and that in disturbed habitats that much effort would be needed to restore the palm (2009, p. 123). Takahashi et al. (2011) assert that because saw palmetto spreads clonally, understanding its genetic diversity through the measurement and distribution of its genets can help us understand its reproduction, life span, and the effects of continued anthropogenic disturbances on the population. Takahashi et al. (2011) concluded that Serenoa primarily propagate via vegetative sprouts and conservatively estimated genet ages to be between 1,227 and 5,215 years (2011, p. 3736) and further conservatively estimated that it could take 100 years for a seedling to become an adult (2011, p. 3737).

Takahashi et al. (2011) further note that saw palmetto has been part of the ecosystem for at least 37,000 years, despite "historical climate oscillations" (2011, p. 3737). Takahashi et al. (2011, p. 3739) note that "its invasion into new sites is unlikely." Though the species is climatically resilient and has remarkable longevity, there is a risk to it from climate change in the form of expected sea level rise (SLR) with associated reduction in habitat availability. The species slow growth will impede its ability to redistribute through the landscape, while continuing anthropogenic land use changes such as the conversion of habitat to agriculture or development will reduce both the quality and amount of habitat available to the palm, compounding its vulnerability.

Saw palmetto is part of an ecological system that is important for Florida wildlife that utilizes the palm for shelter, denning, and more (Maehr and Layne 1996). A reduction of quality habitat may create localized stress for wildlife, and restoration efforts to create a "naturally functioning ecosystem will take considerable time and will be a challenge to accomplish" (Takahashi et al. 2011, p. 3739). Many species rely on the annual palm production of drupes or berries to supplement their diets as the palm produces fruit from September through October, a period when other food sources might be scarce (Maehr and Layne 1996). Maehr and Brady (1984) showed that Florida black bears (*Ursus americanus floridanus*) utilized saw palmetto drupes in their fall diets, leading researchers to turn their attention to the fruiting patterns, reproduction, longevity, and more of the palm (Abrahamson 1995, Abrahamson and Abrahamson 2009, Bennett and Hicklin 1998, Maehr and Layne 1996), though much about the species remains unknown.

Research into habitats associated with the palm, fruiting conditions and more are driven in part by the growth of the berries popularity as an herbal supplement in the United States and as an ingredient in pharmaceuticals in Europe (Bennett and Hicklin 1998). The harvesting, drying, and exporting of saw palmetto fruits, or berries, from Florida has been documented since at least 1898 (Hale 1898). Since the mid-1990s consumer demand for the berry as either a dietary supplement or drug has grown though not much is known about the scale of the harvest to supply the industry, though saw palmetto is the most harvested NTFP in the United States in volume (AHPA 2012). Maehr and Layne wondered in 1996 if competition between the berry industry and wildlife could have deleterious effects on local Florida wildlife (Maehr and Layne 1996). Also noted by Maehr and Layne was the potential negative impact that growing development in Florida could have on both the saw palmetto and palmetto habitat. Population growth in Florida over the decades has led to its becoming the second most populous state in the Nation, with a population greater than New York State.

Population growth, development, and eradication programs on natural and agricultural lands have nearly certainly led to a decline in the amount and quality of saw palmetto habitat throughout Florida, though how much of a decline is unknown. An anonymous author (1947, in Bennett and Hicklin 1998) estimated that after World War II there were about 1.4 million ha of saw palmetto throughout the state, covering about 10 percent of the state's land surface (Bennett and Hicklin 1998). No other estimate has been conducted since then to determine the amount of habitat available throughout the State, except an initial habitat analyses by Mitchell (2014) which showed that a total of 3.7 million ha of habitat may exist, though of this only 804,000 ha is habitat where the saw palmetto is prime or dominant, such as dry prairie which is likely to have been the habitat assessed by the anonymous author in 1947. An initial analysis suggests a decline of 43 percent of dominant habitat (Mitchell 2014, p. 112). The amount of current habitat and where it exists is fundamental to understanding habitat risk due to climate change, the impacts of this potential change on wildlife, and the sustainability of the saw palmetto berry industry harvest. Loss of saw palmetto habitat due to the conversion of natural lands and to sea level rise requires further study to understand potential effects on wildlife and the berry industry.

An analysis of the spatial impacts of SLR on saw palmetto habitat suggest that 59,770 acres (3.3 percent) out of 1,795,316 acres of saw palmetto habitat could be lost due by 2050. By 2100, 102,730 acres (5.72 percent) of saw palmetto habitat could be affected by SLR. Using the U.S. Army Corps of Engineers (USACE 2017) high curve of sea level rise with mean sea level (MSL), the habitat at potential risk of inundation increases to 160,689 acres, or 8.95 percent of the total potential habitat (figure A2.8). The estimated area of saw palmetto habitat that could be affected by sea level rise is less than 6 percent of the total area of suitable habitat under the medium curve scenario, but rises to 9 percent under the high curve scenario by 2100. Like other NTFPs, saw palmetto is not evenly distributed across its range, and not all habitats are high quality habitat that will host an abundance of plants. Some habitat may be suitable but have none of the palms within it, while others may have many saw palmettos. Likewise, people and wildlife are also not evenly distributed across the landscape, thus where habitat is found and potentially affected by sea level rise has several implications for the management of suitable habitat for both palms and wildlife.

The size of saw palmetto habitat patches affected by the MSL rises ranges from just 0.23 acres up to 11,050 acres of continuous habitat. While the mean patch size affected is about 59 acres, a standard deviation of 400 acres suggests that more analysis of which patches and where they occur is necessary. Using the high curve scenario, minimum patch sizes lost are 0.22 acres with a continuing maximum of 11,050 though the mean changes to 35 acres with a standard deviation of 261 acres.

Where habitat can potentially be lost is important as continued conservation efforts seek to protect and expand habitat suitable for wildlife, which includes saw palmetto habitat. In this analysis, both the Big Cypress Wildlife Management Areas within the Big Cypress Preserve and the Picayune Strand Wildlife Management Area lose saw palmetto habitat. The Big Cypress Preserve is home to the Big Cypress subpopulation of Florida black bears whose secondary ranges include coastal areas expected to be affected by sea level rise and which also contain stands of saw palmetto habitat. This suggests that wildlife may have to adapt and range outside of these stands to find saw palmetto for denning, shelter, and food. The saw palmetto berry industry will also see a reduction of suitable stands for harvesting, placing pressure on remaining stands as national and international demand for the berry continues to grow.

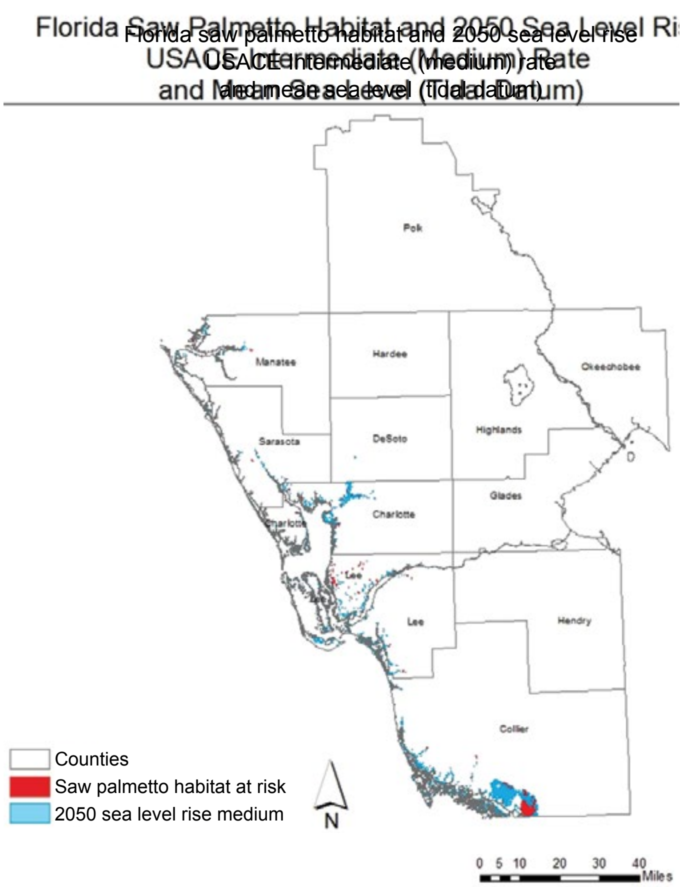

Figure A2.8—Saw palmetto habitat distribution. Results show that almost 60,000 acres of approximately 1.8 million acres of saw palmetto habitat will be lost by sea level rise by 2050. The area in red is habitat at risk. (Map rendered by C.M. Mitchell.)

The saw palmetto risk matrix incorporates the medium and high USACE curves and MSL projections on the X axis, showing an expected decline in suitable habitat ranging from 6 to 9 percent by 2100. The Y axis reflects a high resilience to climate change and medium to high ability to adapt to climate changes. Loss of habitat due to sea level rise, combined with continuing anthropogenic land-use conversions of natural habitat lead to medium to low adaptation capacity.

Risks and the degree of vulnerability associated with these risks are variable for specific sites, in this case habitat vulnerable to sea level rise. Storm wave frequency and intensity, precipitation, and other risk factors need to be accounted for but are outside of the scope of this analysis. Anthropocentric responses to SLR could include increased demand for development inland, placing further pressure on natural areas and wildlife. Though saw palmetto habitat exists throughout Florida, a major threat is the continuing conversion of natural habitats into development. The palm is adapted to drought, fire, and other natural disturbances, but it is unknown how it might respond to higher seasonal temperatures, shifts in rainfall patterns, and other anticipated effects of climate change. The plant becomes less abundant at the northern limits of its range (Georgia, South Carolina). Resilience and adaptation to changing conditions is possible, but assistance may be needed to fully exploit habitat in the northern part of its range, though as Takahashi et al. (2011) noted, seedlings have very slow growth rates and are unlikely to be able to colonize disturbed habitat without assistance, and even then recolonization can be quite slow.

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Sugar Maple (*Acer saccharum* Marshall)

Louis Iverson and Stephen Matthews

The Climate Change Tree Atlas (Prasad et al. 2007) provides information about how individual tree species may respond to a changing climate. Projections of suitable habitat from the Tree Atlas models describe the environmental and climatic factors that could affect species distribution and abundance across the landscape (Iverson et al. 2008). The modifying factors detail life-history traits that may influence the ability of a tree species to cope with disturbances and biological stressors at both broad and fine scales (Matthews et al. 2011). The combined use of these Tree Atlas components allows for a more comprehensive understanding of the response of tree species to climate change and can inform policy and management (Iverson et al. 2011). As with the development of the most recent National Climate Assessment (NCA), risk assessment diagrams are used in this NTFP assessment as a tool for organizing information about key vulnerabilities and risks (Melillo et al. 2014). Risk is defined in the NCA as the product of the likelihood of an event occurring and the consequences or effects of that event. In the context of species habitats, likelihood is related to potential changes in suitable habitat at various times in the future. Consequences are related to the adaptability of a species to cope with the changes, especially the increasing intensity or frequency of future disturbance events. In this context, qualitative or quantitative estimates are used to describe the likelihood of impact (X axis) and the magnitude of consequence (Y axis).

The production of maple syrup is an important NTFP throughout much of its range in the Midwest and Northeast, and sustaining this ecosystem service is of considerable interest and concern (Duchesne et al. 2009; Whitney and Upmeyer 2004). Tree Atlas models project a loss in sugar maple (*Acer saccharum*) habitat throughout the century, especially in locations at the southern portion of its range (figure A2.9); a continuation of current trends in maple decline (Long et al. 2009). As an example of the application of a risk-centered approach to vulnerability assessment, Tree Atlas results for suitable habitat for sugar maple were generated for three locations across the eastern United States, and were translated into a risk matrix for three future periods: 2010 to 2040, 2040 to 2070, and 2070 to 2100 (Iverson et al. 2012a; 2012b;) (figure A2.10). Two scenarios of climate change were also evaluated according to Intergovernmental Panel on Climate Change scenarios (Nakicenovic et al. 2000) ranging from mild changes (PCMlo [Washington et al. 2000]) to harsh climatic changes by century end (Hadleyhi [Pope 2000]). The locations used here include northern Wisconsin (Janowiak et al. 2014), Vermont, and Kentucky (Matthews et al. 2014). This effort was intended as a "proof of concept" on how complex information could be represented in a way that helped to organize thinking regarding climate change vulnerability and risk. In translating the Tree Atlas information into this framework, projected changes in suitable habitat were used to indicate the likelihood of impact. Thus, a large projected decrease in suitable habitat suggests a greater likelihood (the X axis) that that species will have reduced habitat under future climatic conditions. The magnitude of consequence was inversely related to the adaptability of the species to climate change based upon the modifying factors; thus, the lower the capacity to cope, the greater the risk for habitat loss and the greater the consequences

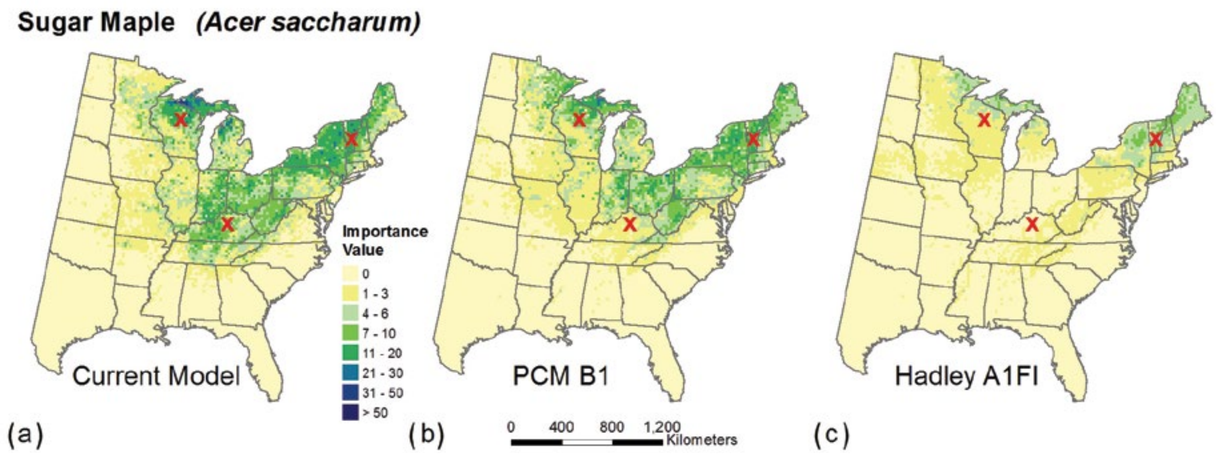

Figure A2.9—Suitable habitat for sugar maple across the eastern United States according to (a) current estimates for 1980 to 2000, (b) projected future habitat for the year ~2100 under a mild scenario of climate change (PCM B1), and (c) a harsh scenario (Hadley A1FI). The Xs mark the northern Wisconsin (upper left), Vermont (upper right), and Kentucky (lower center) locations for the risk matrices presented in figure A2.10.

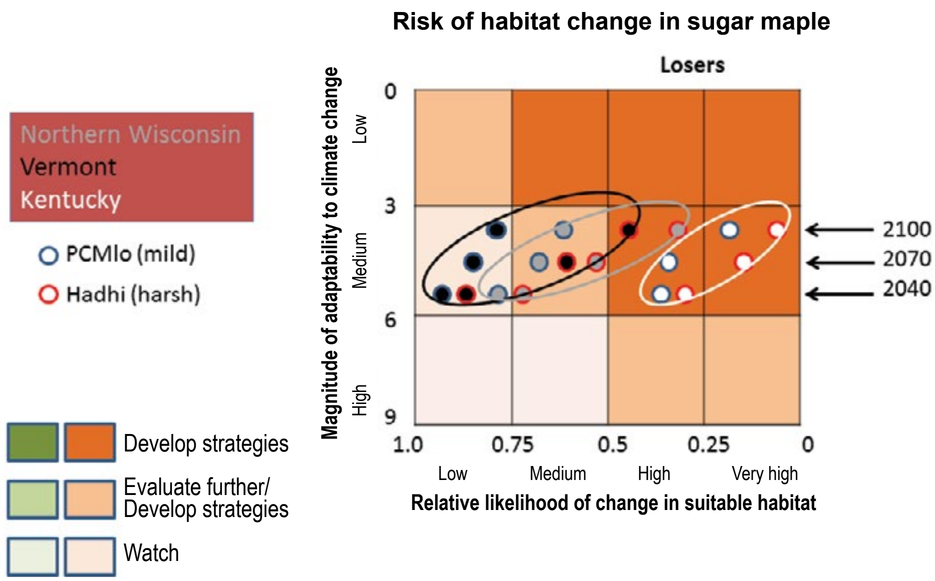

Figure A2.10—Risk matrix for sugar maple in northern Wisconsin, Vermont, and Kentucky. The numbers on the X-axis reflect projected suitable habitat, where 1.0 indicates no change from current values and 0 indicates complete loss of habitat. The numbers on the Y-axis are based on modifying factors, with increasing influence of disturbance factors over time. Values are plotted for three 30-year periods: 2040 (2010 to 2040), 2070 (2040 to 2070), and 2100 (2070 to 2100). (See Iverson et al. (2012b) for complete methods and additional examples.)

from climate change (the Y axis) (Iverson et al. 2012a, 2012b). To assess changes in consequence over time, adaptability scores were adjusted to account for projected increases in disturbance over time (Iverson et al. 2012b).

The risk matrix for the three locations all show increasing risk with time as habitat is projected to move north (figure A2.10). The two northern locations were of fairly similar risk (slightly more risk in Wisconsin than Vermont) of large losses of suitable habitat by century's end according to this analysis, as a result from increasing risk throughout the century especially under the harsh scenario. However, at the southern portion of sugar maple, represented by Kentucky, serious risk is already present according to this analysis.

Based only on the potential for change in habitat and adaptability, in all locations, there is an increased risk of a decline in sugar maple habitat (figure A2.10), but Kentucky is under relatively greater urgency to develop strategies to cope with this decline. However, this risk matrix only paints a portion of the picture for sugar maple. Vermont produces over 30 percent of the maple syrup produced in the United States and ranks first in number of taps while Wisconsin ranks fourth in number of taps whereas in Kentucky, the commercial syrup market less developed (Farrell and Chabot 2012). Thus, this socioeconomic dimension to sugar maple's relative importance/consequences needs to be added to the interpretation of the weightings shown in the matrix. In this case, even though the Kentucky location is projected to lose relatively more habitat, there will be a greater loss in Vermont and Wisconsin of the services that sugar maple provides in terms of monetary and cultural value (Farrell and Chabot 2012, Groffman et al. 2012). These services will not be readily transferable to other species.

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Appendix 3: State Law Websites

Amit R. Patel

Definitions and regulations associated with nontimber forest products (NTFPs) vary considerably between U.S. federal agencies and amongst the nation's states and affiliated territories. While it would be impossible to assemble an exhaustive compendium of all regulatory measures relevant to NTFPs, the information provided in this appendix is intended as a starting point for researchers and decisionmakers interested in laws and policies that impact NTFP species and their harvests. Table A3.1 provides a list of laws and regulations listed elsewhere in this assessment (see, especially, chapter 7). Table A3.2 compiles links to websites relevant to NTFP governance at the state, territorial, and local levels at the time of this writing.

Table A3.1—Laws and acts referenced in this assessment.

Alaska National Interest Lands Conservation Act of 1980
Alaska Native Claims Settlement Act of 1971
Alaskan National Interest Land Claims Act
American Indian Agricultural Resources Management Act
American Indian Freedom of Religion Act
American Indian Law
American Indian Religious Freedom Act of 1978
Cooperative Forestry Assistance Act 1978
Department of the Interior and Related Agencies Appropriations Act of 2000
Department of the Interior and Related Agencies Appropriations Act of 2004
Department of the Interior and Related Agencies Appropriations Act of 2010
Endangered Species Act
Endangered Species Act of Guam
Farm Bill
Federal Indian Law
Food, Conservation, and Energy Act of 2008
Forest and Rangeland Renewable Resources Planning Act of 1974
Immigration Act 06 1986
Indian Self-Determination Act
Lacey Act
Multiple-Use Sustained Yield Act of 1960
National Environmental Policy Act
National Forest Management Act of 1976
National Historic Preservation Act
National Indian Forest Resources Management Act
National Wildlife Refuge Improvement Act
National Wildlife Refuge System Administration Act of 1996
Organic Act
Organic Administration Act of 1987
Pilot Program Act
Rangeland Renewable Resources Planning Act of 1974
Refuge Improvement Act of 1997
Sikes Act
Tribal Forest Protection Act
Tribal Law

Table A3.2—Some State, territory, and local laws relevant to nontimber forest product governance.

State	Website
Alabama	http://codes.lp.findlaw.com/alcode/
Alaska	http://www.dnr.alaska.gov/
American Samoa	http://www.asbar.org/
Arizona	http://www.azleg.gov/
Arkansas	http://www.forestry.arkansas.gov/
California	http://codes.lp.findlaw.com/cacode/
Colorado	http://www.lexisnexis.com/hottopics/Colorado/
Connecticut	https://www.cga.ct.gov/
Delaware	http://www.delcode.delaware.gov/
District of Columbia	http://www.dcregs.dc.gov/
Fed. States of Micronesia	http://www.fsmsupremecourt.org/
Florida	http://www.leg.state.fl.us/Statutes/
Georgia	http://www.lexisnexis.com/hottopics/gacode/
Guam	http://www.guamcourts.org/CompilerofLaws/gca.html
Hawai'i	http://codes.lp.findlaw.com/histatutes/
Idaho	http://www.legislature.idaho.gov/idstat/TOC/IDStatutesTOC.htm
Illinois	http://www.ilga.gov/legislation/
Indiana	http://codes.lp.findlaw.com/incode/
Iowa	https://www.legis.iowa.gov/law/iowacode
Kansas	http://www.kslegislature.org/li/
Kentucky	http://www.lrc.ky.gov/statutes/
Louisiana	http://www.legis.la.gov/legis/lawsearch.aspx
Maine	http://www.legislature.maine.gov/statutes/
Maryland	http://www.mgaleg.maryland.gov/
Massachusetts	https://malegislature.gov/Laws/GeneralLaws/
Michigan	http://www.legislature.mi.gov/
Minnesota	https://www.revisor.mn.gov/pubs/
Mississippi	http://www.lexisnexis.com/hottopics/mscode/
Missouri	http://www.sos.mo.gov/adrules/
Montana	http://codes.lp.findlaw.com/mtcode/
Nebraska	http://www.sos.ne.gov/rules-and-regs/
Nevada	http://www.leg.state.nv.us/law1.cfm
New Hampshire	http://www.gencourt.state.nh.us/
New Jersey	http://www.lexisnexis.com/hottopics/njcode/
New Mexico	http://164.64.110.239/nmac/
New York	http://codes.lp.findlaw.com/nycode
North Carolina	http://www.ncleg.net/gascripts/Statutes/Statutes.asp
North Dakota	http://www.legis.nd.gov/general-information/north-dakota-century-code
Northern Mariana Islands	http://www.cnmilaw.org/
Ohio	http://codes.ohio.gov/orc/
Oklahoma	http://www.oklegislature.gov/osstatuestitle.html
Oregon	https://www.oregonlegislature.gov/
Palau	http://www.paclii.org/pw/indices/legis/palau-national-code-index.html
Pennsylvania	http://www.pacode.com/secure/browse.asp
Puerto Rico	http://www.lexisnexis.com/hottopics/lawsofpuertorico/
Rep. of the Marshall Islands	http://www.rmiparliament.org/
Rhode Island	http://webserver.rilin.state.ri.us/Statutes/Statutes.html
South Carolina	http://www.scstatehouse.gov/code/statmast.php
South Dakota	http://www.legis.sd.gov/Statutes/Codified_Laws/default.aspx
Tennessee	http://www.lexisnexis.com/hottopics/tncode/
Texas	http://codes.lp.findlaw.com/txstatutes
U.S. Virgin Islands	http://www.lexisnexis.com/hottopics/vicode/
Utah	http://www.le.utah.gov/Documents/code_const.htm
Vermont	http://www.lexisnexis.com/hottopics/vtstatutesconstctrules/
Virginia	http://law.lis.virginia.gov/vacode
Washington	http://apps.leg.wa.gov/rcw/
West Virginia	http://www.legis.state.wv.us/
Wisconsin	http://www.legis.wisconsin.gov/rsb/stats.html
Wyoming	http://www.lexisnexis.com/hottopics/wystatutes/

Appendix 4: Nontimber Forest Product Species Referenced in this Assessment

Scientific name	Common name	Harvested organ(s)	Usage(s)	Region
Abies balsamea	Balsam fir	Boughs	Decorative	Midwest, Northeast, Southeast
Abies fraseri	Fraser fir	Whole plant	Landscaping	Southeast
Abies procera	Noble fir	Boughs	Decorative	Northwest, Southwest
Acacia koa	Koa	Wood	Crafts	Hawai'i
Acer negundo	Box elder	Wood		Southeast
Acer nigrum	Black maple	Sap	Edible	Northeast, Southeast
Acer rubrum	Red maple	Sap	Edible	Great Plains, Midwest, Northeast, Southeast
Acer saccharum	Sugar maple	Sap	Edible	Northeast, Southeast
Acorus calamus	Sweet flag	Leaves	Medicinal	Great Plains
Actaea racemosa	Black cohosh	Root	Medicinal	Northeast, Southeast
Actaea rubra	Red baneberry	Root	Medicinal	Great Plains
Adansonia digitata	Baobab tree	Wood	Crafts	Caribbean
Aglaia samoensis	Laga'ali		Cosmetics	Hawai'i
Albizia lebbeck	Woman's tongue		Crafts	Caribbean
Alliaria petiolata	Garlic mustard	Leaves	Edible	Invasive
Allium tricoccum	Ramps, leeks	Whole plant	Edible, medicinal	Northeast, Southeast
Alocasia macrorhiza	Giant taro	Tuber	Edible	Caribbean, Hawai'i
Aloe spp.	Aloe	Leaves	Medicinal	Southwest
Alyxia stellate	Maile	Leaves	Decorative	Hawai'i
Amelanchier alnifolia	Serviceberry	Fruit	Edible	Northwest
Apios americana	Ground nut	Tuber	Edible	Great Plains
Apios priceana	Price's potato-bean	Root	Edible	Midwest, Southeast
Annona muritca	Soursop	Fruit	Edible	Caribbean, Hawai'i
Arabidopsis thaliana	Mouseear cress			Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Areca catechu	Betel nut palm	Fruit	Medicinal	Hawai'i
Arisaema triphyllon	Jack-in-the-pulpit	Roots	Medicinal	Northeast, Southeast
Aristolochia serpentaria	Virginia snakeroot	Root	Medicinal	Great Plains, Midwest, Northeast, Southeast
Aristolochia tomentosa	Dutchman's pipe	Stem	Decorative	Southeast
Arnica cordifolia	Heartleaf arnica	Whole plant	Medicinal	Northwest
Artemisia tridentata	Sage brush	Leaves	Medicinal	Southwest
Artemisia vulgaris	Common wormword	Leaves	Medicinal	Alaska, Great Plains, Midwest, Northeast, Northwest, Southeast
Artocarpus altilis	Breadfruit	Fruit	Edible	Caribbean, Hawai'i
Artocarpus mariannensis	Dokdok	Fruit	Edible	Caribbean
Arundo donax	Giant cane	Stem	Decorative	Southeast
Asarum canadense	Wild giner	Root	Edible	Northeast, Southeast
Asclepias speciose	Milkweed	Fruit		Great Plains
Asimina triloba	Pawpaw	Fruit	Edible	Northeast, Southeast
Azadirachta indica	Neem	Leaves	Medicinal	Caribbean, Hawai'i, Pacific

(continued)

Appendix 4— *(continued)* Nontimber forest product species referenced in this assessment.

Scientific name	Common name	Harvested organ(s)	Usage(s)	Region
Bambusa vulgaris	Bamboo	Stem	Crafts	Southeast
Betula papyrifera	Paper birch	Bark	Decorative	Midwest, Northeast
Bischofia javanica	O'a		Dyes	Hawai'i, Pacific
Bixa orellana	Lipstick tree			Caribbean
Boletus spp.	Bolete	Fruiting body	Edible	Northwest
Bursera simaruba	Turpentine tree	Sap		Caribbean
Callitropsis nootkatensis	Yellow cedar	Wood	Crafts	Alaska
Camassia spp.	Camas			Caribbean
Cananga odorata	Moso'oi		Cosmetics	Hawai'i, Pacific
Cantharellus spp.	Chanterelles	Fruiting body	Edible	
Carapa spp.	African crabwood	Wood	Crafts	Caribbean
Castanea mollissima	Chinese chestnut	Seeds	Edible	Midwest, Northeast, Southeast
Caulophyllum thalictroides	Blue cohosh	Root	Medicinal	Great Plains, Midwest, Northeast, Southeast
Cedrela odorata	Spanish cedar	Wood	Crafts	Caribbean
Chamaelirium luteum	Fairywand	Root	Medicinal	Midwest, Northeast, Southeast
Cirsium edule	Thistle		Medicinal	Great Plains
Citrus x aurantiifolia	Key lime	Fruit	Edible	Southeast
Citrus x aurantium	Sour orange	Fruit	Edible	Caribbean
Cocos nucifera	Coconut	Fruit	Crafts, edible	Southeast
Coffea arabica	Coffee	Fruit	Edible	Hawai'i, Pacific
Collinsonia canadensis	Stone root	Root	Medicinal	Midwest, Northeast, Southeast
Colocasia esculenta	Taro	Tuber	Edible	Hawai'i, Pacific
Cordia alliodora	Spanish cedar	Wood	Crafts	Caribbean
Cornus sericea	Redosier dogwood	Stem	Decorative	Alaska, Great Plains, Midwest, Northeast, Southeast, Southwest
Corylus americana	American hazelnut	Fruit	Edible	Northeast, Southeast
Corylus cornata	Beaked hazel			Alaska, Northwest
Crescentia cujete	Common calabash tree			Southeast
Cryptosperma merkusii	Gallen			Hawai'i, Pacific
Cucurbita foetisdissima	Buffalo gourd	Tuber	Edible	Great Plains
Cuscuta spp.	Dodder			Great Plains
Cypripedium spp.	Lady's slipper	Whole plant	Landscaping	Southeast
Dennstaedtia punctilobula	Eastern hayscented fern	Leaves	Decorative	Northeast, Southeast
Dichelostenna capitatum	Bluedicks			West
Dionaea muscipula	Venus fly-trap	Whole plant	Medicinal, decorative	Southeast
Dioscorea spp.	Yam	Tuber	Edible	Hawai'i, Pacific
Dioscorea villosa	Wild yam	Tuber	Edible, medicinal	Great Plains, Midwest, Northeast, Southeast
Diospyros virginiana	Common persimmon	Fruit	Edible	Northeast, Southeast
Dodonae viscosa	A'ali'i			Hawai'i, Pacific
Echinacea angustifolia	Blacksamson echinacea	Root and herb	Medicinal	Great Plains, Midwest, Southeast, Southwest

(continued)

Appendix 4— *(continued)* Nontimber forest product species referenced in this assessment.

Scientific name	Common name	Harvested organ(s)	Usage(s)	Region
Echinacea pallida	Pale purple coneflower	Root and herb	Medicinal	Great Plains, Midwest, Northeast, Southeast
Echinacea purpurea	Eastern purple coneflower	Root and herb	Medicinal	Great Plains, Midwest, Northeast, Southeast, Southwest
Epilobium angustifolim	Fireweed	Seeds	Landscaping	Northwest
Epilobium latifolium	Dwarf fireweed	Seeds	Landscaping	Northwest
Ericameria nauseosa	Rubber rabbit bush			Southwest
Erythrina subumbrans	Erythrina	Leaves	Edible (fodder)	Hawai'i, Pacific
Eucalyptus globulus	Tasmanian bluegum	Essential oil	Invasive	Southwest
Euphorbia antisyphilitica	Candelilla	Sap	Medicinal	Southwest
Euthrochium spp.	Joe Pye weed	Leaves	Medicinal	Southeast
Fluegga acidoton	Simple leaf bushweed			Hawai'i, Pacific
Forsythia suspensa	Weeping forsythia	Stem	Decorative	Great Plains, Midwest, Northeast, Southeast, Southwest
Fragaria spp.	Strawberry	Fruit	Edible	Alaska, Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Frangula purshiana	Cascara buckthorn	Bark	Medicinal	Northwest
Fraxinus nigra	Black ash	Wood	Crafts	Northeast, Southeast
Fraxinus pennsylvanica	Green ash	Wood	Crafts	Northeast, Southeast
Fraxinus spp.	Ash	Wood	Crafts	Northeast, Southeast
Freycinetia arborea	Ie'ie			Hawai'i, Pacific
Furcraea foetida	Mauritius hemp	Fiber	Crafts	Caribbean
Galax urceolata	Galax	Leaves	Decorative	Southeast
Gaultheria shallon	Salal	Leaves	Decorative	Northwest
Gaylussacia spp.	Huckleberry	Fruit	Edible	Northwest
Geranium erianthum	Geranium			
Ginkgo biloba	Ginkgo	Leaves	Medicinal	Midwest, Northeast, Southeast
Guaiacum officinale	Lignum-vitae	Wood	Crafts, medicinal, ornamental	Southeast
Guarea guidonia	Muskwood	Wood	Crafts	Caribbean
Gymnoderma lineare	Rock gnome lichen	Whole plant	Medicinal	
Hamamelis virginiana	American witchhazel	Bark	Medicinal	Great Plains, Midwest, Northeast, Southeast
Helianthus tuberosus	Jerusalem artichoke	Tuber	Edible	Great Plains
Hepatica nobilis	Hepatica, liverwort			Midwest, Northeast, Southeast
Hibiscus tiliaceus	Sea hibiscus			
Hierochloe odorata	Alpine sweetgrass	Stem	Crafts	Great Plains, Northeast
Hydnum repandum	Hedgehog mushroom	Fruiting body	Edible	
Hydrastis canadensis	Goldenseal	Root and leaf	Medicinal	Great Plains, Midwest, Northeast, Southeast
Hymenaea courbaril	West Indian locust	Wood	Crafts	Caribbean
Hypnum curvifolium	Curveleaf hypnum moss	Whole plant	Decorative	Southeast
Hypnum imponens	Hypnum moss	Whole plant	Decorative	Southeast
Hypomyces latifolium	Lobster mushroom	Fruiting body	Edible	
Ilex verticillata	Common winterberry	Leaves, twigs	Decorative	Great Plains, Midwest, Northeast, Southeast
Inga laurina	Guamo			Caribbean

(continued)

Appendix 4— *(continued)* Nontimber forest product species referenced in this assessment.

Scientific name	Common name	Harvested organ(s)	Usage(s)	Region
Inga vera	River koko			Caribbean
Intisa bijuga	Ifilele	Wood	Crafts, canoe	Hawai'i, Pacific
Ipomoea leptophylla	Brush morning glory			Great Plains
Juglans nigra	Black walnut	Fruit	Edible, medicinal	Great Plains, Midwest, Northeast, Southeast, Southwest
Juniperus communis	Common juniper			Alaska
Juniperus virginiana	Eastern redcedar			Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Kalmia latifolia	Mountain laurel	Whole plant	Landscaping	Midwest, Northeast, Southeast
Ledum groenlandicum	Bog labrador tea	Fruit, leaves	Edible, medicinal	Alaska
Lentinula edodes	Shiitake	Fruiting body	Edible	
Ligusticum porteri	Osha	Root	Medicinal	Great Plains, Southwest
Liquidambar styraciflua	Sweetgum	Bark	Medicinal	Great Plains, Midwest, Northeast, Southeast, Southwest
Liriodendron tulipifera	Tuliptree	Bark	Siding	Great Plains, Midwest, Northeast, Southeast
Lithospermum incisum	Puccoon			
Lomatium bradshawii	Bradshaw's lomatium			
Lomatium dissectum	Fernleaf biscuitroot			Great Plains, Northwest, Southwest
Lomatium spp.	Wild celeries			
Lonicera spp.	Honey suckle			
Lupinus littoralis	Seashore lupine			
Lupinus nootkatensis	Noothka lupine			Alaska
Lupinus spp.	Lupines			Alaska, Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Lycopodium obscurum	Rare club moss			Northeast
Lycopodium spp.	Clubmoss	Whole plant	Decorative	Alaska, Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Lyonia ferrugina	Crooked wood	Stem	Decorative	Southeast
Lysichiton americanus	American skunkcabbage	Root	Medicinal	Alaska
Maclura pomifera	Osage-orange			Great Plains
Mahonia nervosa	Cascada barberry	Leaves, roots, stem	Decorative	Northwest
Mammea americana	Mamee apple	Fruit	Edible	Caribbean, Hawai'i, Pacific
Mangifera indica	Mango	Fruit	Edible	Southeast
Matelea biflora	Star milkweed			Great Plains
Matteuccia struthiopteris	Ostrich fern	Frond	Edible	Alaska, Great Plains, Midwest, Northeast, Southeast
Melicoccus bijugatus	Spanish lime	Fruit, wood	Charcoal, edible	Southeast
Metrosideros polymorpha	Ohia	Leaves	Decorative	Hawai'i, Pacific
Microlepia strigosa	Palapalai			Hawai'i, Pacific
Microstegium vimineum	Japanese stiltgrass		Invasive	Great Plains, Midwest, Northeast, Southeast
Morchella spp.	Morel	Fruiting body	Edible	
Morinda citrifolia	Noni	Fruit	Medicinal	Caribbean, Hawai'i
Moringa oleifera	Moringa	Leaves, pods	Medicinal	Caribbean, Hawai'i

(continued)

Appendix 4— *(continued)* Nontimber forest product species referenced in this assessment.

Scientific name	Common name	Harvested organ(s)	Usage(s)	Region
Morus nigra	Black mulberry	Fruit	Edible	Great Plains, Midwest, Northeast, Southeast
Muhlenbergia filipes	Sweetgrass	Leave	Crafts	Southeast
Muhlenbergia rigens	Deergrass			
Muhlenbergia sericea	Sweetgrass	Leaves	Crafts	Southeast
Musa spp.	Banana	Fruit	Edible	Caribbean, Hawai'i, Pacific
Myrciaria floribunda	Quava berry	Fruit	Edible	Caribbean
Nypa fruticans	Nipa palm	Leaves	Decorative	Caribbean, Hawai'i, Pacific
Oplopanax horridus	Devilsclub	Bark	Medicinal	Alaska
Opuntia polyacantha	Plains prickly pear			Great Plains
Panax quinquefolius	American ginseng	Root	Medicinal	Northeast, Southeast
Pandanus tectorius	Tahitian screwpine	Fruit, leaves, wood	Crafts, edible	Hawai'i, Pacific
Pediomelum esculentum	Prarie turnip	Root	Edible	Great Plains, Midwest, Northeast, Southeast, Southwest
Persea americana	Avocado	Fruit	Edible	Southeast
Phytolacca americana	American pokeweed	Young shoots	Edible, medicinal	Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Picea sitchensis	Sitka spruce	Tips	Edible, crafts	Alaska
Pimenta racemosa	Bayrum treet	Leaves	Cosmetics	Caribbean
Pinus contorta	Lodgepole pine			Alaska, Great Plains, Northwest, Southwest
Pinus edulis	Twoneedle pinyon	Seeds	Edible	Southwest
Pinus elliotti	Slash pine	Needles	Decorative	Southeast
Pinus jeffreyi	Jeffery pine			Southwest
Pinus monophylla	Singleleaf pinyon	Seeds	Edible	Northwest, Southwest
Pinus palustris	Longleaf pine	Needles	Decorative	Southeast
Pinus ponderosa	Ponderosa pine			Southwest
Pinus taeda	Loblolly pine	Needles	Decorative	Southeast
Piper methysticum	Kava	Fruit	Edible	Hawai'i, Pacific
Pleurotus ostreatus	Oyster mushroom	Fruit	Edible, medicinal	Alaska, Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Pluchea carolinensis	Cure-for-all			Caribbean
Podophyllum peltatum	Mayapple	Roots	Medicinal	Great Plains, Southeast
Polygonum cuspidatum	Japanese knotweed	Leaves	Edible	Invasive
Polystichum munitum	Western swordfern	Leaves	Decorative	Northwest
Populus balsamifera	Balsam poplar	Wood	Crafts	Alaska
Populus deltoides	Cottonwood			Great Plains, Southwest
Prosopis spp.	Mesquite	Wood	Cooking	Southwest
Prunus americana	American plum	Fruit	Edible	Great Plains
Prunus virginiana	Chokecherry			Alaska, Great Plains
Pseudotsuga menziesii	Douglas-fir	Branches, needles, tips, poles	Ceremonial, crafts	Northwest, Southwest
Pteridium aquilinum	Western brackenfern	Leaves	Edible	Alaska, Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Pycnanthemum spp.	Mountain mint			Great Plains, Midwest, Northeast, Southeast, Southwest
Quercus marilandica	Blackjack oak			Great Plains

(continued)

Appendix 4— *(continued)* Nontimber forest product species referenced in this assessment.

Scientific name	Common name	Harvested organ(s)	Usage(s)	Region
Quercus spp.	Oak	Wood	Crafts	Northeast, Southeast
Rhododendron maximum	Great laurel	Whole plant	Landscaping	Southeast
Rhododendron spp.	Azalea, rhododendron	Whole plant	Landscaping	Northeast, Southeast
Rhus glabra	Smooth sumac			Great Plains, Midwest, Northeast, Southeast, Southwest
Ribes bracteosum	Stink currant	Fruit	Edible	Alaska
Ribes lacustre	Prickly currant	Fruit	Edible	Alaska
Ribes laxiflorum	Trailing black currant	Fruit	Edible	Alaska
Roystonea regia	Royal palm	Fruit, leaves		Caribbean
Rubus arcticus	Arctic raspberry	Fruit	Edible	Alaska
Rubus armeniacus	Himalayan blackberry	Fruit	Edible	Northwest
Rubus idaeus	American red raspberry	Fruit	Edible	Alaska, Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Rubus leucodermis	Whitebark raspberry	Fruit	Edible	Alaska
Rubus spectabilis	Salmonberry	Fruit	Edible	Alaska, Northwest
Sabal palmetto	Cabbage palmetto	Leaves	Crafts	Southeast
Salix alba	White willow	Bark	Medicinal	Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Salix purpurea	Purpleosier willow	Stems	Decorative	Midwest, Northeast, Southeast, Southwest
Sambucus canadensis	American black elderberry	Fruit	Medicinal	Great Plains, Midwest, Northeast, Southeast, Southwest
Sanguinaria canadensis	Bloodroot	Root	Medicinal	Northeast, Southeast
Santalum paniculatum	Sandalwood	Wood	Crafts	Hawai'i
Sarracenia spp.	Pitcherplants	Whole plant	Decorative	Southeast
Sassafras albidum	Sassafras	Bark, leaves	Edible, medicinal	Northeast, Southeast
Serenoa repens	Saw palmetto	Fruit	Medicinal	Southeast
Shepherdia argenta	Silver buffalo berry	Fruit	Edible	Alaska
Smilax coriacea	Smilax			Caribbean
Solidaga spp.	Goldenrod			Great Plains
Sphenomersi chinensis	Chinese creeping fern			Caribbean
Spiraea virginiana	Virginia meadowsweet			Midwest, Northeast, Southeast
Stachytarpheta jamaicensis	Worrywine		Medicinal	Caribbean
Streptopus amplexifolius	Claspleaf twistedstalk	Fruit	Edible	Alaska
Streptopus roseus	Twistedstalk	Fruit	Edible	Alaska
Swetenia macrophylla	Mahogany	Wood	Crafts	Caribbean
Swetenia mahagani	Mahogany	Wood	Crafts	Caribbean
Symphoricarpus occidentalis	Western snowberry	Fruit	Edible	Southwest
Syringa spp.	Lilacs	Whole plant, flowers	Decorative, landscaping	
Tamarindus indica	Tamarind	Fruit	Edible	Caribbean
Taraxacum officinale	Common dandelion	Leaves	Edible	Alaska, Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Taxus brevifolia	Pacific yew	Bark	Medicinal	Northwest
Taxus canadensis	Canada yew	Bark	Medicinal	Northwest

(continued)

Appendix 4— *(continued)* Nontimber forest product species referenced in this assessment.

Scientific name	Common name	Harvested organ(s)	Usage(s)	Region
Terminalia catappa	Tropical almond			Caribbean
Terminalia carolinensis	Terminalia	Wood	Crafts	Caribbean, Hawai'i, Pacific
Teucrium canadense	American germander			Great Plains
Theobroma cacao	Cacao	Fruit	Edible	Caribbean, Hawai'i, Pacific
Thuidium delicatulum	Delicate thuidium moss	Whole plant	Decorative	Southeast
Thuja plicata	Western redcedar	Wood	Crafts	Alaska, Northwest
Tillandsia usneoides	Spanish moss	Whole plant	Decorative	Southeast
Tricholoma magnivelare	Matsutake	Fruit	Edible	Northwest
Trillium erectum	Red trillium	Whole plant	Decorative	Midwest, Northeast, Southeast
Trillium spp.	Trillium	Whole plant	Landscaping	Southeast
Tsuga heterophylia	Western hemlock	Wood	Crafts	Alaska
Tsuga mertensiana	Mountain hemlock	Wood	Crafts	Northwest
Tuber gibbosum	Truffles	Fruiting body	Edible	
Ulmus rubra	Slippery elm	Bark	Medicinal	Northeast, Southeast
Urtica dioica	Stinging nettle	Leaves	Edible, medicinal	Northwest
Usnea spp.	Beard lichen	Whole plant		Alaska, Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest
Vaccinium alaskaense	Alaska blueberry	Fruit	Edible	Alaska
Vaccinium angustifolium	Lowbush blueberry	Fruit	Edible	Midwest, Northeast, Southeast
Vaccinium edule	Highbush cranberry	Fruit	Edible	Alaska
Vaccinium myrtilloides	Velvetleaf huckleberry	Fruit	Edible	Great Plains, Midwest, Northeast, Northwest, Southeast
Vaccinium ovatum	California huckleberry	Branch tips, fruit, vines	Decorative	Northwest
Vaccinium oxycoccos	Bog cranberry	Fruit	Edible	Alaska
Vaccinium parvifolium	Red huckleberry	Branches	Decorative	Northwest
Vitis spp.	Grape vine	Vine	Decorative	Southeast
Vitis rotundifolium	Muscadine grape	Fruit	Edible	Southeast
Xanthosoma sagittifolium	White yam	Tuber	Edilbe	Caribbean
Xerophyllum tenax	Common beargrass	Leaves	Decorative	Northwest
Xylocampus granatum	Cedar mangrove			Caribbean
Yucca spp.	Yuca			Southwest
Zizania palustris	Northern wildrice	Seeds	Edible	Great Plains, Midwest, Northeast, Northwest, Southeast, Southwest

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Nontimber forest products (NTFPs) are fundamental to the functioning of healthy forests and play vital roles in the cultures and economies of the people of the United States. However, these plants and fungi used for food, medicine, and other purposes have not been fully incorporated into management, policy, and resource valuation. This report is a forest-sectorwide assessment of the state of the knowledge regarding NTFPs science and management information for U.S. forests and rangelands (and hereafter referred to as the NTFP assessment). The NTFP assessment serves as a baseline science synthesis and provides information for managing nontimber forest resources in the United States. In addition, this NTFP assessment provides information for national-level reporting on natural capital and the ecosystem services NTFPs provide. The report also provides technical input to the 2017 National Climate Assessment (NCA) under development by the U.S. Global Change Research Program (USGCRP).

Keywords: Climate variability, ecosystem services, nontimber forest products (NTFP), management, regulations.