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Assessment of Nontimber Forest Products in the United States Under Changing Conditions

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Assessment of Nontimber Forest Products in the United States Under Changing Conditions

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Contents

Acronyms

ABC
American Botanicals Council

AHPA
American Herbal Products Association

AMPGA
Alabama Medicinal Plant Growers Association

AMS
Agricultural Marketing Service

ANCSA
Alaska Native Claims Settlement Act

ANILCA
Alaska National Interest Lands Conservation Act

APHIS
Animal and Plant Health Inspection Service

BIA
Bureau of Indian Affairs

BLM
Bureau of Land Management

CBD
Convention on Biological Diversity

CITES
Convention on International Trade in Endangered Species of Wild Fauna and Flora

CNMI
Commonwealth of the Northern Mariana Islands

CSIRO
Commonwealth Scientific and Industrial Research Organization

DoD
U.S. Department of Defense

EPA
Environmental Protection Agency

ESA
Endangered Species Act

FIA
Forest Inventory and Analysis

FWS
U.S. Fish and Wildlife Service

GFDL
Geophysical Fluid Dynamic Laboratory

IPCC
Intergovernmental Panel on Climate Change

ITTA
International Tropical Timber Agreement

ITTO
International Tropical Timber Organization

IUCN
International Union of Conservation of Nature

MCPFE
Ministerial Conference on the Protection of Forests in Europe

MPSG
Medicinal Plant Specialist Group

MPWG
Montreal Process Working Group

NAICS
North American Industrial Classification System

NASS
National Agricultural Statistics Service

NASA
National Aeronautics and Space Administration

NCA
National Climate Assessment

NEPA
National Environmental Policy Act

NFMA
National Forest Management Act

NFS
National Forest System

NFWPCAP
National Fish, Wildlife, and Plants Climate Adaptation Partnership

NOAA
National Oceanic and Atmospheric Administration

NPS
National Park Service

NRAP
Northern Rockies Adaptation Partnership

NWOS
National Woodland Owner Survey

ODF
Oregon Department of Forestry

RPA
Forest and Rangeland Renewable Resources Planning Act

SRES
Special Report on Emissions Scenarios

SUSB
Statistics of U.S. Businesses

TFPA
Tribal Forest Protection Act

USACE
U.S. Army Corps of Engineers

USDA
U.S. Department of Agriculture

USVI
U.S. Virgin Islands

Executive Summary

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[1] (NCA) under development by the U.S. Global Change Research Program (USGCRP).

This assessment is the result of a collaborative effort by 60 scientists, professionals, and experts from the Forest Service, an agency of the U.S. Department of Agriculture (USDA), and other state and Federal agencies, NGOs, tribal forest stakeholders, private corporations, research institutions, and universities across the United States. Focal areas in this assessment include ecological, social, and cultural issues, as well as economic and regulatory analyses of NTFPs and impacts from climate variability and change on forest and rangeland NTFPs.

This NTFP assessment used an iterative process to elicit input from public, private, and tribal forest stakeholders, NGOs, academics, professional organizations, private corporations, and Federal agencies, culminating in a national stakeholder workshop. Stakeholder suggestions helped to frame the subject matter content and management options in the report, ensuring relevance for decisionmakers and resource managers. The assessment closely follows the Intergovernmental Panel on Climate Change (IPCC) process, which is organized with convening lead authors, lead chapter authors, and contributing authors. The convening authors were responsible for having all chapters peer reviewed, and the lead authors and contributing authors revised the text in response to reviewer comments.

The introduction to this NTFP assessment provides an overview of the findings and discusses interrelated aspects of the biophysical, social, cultural, economic, and policy dimensions of nontimber forest products and the implications of the effects of climatic variability and change for them. This is followed by chapters synthesizing the state of knowledge on these topics:

- Products and production
- Ecological dimensions
- Cultural dimensions
- Social dimensions
- Economics
- Laws, policies, and regulations
- Implications in an era of changing climate

Appendixes summarize selected NTFPs relative to geographic regions across the country.

Concluding whether observed trends or changes in ecological phenomena are the results of climatic variability or other factors is difficult. Regardless, NTFPs of the United States at the end of the 21st century may be significantly different than those of today due to changes resulting from stressors such as drought, fire, insects and disease, and climatic variability.

We discuss in the following sections important issues that emerged from the assessment, including a brief summary of regional issues.

Effects of Climatic Variability on Nontimber Forest Resources

Variability in temperature and in seasonality will alter the growing environment for plants and fungi harvested for nontimber forest products throughout the United States. This may reduce the range and abundance of some while increasing those for others. Physical and phenological characteristics of plants and fungi will change in response to altered climatic conditions, which in turn affects their availability and suitability for use.

The relationships between individual species and their associated environments will condition their responses to climatic variability. Likewise, changes in the overall ecology of forests will affect NTFP species, as many

[1] In preparation, Fourth National Climate Change Assessment. For more information, see https://www.globalchange.gov/nca4.

of the products are derived from trees or understory species strongly influenced by the forest overstory. Predicted effects on forest ecology with implications for these products include changes in the volume and timing of precipitation, frequency and intensity of disturbances (e.g., wildfires, storms, insects and disease outbreaks), and changes in forest productivity.

Some NTFP species are ephemeral or have their desired properties for only brief periods during a year. Altered phenology (the timing of stages in life cycles) and phenological asynchronies (decoupling of previously co-occurring life stages in different species) as a result of changes in seasonality will have adverse consequences for supply and ecological viability. For example, early arrival of spring may induce flowering before pollinators are present or increase risk of frost damage, conditions that would impede fruiting.

Nontimber forest product species that occur in specialized habitats or climatic conditions likely will be more vulnerable to variability than those that grow across a range of conditions. Most models project that species habitat will move up in elevation or northward in latitude as suitability of those at lower elevations and latitudes declines. Populations of species that do not keep up with the pace of change will decline, be extirpated, or go extinct. Responses to climatic change along with harvest pressure may increase risk for some populations and species.

Effects of Climatic Variability on Social, Cultural, and Economic Values

Ecological shifts that condition NTFP availability will affect their utility as social, cultural, and economic resources. Nontimber forest products make microeconomic and macroeconomic contributions through nonmarket and market means, including both informal and formal markets. NTFP consumers and enterprises already face uncertainties, and climate change may add additional risks. Increased fluctuations in price and supply of commercially traded plants and fungi have the potential to increase seasonal unemployment, decrease household incomes and business profits, and increase dependence on social safety net programs.

Demand for wild plants and mushrooms may be influenced by climatic variability. For example, climate-induced migration and accompanying economic distress could increase the numbers of people who depend on NTFPs as direct sources of food, fuel, and utilitarian materials. At the same time, some nontimber forest product-based opportunities likely will arise as a result of climatic change. In some cases, changing conditions may favor the presence of new species or increases in the population of previously scarce species. Where this occurs, it could result in increased supplies for subsistence, personal consumption, and sale in unprocessed and value-added forms.

Changes associated with altered climate also may impact cultures in significant ways. Among the contributions of NTFPs to human well-being that may be at risk are the roles NTFPs play in food security, social cohesion, and livelihoods. Among the diverse American peoples who will be affected, particular attention will be required to comply with laws relevant to the cultural values of plants and mushrooms to American Indians, Native Hawaiians, Alaska Natives, and other indigenous populations. The resilience of cultures and their nontimber forest product-based practices may be a function of the intensity, speed, and duration of events that pose ecological or social challenges.

Nontimber Forest Product Regulations and Policies

The use, conservation, and protection of nontimber forest products in the United States are governed through policies and regulations promulgated at levels from municipalities to Federal and tribal governments, as well as nonbinding international agreements. Laws and policies have been driven by objectives that include preventing the spread of diseases and invasive species, assessing taxes, and protecting endangered species. In some states, laws and policies relative to NTFPs have ensured access to these products by Native peoples, while restricting access by others.

Recognition of NTFPs as important natural resources and NTFP integration into policy and management across jurisdictions remain a challenge for sustainable use and conservation. Consequences of this may become more acute as a result of climatic variability. Challenges to crafting appropriate regulations and administrative structures include limited ecological, social, and economic knowledge and the diversity of stakeholders affected by them.

Addressing these challenges will require attention to the diversity of land ownerships, ecologies, and cultures in the United States. Adaptive policy and management approaches suited to the scales at which they will be implemented (i.e., local, regional, national) will increase the likelihood for successful outcomes. Opportunities include ongoing dialog with stakeholders and making special efforts to include those most likely to be overlooked. Baseline information about species and their habitats, coupled with models of their likely response to climatic change, will provide needed ecological information. Adaptive strategies may include management programs such as developing populations of NTFP species in suitable new habitats with careful attention to social and ecological considerations. Assisted migration to new habitats is a deliberate effort to establish populations in areas that are expected to have a suitable climate in the future to at least partially offset losses on sites no longer suitable. However, the effectiveness of widespread assisted migration is not yet known, and some have expressed concerns about the risk of introducing invasive species (Vose et al. 2016). One way to resolve the debate is to subdivide assisted migration into "rescue-assisted migration" and "forestry-assisted migration" (Peterson et al. 2013). Rescue-assisted migration moves species to minimize the risk of extinction and extirpation given climatic impacts and is the source of most of the controversy. Forestry-assisted migration aims to maintain high productivity and diversity in forest species that are commercially, socially, culturally, or ecologically valuable (Peterson et al. 2013).

Regional Effects of Climatic Variability and Change on Nontimber Forest Products

This assessment incorporates regional perspectives and highlights key issues for NTFPs in NCA regions in the United States.

Alaska

- Subsistence harvest of the products is a cultural tradition with important economic implications for Native and other rural households and communities.
- The Alaska National Interest Lands Conservation Act of 1980 (ANILCA) establishes that all rural residents be given "reasonable access to subsistence resources including nontimber forest products on the public lands."
- Harvest and use of traditional foods provide connections to place, belief, and history that are particularly critical to maintaining Native culture and identity.
- Warming temperatures and sea level rise already are affecting the products and people who rely on them.

Hawai‘i and the Pacific Territories

- Native Hawaiians have the right to gather NTFPs for subsistence purposes; this right is codified in the Hawai‘i State Constitution.
- Pacific Island cultures have a rich ethnobotanical tradition, with 60 plant species said to be useful as medicine in just one Marshall Island village.
- Increased frequency and severity of storms, drought, and wildfires will impact forest habitats; high-elevation ecosystems in Hawai‘i already show effects of drought.
- Key products are at risk from saltwater intrusion from sea level rise and storm surges.
- Mangrove forests and the nontimber products harvested from them are expected to shrink due to sea level rise.

Northwest

- Quality and abundance of many NTFPs are associated with distinct post-disturbance (i.e., fire, wind storms) stages and will be affected as disturbance frequency and severity shift.
- Ecological or climatic niches of the species may shift outside the areas covered by current governance structures, with particular consequences for treaty-guaranteed rights.
- Food resources of special importance to tribes are at risk as a result of prolonged drought and altered fire regimes.
- Commercially and culturally important mushroom species are susceptible to changes in temperature and precipitation, and the effects these changes have on forest health.

Southwest

- Prolonged drought and changes in precipitation and temperature are adversely affecting NTFP food resources such as pinyon pines (*Pinus* spp.) that produce the edible pine nut.
- Increasing extent and severity of wildfires, coupled with insect-induced mortality of conifer trees, are impacting forests and the habitat of many nontimber species.

- California Indian tribes have reduced access to key cultural foods (e.g., acorns, nuts, berries) resulting from climate-related drought, disease outbreaks, and regulations.
- Forest managers and communities and cultures dependent on NTFPs are challenged to find mutually agreeable strategies to increase resilience in the face of climate-induced disturbances and wildfire response.

Great Plains

- A common practice shared by all tribes in the region was the gathering of native plants for food, medicine, religious rites, or material culture. Many of these plants are grassland species, the dominate vegetation in the region.
- Changes in temperature and precipitation regimes will have dramatic effects on agricultural crops as well as native plants.
- Studies of the flowering phenology patterns of 178 native plant species in North Dakota over 100 years found significant shifts in earlier emergence from dormancy, which can make plants more susceptible to spring freezes.
- Plant species may be more or less sensitive to changes in temperature and precipitation, but even small shifts in timing can disrupt ecological balances in natural systems.

Midwest

- Longer growing seasons and shorter, warmer winters will benefit some species but are detrimental to others, especially species that depend on cold cycles for their reproduction.
- 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 habitats, with wild rice in the Great Lakes region particularly at risk.
- The extent of the populations of some species, such as black cohosh, likely will be reduced with drier climate regimes and lower soil moisture.
- Climate variability impacts will be amplified by increased pressure from pests and pathogens, with implications for culturally and commercially important species including black ash, black walnut, and slippery elm.
- Boreal forests of the upper Midwest may disappear by the end of the century, impacting the livelihoods of thousands of seasonal workers who harvest balsam fir branches.

Northeast

- Rising temperatures and changes in snowfall and ice and snow melt will affect species such as ostrich fern, which is harvested for the edible fiddlehead.
- Area of spruce-fir forest habitat and associated nontimber species is expected to decline.
- The Northeast leads the Nation in maple syrup production, with an average annual production of 2.37 million gallons between 2008 and 2013. Production is expected to be adversely impacted by earlier springs and changing freeze-thaw cycles. Higher spring temperatures may shift production earlier in the season and reduce the number of sap flow days, with overall production predicted to decline by 15 to 20 percent.
- Species that depend on leafless overstories for photosynthesis and reproduction may be imperiled by early spring onset and the advanced timing of leafout on trees.

Southeast

- Coastal species such as sweetgrass (*Muhlenbergia capillaris* (Lan.) Trin) are especially vulnerable to sea level rise and saltwater incursions.
- The important medicinal forest product, saw palmetto (*Serenoa repens*), that grows throughout Florida, is particularly vulnerable to sea level rises.
- Increased frequency and intensity of extreme weather events may result in significant changes to habitat that favor some nontimber species while eliminating others.
- Spring ephemeral forest herbs that are affected by small changes in temperature and moisture will be vulnerable to altered seasonality, temperature, and precipitation.

- Many NTFP species in upland mountain regions are at their southern extent and may be extirpated as suitable habitat conditions shift north, impacting overall species diversity.

Managing Nontimber Forest Products to Increase Resiliency

NTFPs have supported the peoples and cultures of the United States and its affiliated territories since before the founding of the Nation. The earliest people to inhabit the forests of this Nation used these products for food, medicine, and essential sundries. Harvesting from natural populations of the plants and fungi, commonly referred to as wild-harvesting, continues to sustain personal and commercial consumption of these products. Cultivation, including forest farming of native plants, provides alternatives to wild-harvesting. The products are sources of income for people with limited options for other earnings and are the foundation for rural community-based enterprises to multinational corporations.

The plants and fungi species whence the products originate are diverse. They range from long-lived species such as trees to ephemeral forest herbs that are only available for harvest during a short time each year, and from rare to very common species. Each will respond in distinct ways to climatic changes, but many share commonalities that will propel these responses and limit the repertoire of possible mitigation strategies. Nontimber forest resources will be impacted at the ecoregion (Southeast Regional Summary, appendix 1), landscape, forest-type (Northeast Regional Summary, appendix 1), watershed, stand, community, and species levels, with associated impacts to humans who collect and use the plants and fungi as disturbance regimes change in response to climate, especially extreme weather, prolonged drought, and increased fire events (Millar et al. 2007). Complete reorganization of forest structure, or a major ecological shift from forest to shrub or grassland, could reduce or eliminate desired products. Conversely, the reorganization could increase productivity for other species.

The possibility that many nontimber forest species may not be able to keep pace with the ecological shifts or be able to effectively colonize new areas with more favorable ecological conditions due to limited dispersal mechanisms and other factors (Davis et al. 2005; see chapter 3) is a major concern among forest ecologists. Habitat loss and fragmentation may severely limit the ability of some species to migrate. Forest management plans, prescriptions, and practices that integrate nontimber species that are climatically suitable to future conditions would lead to improved forest productivity, resilience, and health.

Assisted migration may be an option to secure some species in the medium term (Svenning et al. 2009). Some species might be planted in agroforestry settings, to make use of favorable environmental microcosms created by associated trees (Boothroyd-Roberts et al. 2013, Lugo 1997). Assisted migration of nontimber forest species should aim to maintain genetic diversity within populations and promote gene flow between populations. Experimentation with assisted migration of some tree species is occurring in parts of northern Minnesota with the pilot Adaptation Forestry Project[2].

Silvicultural prescriptions might be tailored to manage for nontimber forest products. In general, the silviculture of naturally regenerated forests is designed to provide multiple goods and services that could include these products. The diversity of species and functional groups dictates the need for management plans that consider a broad range of biotic, abiotic, and social factors for success. While a balance between spatial, temporal, and economic scales must be maintained, an increase in management complexities can be expected with integration of NTFPs. The plants and fungi facilitate maintenance of ecosystem processes by contributing to structural, compositional, and functional diversity of forest habitats. Including them in silvicultural prescriptions will help to strengthen forest health and well-being.

Diversification and intensification through sustainable management of NTFPs may help offset some negative economic and ecological effects of climatic variability. Forest farming (an agroforestry practice) has been suggested as an alternative income source for private forest landowners, as well as an approach to conserve natural populations that are wild-harvested (see chapter 2) (Schoeneberger et al. 2017). The intentional cultivation and reintroduction of species of vulnerable NTFPs

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[2] The Nature Conservancy. Adaptation forestry in Minnesota's North Woods. Available at: https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/minnesota/howwework/adaptation-forestry-nemn-factsheet.pdf. [Date accessed: 21 August 2017]

may reduce pressure on natural populations and may assist in reforestation efforts in impacted forests.

Some NTFPs are responding to altered conditions attributable to changing climate such as saltwater incursion (see Hawai'i Regional Summary) and permafrost thawing (see Alaska Regional Summary). These responses can be expected to intensify and include moving northward (including north of the U.S.-Canada border), establishing at higher elevations, and adapting in place. Changes in the composition of communities of these plants and fungi will permanently affect forest health and ecology, the social and cultural fabric of the people who benefit from these resources, and the economies that depend on the sustainable harvest of the materials. There are clear and defined actions that can be taken now to help mitigate from impacts of climatic variability and change on these important natural resources.

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CHAPTER 1

Introduction

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The plants and fungi that are harvested from forests for purposes other than timber are not fully incorporated into management, policies, or resource valuation. These nontimber forest products (NTFPs) have important social, economic, and ecological values and they are integral to the culture of the people of the United States. The plants and fungi are fundamental to the functioning of healthy forests and are essential for the resilience of these ecosystems.

NTFPs are used for myriad purposes, providing cultural, social, and economic functions. People harvest and use these products for food, medicine, arts and crafts, and religious and cultural rituals. They also harvest, trade, and sell NTFPs in local to global markets. Harvesters represent a wide swath of the population, across generations, cultural groups, and sectors of society. This national NTFPs assessment provides the state of knowledge regarding the plants and fungi that comprise NTFPs and the people and markets that rely on them. The assessment also identifies challenges that climate variability and change may pose to these resources and to the services they provide.

In chapter 2, the assessment provides an overview of the diversity of products harvested in the United States as well as their means of production. Most NTFPs are harvested from natural populations across a mix of land ownerships. An estimated 20 to 25 percent of the United States population harvest NTFPs for personal use, and collection occurs on close to a quarter of family forest lands (Butler 2008, Butler et al. 2016, Cordell and Tarrant 2002). The industry can be divided into five broad market segments: culinary products, medicinal and dietary supplemtents, decorative products, nursery stock and landscaping, and fine arts and crafts. American ginseng (*Panax quinquefolius* L.; figure 1.1) is the iconic medicinal forest product; more is known about this forest herb than any other medicinal plant because of its long standing and widespread commercial harvest and its listing in appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Chamberlain et al. 2013b). Common beargrass (*Xerophyllum tenax* (Pursh) Nutt.), a nontimber product from Pacific Northwest forests, is a prime example of a decorative product. Research on this species has demonstrated the importance of integrating traditional ecological knowledge and scientific knowledge into NTFP management (Hummel and Lake 2015, Hummel et al. 2012). Bareroot stock of Fraser fir (*Abies fraseri* (Pursh) Poir.), endemic to northwest North Carolina, is an example of the nursery stock and landscaping segment of the industry. Baskets of white birch bark are emblematic of NTFPs used for fine

Figure 1.1—American ginseng (*Panax quinquefolius* L.) is the iconic medicinal nontimber forest product. More is known about this forest herb than any other medicinal plant because of its long-standing and widespread commercial harvest and its listing in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. (Photo credit: Gary Kauffman, U.S. Department of Agriculture, Forest Service.)

arts and crafts (Emery et. al. 2014). Each geographic region in the United States also has its own culinary icon—maple syrup in the Northeast; fiddleheads (ostrich fern; *Matteuccia struthiopteris* (L.) Todaro) in Maine; pine nuts in the Southwest; mushrooms in the Northwest; ramps (*Allium tricoccum* Ait.) in the Southern Appalachia; and tropical fruits throughout Hawai'i, the Caribbean, and other island areas.

Standard silvicultural practices can be used to improve production of NTFPs, although there is little science-based management of the resources for these products. Forest farming, an agroforestry practice, can provide additional revenue for landowners who grow NTFPs under forest canopies. For most NTFP species, the science of forest farming is not well-developed, but there are many practical guidelines to lead implementation (Chamberlain et al. 2009, Mudge and Gabriel 2014). Forest farming of a few species, such as American ginseng and goldenseal (*Hydrastis canadensis* L.), has been occurring for over 100 years and is well-developed and understood. These model species provide valuable insights for other nontimber forest species.

Most NTFP species are harvested from natural populations, and the potential ecological impacts of harvesting, the possibilities for sustainable harvest, and some of the challenges that may impact NTFPs from climatic variability are discussed in chapter 3. The harvest of the plants and fungi can have impacts at multiple ecological scales—individuals, populations, communities, ecosystems, and landscapes (Ticktin 2004, 2015). The resilience or vulnerability of NTFP populations to harvest depends on the ecological, management, and social context of harvest.

The type of organ (e.g., roots and leaves) harvested and the plant's life history are two important factors that influence a species' potential resilience or vulnerability. The extraction of flowers, fruit, and seeds of long-lived perennials like trees has very high potential for sustainable harvest. Conversely, long-lived perennials tend to be highly sensitive to practices that impact adult survival (Franco and Silvertown 2004); therefore the harvest of bark, roots, rhizome, and bulbs, which leads to mortality of adult individuals, may have large negative impacts on population persistence (Chamberlain et al. 2013a, Schmidt et al. 2011). Almost all medicinal NTFPs that are commercially harvested are valued for their underground organs or for the whole plant (Alexander et al. 2011), and evidence indicates that these species can sustain only very low levels of harvest.

Harvest timing and management methods are important in determining the potential for sustainable harvest. Weed control, overstory manipulation, and replanting germplasm can increase growth, survival, and/or regeneration of natural populations. The seasonal timing of harvest; timing of harvest in the plant life cycle; and the frequency, intensity, and methods and size of harvest (e.g., Albrecht and McCarthy 2006, Sanders and McGraw 2005, Van der Voort and McGraw 2006) have ecological implications on natural populations. These practices are often part of traditional or local ecological knowledge and practice systems and can improve management efforts (Anderson 2005, Turner et al. 2000).

Sustainability of NTFP harvests requires understanding individual species and populations, as well as maintaining interspecific interactions, resistance to herbivore pressure, resilience to natural and anthropogenic disturbances, appropriate landscape management, and competing land uses or management objectives.

Climatic variability may present significant threats to forest-based plants and fungi species that are harvested for their nontimber products (figure 1.2). Predicted shifts in species distributions and phenology as a result of climatic variability may affect their production and ecology. Many NTFPs have wide distributions, although they may be adapted to local conditions, which may narrow their thermal niche, thus increasing vulnerability (Atkins and Travis 2010). Species composed of many locally adapted populations may be less likely to follow conditions of those natural sites as climate changes (Davis et al. 2005). Many species have limited seed dispersal distances, which increases the likelihood of local adaptation (Bennington and McGraw 1995, McGraw 1985), and increases their vulnerability to climatic variability (Davis et al. 2005, Etterson 2004).

NTFPs that are characterized by slow growth, long regeneration times, and low rates of reproduction will be slower to adapt to climatic variability than species that disperse seeds over long distances (Souther and McGraw 2014). Adaptation potential may be further reduced when harvest has decreased genetic variation, as this variation is a requisite for evolution to occur. Nontimber forest species are potential candidates for *ex situ* conservation programs, such as managed

Figure 1.2—Morel mushrooms (*Morchella* sp.). Mushrooms may be particularly susceptible to climatic variability and changes in disturbance regimes. (Photo credit: Michelle J. Baumflek, U.S. Department of Agriculture, Forest Service.)

relocation, but the relative benefits and risks of this conservation strategy need to be fully examined.

In addition to ecological considerations, NTFPs provide provisioning and cultural ecosystem services through contributions to food and health security, livelihood strategies, and spiritual and ceremonial observances, which may be affected by climatic variability (see chapter 4). The centrality of NTFPs for indigenous cultures is illustrated by a 1905 U.S. Supreme Court decision, which described access to such resources as "not much less necessary to the existence of the Indians as the air they breathe" (U.S. vs. Winans 1905). NTFP uses by other U.S. cultural groups include traditional knowledge systems and practices adapted from their place of origin, as well as knowledge learned from indigenous peoples (Turner and von Aderkas 2012), which together may help sustain the cultural identity and resilience of these communities, whether they have been in the country for generations or a few years. Loss of access to NTFPs as a result of climatic variability may present significant risk to cultural survival and material well-being of both individuals and groups (Emery et al. 2014, Garibaldi and Turner 2004).

Changes in spatial and temporal distributions of plants and fungi as a result of climatic variability may have some of the most immediate consequences. Changes in suitable habitat may mean that culturally important species are no longer available within the treaty territory of a tribe or become effectively inaccessible (Ginger et al. 2011). Observances central to cultural identity and the transmission of cultural knowledge may be compromised by shortages in species whose life cycles are dependent on particular climatic conditions. Altered seasonal variations in temperature and precipitation may result in phenological asynchronies that reduce the effectiveness of traditional ecological knowledge or result in a decline in the availability of species at key moments in culturally-defined livelihood cycles. The physical properties of NTFPs also may be altered by changes in hydrology and temperature or by pests and diseases. Increased climate variability also may affect the social structures and values of NTFPs through processes such as increased demand for species as a result of disruptions in food and medicine supplies or displacement and migration of peoples.

A full understanding of the role of NTFPs requires examination of additional social dimensions (chapter 5), including harvester demographics, knowledge, and stewardship practices. NTFP harvesters often possess extensive local and traditional knowledge and including them in planning for climatic variability offers an opportunity to improve management and governance outcomes. Many harvesting communities may be marginalized due to socioeconomic class, language challenges, or cultural barriers (Emery and Barron 2010, Watson 2010), however, and particular effort will be necessary to assure their participation in such planning.

NTFPs contribute to the economy of this country (chapter 6). They provide part-time and full-time income and employment and can provide viable returns on investment. The products' market values can mitigate economic risks of low-income households, while their nonmarket values provide for subsistence, as well as cultural and recreational benefits. Changes in climate and related stressors may have significant impacts on these and other economic factors.

Some NTFPs have formal markets, while others are traded through informal markets. Harvest volumes of American ginseng are reported and tracked because it is regulated by an international convention. Other highly valued NTFP commodities (e.g., maple syrup, blueberries, moss, and lichens) are tracked by the U.S. Department of Commerce or the National Agricultural Statistics Service. However, the harvest of most NTFPs is neither tracked, monitored, nor recorded, making estimates of volumes and value of trade next to impossible.

Estimating a comprehensive value of NTFPs to the economy is challenging, as many products are traded in informal markets and collected for personal use (McLain et al. 2008). Products traded in the formal economy are easier to value, but still challenging. Using harvest permit data from Forest Service and U.S. Department of the Interior, Bureau of Land Management, Chamberlain et al. (2018) used methods developed by Alexander et al. (2011) to estimate the total wholesale value of NTFPs, which averaged approximately $253 million for the ten years (2004-2013) analysed.

NTFPs can play an important role as a revenue stream for forest landowners and landless households. Input costs for people who harvest from natural populations involve labor, transportation, equipment, and possibly permit fees to access the resource. Forest farming may involve higher input costs and the opportunity cost of the land needed for production. The opportunity cost of labor makes forest farming of some NTFPs not particularly profitable. Forest farming high-valued NTFPs, however, may be viable and coproduction of timber and nontimber products can improve profitability of forest operations, as well.

NTFPs also contribute monetary, and nonmonetary benefits to households. People derive value from harvesting for recreational or cultural purposes. Households may turn to NTFPs in times of economic crisis, such as when coal mines temporarily close (Bailey 1999) or when economic shocks affect individual households. The products also are used to build and maintain social capital, indirectly contributing to another household strategy for dealing with risk. Gift-giving and fundraising can strengthen local social capital (Baumflek et al. 2010, Emery et al. 2006). NTFPs contribute to household well-being by improving nutritional status, food and healthcare sovereignty, inputs to household maintenance, and the quality of recreational and cultural life.

There is much uncertainty in terms of the true economic impact of climatic variability on NTFPs. Extreme weather events may cause acute (short-term but strong magnitude) impacts. During more frequent crises, communities may rely more heavily on NTFPs, or they may lose access to NTFP resources due to declines in populations or changes in their natural habitats. Thus, there is a risk of an added economic impact that may adversely affect those communities in crises.

Finally, the regulatory landscape for managing NTFPs is as complex as the broad spectrum of harvesters, users, species, and products. Regulations and policies that address access to, management, extraction, trade, or conservation of NTFPs exist at multiple governmental levels (chapter 7). Many national legal and administrative frameworks that impact NTFPs pertain to controlling their harvest based on protected status, commodity type, or the purpose of the extraction. Early approaches resulted in regulations to restrict access, prevent spread of plant disease or invasive species, or assess taxes for commerce. Reserved federally recognized rights of American Indians and Alaska Natives, and state-level subsistence regulations increase the complexity for balancing the rights to harvest with the need to conserve the resources.

The major principles shaping national regulations and policies stem from the shift to ecosystem-based management in the 1990s to recent efforts to be more inclusive in conservation of the resources. Several national laws relevant to NTFPs apply across all agencies, and the major land management agencies are governed by specific regulations and have operating policies that shape their behavior with respect to NTFPs. Different international and Federal policies are applicable to indigenous and tribal peoples to access, use, and conserve NTFPs. The variety of agencies and expertise involved in the regulation of the products and the policies generated from them are variable and distinct to each State, and may range from no specific regulations to a complex regulatory environment incorporating NTFPs within natural resource management regulations. County and municipal-level regulations are expected to comply with overarching Federal, tribal, and state-level regulations and may be based on laws that delineate conversion of land uses that affect forest cover.

NTFP policies and regulations exist within complex and dynamic socioecological governance systems. Development of policies for the sustainable use and access of NTFPs are complicated by lack of species-specific biological information on how much harvest pressure species can withstand while remaining viable elements of forest ecosystems. Natural resource policy recognizes the merits of community-based conservation and the reliance of communities on natural resources for health, subsistence, and economic needs. Participation in international dialogues regarding NTFPs provides opportunities for a broader understanding of the conservation and management of these resources.

The forest plants and fungi that provide nontimber products are rarely considered in national climate change research and discussions and are underrepresented in related policies. Potential impacts must often be inferred from forest-level studies that focus on predominant tree species. Few policies and assessments address the dependence of forest-based communities on NTFPs and the vulnerability of associated social, cultural, and economic systems to climatic variability. This report takes an important first step, by providing a comprehensive assessment of the multiple dimensions NTFPs, the ecosystem goods and services they provide, and the threats that climate variability and change may pose to their long-term availability.

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CHAPTER 2

Nontimber Forest Products and Production

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2.1 Nontimber Forest Products and their Production

Many products are harvested from U.S. forests that are not derived from timber. These nontimber forest products (NTFPs) are called by many names; regardless of the term, they are products made from plant materials and fungi that are found in the forest soils and throughout the aboveground vegetation, from the duff to the topmost tree canopy. The products are collected for many reasons, including personal enjoyment, cultural and spiritual importance, and commercial gain.

This chapter explores fundamental aspects of the products and their production, in natural and in managed forests. The first section (2.1) explores the terminology, the scale of harvesting, and the product markets. Nontimber forest products contribute to markets that expand the definition of forest products beyond traditional timber industry. Silvicultural practices for timber production are well developed and as discussed in section 2.2 are applicable and appropriate for nontimber products, as well. Forest farming (section 2.3), an agroforestry practice, is viewed as an approach to generate additional income and to conserve natural populations of NTFP species. A brief assessment of the markets and economics is provided in section 2.4, and the reader is directed to chapter 6 for a more comprehensive assessment of the economics. NTFPs occur throughout contiguous United States, Alaska, Hawai‘i (section 2.5), and the Caribbean and insular areas of the United States (section 2.6). In the United States there are well-developed systems to inventory trees in forests, yet as discussed in section 2.7 the inventory and analysis of nontimber forest resources is lacking. Methods and strategies for tracking and monitoring NTFPs are explored in section 2.8. Gaps in knowledge are identified in section 2.9, while possible impacts of climate variability are explored in section 2.10. Key findings (section 2.11) and key information needs (section 2.12) are highlighted. A brief set of conclusions (section 2.13) summarizes the chapter.

2.1.1 What Are Nontimber Forest Products?

Nontimber forest products are referred to by many names, including nontraditional, special, specialty, minor, as well as secondary products. We use the definition that NTFPs originate from plants and fungi that are harvested from forests. The products come from forest herbs, fungi, lichens, mosses, shrubs, vines, as well as trees.

The U.S. Department of Agriculture, Forest Service (2001) refers to these products as special forest products (SFPs) and defines them as:

“products collected from National Forest System land that include, but are not limited to, bark, berries, boughs, bryophytes, bulbs, burls, Christmas trees, cones, epiphytes, fence material, ferns, firewood, forbs, fungi (including mushrooms), grasses, mine props, mosses, nuts, pine straw, posts and poles, roots, sedge, seeds, shingles and shake bolts, transplants, tree sap, rails, and wildflowers. Special forest products do not include animals, animal parts, cull logs, derrick poles, house logs, insects, minerals, non-saw log material removed in log form, pulpwood, rocks, sawtimber, small roundwood, soil, telephone poles, water and worms.”

Although the preceding definition is specific to national forests, it can be applied to all nontimber forest products. In 2000, the U.S. Congress directed the Secretary of Agriculture to implement a program to collect fees for the harvest and sale of “forest botanical products” (DOI appropriations 2000, 2004, 2008, 2010, 2014; see chapter 7, section 7.2.3). The U.S. Department of the Interior, Bureau of Land Management (BLM) uses the term special forest products and describes the products as “vegetative material found on public lands that can be harvested for recreation, personal use, or as a source of income” (BLM 2014).

For this assessment, NTFPs, SFPs, and FBPs (forest botanical products) are synonymous. Appendix 4 identifies forest plant and fungi species that are presented in the chapters of this national NTFP assessment. The list is neither exhaustive nor comprehensive but illustrative of the diversity of species, organs, uses, and geographic distribution. More than one-half of the 350 plus plant and fungi species identified are found in tropical areas, yet NTFPs from temperate forests are diverse and plentiful as well. Across all forest ecosystem landscapes, a vast number of plants and fungi are being harvested for their nontimber values. The great variety of products amplifies the complexities of social and cultural dimensions that affect economic and ecological dynamics. To fully comprehend these requires an initial understanding of the products and their production.

2.1.2
Plant and Fungi Organs Used

Many different parts (organs) of plants and fungi are harvested for nontimber products that are valued for monetary gain or personal enjoyment. These include the roots, tubers, leaves, bark, twigs and branches, fruit, and sap, as well as small-diameter wood for firewood and arts and crafts. The fruiting body of mushrooms and other fungi are used for food and medicine. In some cases, such as ramps (*Allium tricoccum* Aiton) the entire plant is removed and consumed. Likewise the entire plant of goldenseal (*Hydrastis canadensis* L.) is harvested and separated into aboveground (leaves and stems) and belowground (roots and rhizomes) parts, which are used differently for medicinal purposes.

The roots and/or rhizomes of many plants are harvested to make medicinal products. Roots of American ginseng (*Panax quinquefolius* L.) have been harvested commercially for more than 250 years from eastern hardwood forests for their value as an herbal medicine. Of the 22 medicinal plant species that the American Herbal Products Association (AHPA) tracks, 10 are harvested exclusively for the roots and rhizomes (AHPA 2012). Another four medicinal plant species are harvested for their roots/rhizomes, as well as their aboveground parts.

The fruiting bodies of many different mushrooms and fungi are harvested for personal consumption and for generating income. Dozens of species are enjoyed as edible forest products. More than 20 species are harvested from forests of the Pacific Northwest (Pilz and Molina 2002). In the late 1990s and early 2000s research was undertaken on various aspects of these nontimber products, including viability, economics, sustainability, and management. Schlosser and Blatner (1995) estimated that in 1992 approximately 65 percent of mushroom harvesters in the Pacific Northwest collected for supplemental income, while the remaining portion used the sale of these products for their primary source of income. Pilz and Molina (2002) discussed management and monitoring issues that affect sustainability of mushrooms. Alexander et al. (2002) examined economic nuances of managing for mushrooms and timber. Further, the ecology and management of chanterelle mushrooms were examined as the harvest of this NTFP was reportedly a multimillion-dollar industry (Pilz et al. 2003). The productivity of morel mushrooms in northeast Oregon relative to healthy, burned, and insect-damaged forests has been examined, as well (Pilz et al. 2004). Although these studies provided important insights about various aspects of the products, there has been little reoccurring studies or long-term monitoring or assessments undertaken. Much of the knowledge about the products is based on dated studies, research done in the late 1990s or early 2000s.

2.1.3
Scale of Harvest

The scale of harvest often reflects harvesters' motives. An often-used classification for harvesting is personal versus commercial. People collect NTFPs for their own use, whether for spiritual benefit, consumption of luxury goods, subsistence, or recreational purposes (Emery and Pierce 2005). Luxury goods are nonessential items and harvest typically fluctuates with income. Subsistence, like most noncommercial uses of NTFPs, includes resource use to meet material and cultural objectives separate from commerce (Emery and Pierce 2005). NTFPs are collected on family forest lands, for personal use, and categorized as edible or decorative (Butler 2008, Butler et al. 2014). Cordell and Tarrant (2002) estimated that nearly one-quarter of the U.S. population may gather NTFPs for personal use. Estimating the sheer number of people who collect NTFPs is impractical with any degree of certainty and unnecessary as anyone who harvests NTFPs for any reason may be considered a harvester. Determining the number and volume of products collected for personal uses is challenging, as well. The number of products is limited only by the collectors' personal needs, and the amounts of products harvested are rarely recorded. The 138 products from 80 forest species used by people in Michigan's Upper Peninsula, identified by Emery (1998), illustrate the diversity of plants and their uses. In general, the volumes harvested for personal use are less than those harvested for commercial gain.

The best available data, albeit with challenges to quality and quantity, are from permits for harvesting on Federal lands and industry association surveys. Data from these sources may not fully represent the total harvest, but they provide the best assessment of harvest volumes. The scale of commercial harvesting is influenced by market demand, product value, and availability of the desired NTFP. The Forest Service (national forests) and BLM record volumes and values of permitted harvests that provides some of the best data on NTFPs from public lands. Table 2.1 summarizes the volumes of

Table 2.1—2013 permitted harvest volumes of NTFPs from Forest Service and Bureau of Land Management land by product category, unit of measure, and region. Sources: Cut and sold reports of national forests (USDA Forest Service 2015a) and Bureau of Land Management records.

Product category	Unit	Alaska	North	Rocky	South	West	All United States
Arts, crafts, and floral	Bunches	0	0	100	0	0	100
	Bushel	0	40	590	100	71,093	71,823
	Cords	0	0	5	0	93	98
	Cubic feet	0	0	295	348	22	665
	Number	0	0	1,000	0	0	1,000
	Pounds	150	5,630	116,743	201,506	5,321,503	5,645,532
	Ton	0	651	293	65	6,716	7,725
Christmas trees	Each/number	0	2,678	133,577	249	76,240	212,744
	Linear feet	0	0	1,566	0	175	1,741
Edible fruits, nuts, berries, and sap	Gallon	0	0	890	0	302,858	303,748
	Pounds	200	400	226,868	30	443,228	670,726
	Taps	0	18,430	0	0	0	18,430
Grass and forage	Pounds	0	104	10	0	4,120,869	4,120,983
	Ton	0	295	3	8	830	1,136
Fuelwood	CCF	244	21,431	351,664	18,397	219,759	611,496
Medicinal	Pounds	0	856	12,148	14,936	14,710	42,650
Nonconvertible	Acre	0	0	0	28	0	28
	Bushel	0	0	6	100	0	106
	Cubic feet	0	0	500	750	450	1,700
	Each/piece	0	3,604	250	2,469	6,129	12,452
	Pounds	3,000	0	0	4,320	56,776	64,096
	Ton	0	0	43	0	1	44
Nursery and landscape	Each/number	600	204	9,827	24,942	10,926	46,499
	Ton	0	0	1	0	0	1
Posts and poles	CCF	0	7,538	11,399	97	16,369	35,403
	Linear feet	0	0	0	0	2,140	2,140
	Number	0	100	22,253	0	6,547	28,900
Regeneration and silviculture	Bushel	0	10	2,193	0	3,513	5,706
	Pounds	0	0	316,744	0	17,037	333,781

Note: units were maintained for all categories except for fuelwood and for posts and poles; these two categories were converted to CCF (100 cubic feet) wherever possible.

permitted harvest from national forest and BLM lands in 2013. AHPA is a leader in tracking medicinal plants used by the herbal industry (AHPA 2012) and regularly reports on estimated harvest volumes of 22 medicinal forest products used by its members (table 2.2).

2.1.4 Market Segments

In general, there are five broad market segments (table 2.3) of commercially traded NTFPs: (1) culinary products, (2) medicinal and dietary supplements, (3) decorative products, (4) nursery stock and landscaping, and (5) fine arts and crafts (Chamberlain et al. 1998, Molina et al. 1997). There is no known regular monitoring or tracking of these market segments. The few studies that have been done regarding market aspects provide invaluable though limited insights. Like all markets, NTFP market segments are dynamic. Additional categories may evolve as knowledge about the markets and industry develops. As well, the volumes and values of product harvests change with supply and demand. NTFP markets are commonly described as volatile, informal, secretive, and amorphous, so a clear description of them may remain elusive. The following synopses of each segment provide insight into the breadth and depth of these markets.

Culinary products—Forest products used for edible purposes include the fruit, sap, leaves, tubers, and bulbs. The fruiting bodies of edible fungi, particularly mushrooms, are perhaps the most well-known and documented edible forest product. The geographic distribution of edible forest products is dependent on ecological conditions of suitable habitats. For example, much of the commercial mushroom harvest is centered in the Pacific Northwest. Schlosser and Blatner (1995) identified more than 25 species of fungi commercially harvested in Idaho, Oregon, and Washington. They estimated that in 1992 approximately 3.9 million pounds (lbs) of mushrooms were harvested for commercial markets. From 2009 through 2013, the Forest Service and BLM issued permits for the harvest of more than 2 million lbs of edible fruits, nuts, berries, and

Table 2.2—Average annual harvest of plant species wild-harvested for herbal or medicinal purposes by plant part used. Source: AHPA (2012).

Latin name	Common name	Plant part	Average annual harvest 2001–2005	Average annual harvest 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
Arnica spp.	Arnica	Whole plant	63	715	1,044.0
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
Echinacea angustifolia	Blacksamson echinacea	Root and herb	35,446	36,394	2.7
Echinacea pallida	Pale purple coneflower	Root and herb	12,916	812	-93.7
Echinacea purpurea	Eastern purple coneflower	Root and herb	22,411	3,994	-82.2
Echinacea spp.	Purple coneflower	Root and herb	70,772	41,200	-41.8
Frangula purshiana	Cascara buckthorn	Bark	166,034	366,272	120.6
Hydrastis canadensis	Goldenseal	Root and leaf	73,619	74,708	1.5
Ligusticum porteri	Porter's licorice-root	Root	828	2,095	153.1
Lomatium dissectum	Fernleaf biscuitroot	Root	584	809	38.4
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
Usnea spp.	Beard lichen	Whole plant	1,165	1,300	11.6

Table 2.3—Major nontimber forest product market segments with examples of prominent species, the regions where they are most prominent, and the plant organ used. Some species may have multiple uses for multiple markets. For a more extensive the list, see appendix 4.

Market segment	Species	Common name	Region	Organ
Culinary	*Acer saccharum*	Sugar maple	Northeast, Southeast	Sap
	Allium tricoccum	Ramps, leeks	Northeast, Southeast	Whole plant
	Boletus spp.	Bolete mushroom	Northwest	Fruiting body
	Pinus edulis, P. monophylla	Pinyon pine	Southwest	Seeds
Medicinal and dietary supplement	*Arnica cordifolia*	Arnica	Northwest	Whole plant
	Oplopanax horridus	Devil's club	Alaska	Roots
	Panax quinquefolius	American ginseng	Northeast, Southeast, Midwest	Roots
	Serenoa repens	Saw palmetto	Southeast	Fruit
Decorative	*Abies balsamea*	Balsam fir	Midwest, Northeast, Southeast	Boughs
	Galax urceolata	Galax	Southeast	Leaves
	Gaultheria shallon	Salal	Northwest	Leaves
	Xerophyllum tenax	Beargrass	Northwest	Leaves
Nursery stock and landscaping	*Abies fraseri*	Fraser fir	Southeast	tree
	Arctostaphylos columbiana	Hairy manzanita	Northwest	Shrub
	Cypripedium spp.	Lady's slipper	Southeast	Orchid
	Echinacea purpurea	Purple coneflower	Great Plains	Herb
Fine arts and crafts	*Betula papyrifera*	Paper birch	Midwest, Northeast	Bark
	Callitropsis nootkatensis	Yellow cedar	Alaska	Wood
	Hierochloe odorata	Alpine sweet grass	Northeast	Stem

mushrooms (Alexander et al. 2011, Chamberlain et. al. 2018). In 1998, approximately 25 million lbs of black walnut (*Juglans nigra* L.) nuts were harvested from natural populations (Chamberlain et al. 1998). In 2007, the United States exported pine nuts harvested from southwestern forests worth more than $20,000 (Alexander et al. 2011). "Maine was the leading producer of lowbush, or 'wild' blueberries, harvesting 91.1 million pounds in 2012" (NASS 2013). Maple syrup is primarily produced in Northeastern United States, from Ohio to Maine, with production extending south into Virginia. Vermont is the main producer, followed by Maine and New York. The harvesting of wild onions (ramps or leeks) from eastern hardwood forests has increased over the last 25 years, from personal and community uses (festivals) to large-scale harvesting for corporate and global markets.

Medicinal and dietary supplements—The use and trade of herbal medicines derived from forest plants has a long history and may constitute the highest economically valued segment of the NTFP industry. The roots of American ginseng have been commercially harvested from eastern hardwood forests for over 250 years (Taylor 2006). Farnsworth and Morris (1976) estimated that more than 25 percent of all prescriptions dispensed in the United States contained active ingredients extracted from higher ordered vascular plants. Foster and Duke (1990) cataloged more than 500 medicinal plants in the United States. AHPA (2012) tracks 21 medicinal plant species that are in commerce (table 2.2). The average annual usage (2006–2010) ranged from 43 dry lbs of Virginia snakeroot (*Aristolochia serpentaria* L.) to 2.4 million lbs of saw palmetto (*Serenoa repens* (W. Bartram) Small) berries. The average annual harvest for about half of the products increased from 2001 to 2005, compared to 2006 to 2010. Some products, such as arnica (*Arnica cordifolia* Hook.), saw tremendous growth (i.e., more than 1,000 percent), while others such as echinacea (*Echinacea pallida* Nutt.) declined drastically. Market segments of the NTFPs industry discussed in the following sections have similar dynamics.

In 1995, the U.S. Pharmacopoeia listed more than 25 tree species, 65 herbaceous plants, and 29 shrubs for their medicinal properties (Foster 1995). In the early 1990s extract from the bark of the Pacific yew (*Taxus brevifolia* Nutt.) was found effective in treating ovarian cancer, which resulted in substantial harvesting of the tree from public forest lands in the Pacific Northwest. Saw palmetto, which is used to treat benign prostatic hyperplasia, is sourced primarily from pine forests of Florida (Mitchell 2014).

Decorative products—Many forest plants and their parts are used in decorative arrangements, to complement and furnish the backdrop for flowers, as well as for the main component of fresh and dried arrangements or ornaments. The end uses for many forest-harvested decoratives include fresh/dried flowers, greenery, basket filler, wreaths, swags, and roping. In the Pacific Northwest, forest plants harvested for their decorative values include salal (*Gaultheria shallon* Pursh), evergreen huckleberry (*Vaccinium ovatum* Pursh), Oregon-grape (*Mahonia nervosa* Pursh), and beargrass (*Xerophyllum tenax* (Pursh) Nutt.) (Vance et al. 2001). Spanish moss (*Tillandsia usneoides* (L.) L.) is collected from forests of Florida, Georgia, and Mississippi and exported for use as packaging material for flower bulbs, which may be imported, later, from Europe. In southern Appalachia, grape vine (*Vitis* spp. L.) and Dutchman's pipe (*Aristolochia tomentosa* Sims) are harvested for making wreaths. Western North Carolina is the major source of galax (*Galax urceolata* (Poir) Brummitt) leaves (figure 2.1) for the international floral industry (Predny and Chamberlain 2005).

There are markets for seasonal cuttings of some woody understory shrubs, as well. In New England, collectors of mountain laurel (*Kalmia latifolia* L.) may sign harvest contracts with landowners, while some private landowners collect and sell winterberry holly (*Ilex verticillata* (L.) A. Gray) from their lands (Monthey 2011). Some species, such as pitcherplants (*Sarracenia* spp.) in the Southeast, have strong markets and are vulnerable to over-harvesting, which has led to concern for their conservation (Robbins 1998). Conifer boughs may be the most widely sold decorative forest product in the United States (Chamberlain 2000). In the Pacific Northwest, the harvest and sales of boughs was estimated to employ more than 10,000 seasonal and permanent positions (Schlosser et al. 1991). In 1995, the United States exported more than $14 million in forest-harvested mosses and lichens, most of which originated from Appalachia and the Pacific Northwest (Goldberg 1996).

Nursery stock and landscaping—Live forest plants are collected for the nursery and landscaping industry. These may be marketed as bareroot stock or balled live plants for direct planting. In North Carolina, Fraser fir (*Abies fraseri* (Pursh) Poir.) seedlings are pulled from natural populations to be transplanted to nurseries for Christmas tree production. Rhododendron (*Rhododendron* spp. L.), azaleas (*Rhododendron* spp. L.), and mountain laurel, as well as cacti from Southwestern United States are dug from forests and sold for landscaping. In 2013, the largest volume of forest plants harvested as transplants, for nurseries and landscaping, came from the national forests of North Carolina (USDA Forest Service 2015b).

Collection of forest understory wildflowers for horticultural sales is a cottage industry in the southern Appalachian region and, to a limited extent, throughout New England. Bareroot lady's slipper orchids (*Cypripedium* spp. L.), trillium (*Trillium* spp. L.), and other wildflowers are available through Internet sales and box stores (Botanical Wonders 2015, Cullina 2000, Mainely Crafts 2015). Five states

Figure 2.1—Galax (*Galax urceolata*) leaves are harvested from western North Carolina and shipped worldwide for use in the floral industry. (Photo credit: Gary Kauffman, U.S. Department of Agriculture, Forest Service.)

(California, Colorado, Idaho, Nevada, and Utah) reported more than 99 percent of the national harvest of nuts, seed, and seed cones for forest regeneration plantings (USDA Forest Service 2015a). Government programs that promote the use and salvage of native plants are found at local and Federal levels (U.S. Environmental Protection Agency 2015, Water and Lands Resource Division of King County 2015).

Fine arts and crafts—Artisans that use NTFPs to craft items find the ingredients for their creations in forest plants and fungi. The number of NTFPs used to make fine art and crafts is limited only by the crafters imagination. Wood collected from forests may be used for carvings, turnings, walking sticks, utensils, and containers. Mosses, lichens, and seeds may be formed into jewelry. Vines are crafted into wreaths, sculptures, and statues. Baskets are crafted from the bark of paper birch (*Betula papyrifera* Marshall) that is stripped from trees in northern Minnesota, splints of wood from oak (*Quercus* sp.) and ash (*Fraxinus* spp.) trees, and stems of sweetgrass (*Muhlenbergia filipes* M.A. Curtis, or *M. capillaris*)[1] harvested from wetlands of South Carolina (Hurley et al. 2008, Moser et al. 2015).

NTFPs used for arts and crafts contribute to a multimillion-dollar handicraft industry. Determining the proportional value of NTFPs to this industry is problematic because differentiating the contribution of crafts' ingredients is not possible. The outlets for these fine arts are varied as well. Some artisans prefer local and regional craft fairs, while others may market their products through specialty retail stores or Internet-based outlets.

2.1.5
Iconic Nontimber Forest Products

The total number of NTFPs remains an enigma; by some reports there are hundreds, perhaps thousands of products (Chamberlain et al. 1998, Emery 1998) and listing all of them is not possible. Appendix 4 provides a list of NTFP species discussed in this report. We present in this section brief summaries of iconic NTFPs—products that are familiar to all and may be so important to the culture of the people who use them that the loss of the product due to climate change or other stressors (e.g., over-harvesting, lack of management) would have significant negative impacts on the people and places associated with them.

American ginseng—The extent of this plant's range is in eastern United States, though it occurs in southern Quebec and Ontario. A medicinal forest product, American ginseng grows throughout mixed hardwood forests from Maine to Minnesota, south to Alabama, Arkansas, Georgia, Louisiana, and Oklahoma (Goldstein 1975, Nantel et al. 1996, Stockberger 1928). These forests are some of the most biologically diverse temperate forests in the world. American ginseng shares them with many forest herbs that are harvested for their commercial value. More than 60 percent of the 20 or so medicinal plants tracked by AHPA (2012) grow in the same forest habitat.

Harvesting of American ginseng has impacted the ecology of the forests as well as the economic livelihood of the harvesters. The plant's roots have been commercially harvested for more than 250 years (Chamberlain et al. 2013b). From the mid-18th century to the turn of 20th century, the United States exported an estimated 20 million lbs of American ginseng root. Table 6.3 (Chapter 6: Economics) summarizes harvest volumes by state for the period 2000 to 2007. Chamberlain et al. (2013b) estimate that, between 2000 and 2007, harvesters received on average about $27 million each year (table 6.3). They also demonstrate that ginseng harvests are greater in forests with more growing stock volume. Chandler and McGraw (2015) argue that harvesting of eastern forests for timber has impacted the survival, growth, and reproduction of American ginseng. Removal of underaged or undersized plants reduces population growth below replacement levels (Van der Voort and McGraw 2006). Analysis of herbaria specimen suggests that the plant was more abundant (Case et al. 2007), and patterns of genetic variation show greater diversity in populations that have been protected from harvest (Cruse-Sanders and Hamrick 2004). By the first decade of the 20th century, concerns had been voiced about the declining supply of this medicinal forest product (Taylor 2006).

In 1975, American ginseng was listed in appendix II of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES, n.d.), an agreement to which the United States is party. The U.S. Fish and Wildlife Service (FWS) is

[1] Note: The common name "sweetgrass" refers to *Muhlenbergia filipes*, not to be confused with *Hierochloe odorata* (alpine sweetgrass).

the implementing agency for the United States and is charged with determining if the export of ginseng root would be detrimental to the survival of the species and certifying that states that want to export ginseng have an acceptable management and monitoring program. The FWS has approved 19 states to export wild roots: Alabama, Arkansas, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Minnesota, Missouri, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin. There are nearly 40 years of harvest data by state and county for ginseng because of its listing in CITES. More is known about the harvest of American ginseng than any other medicinal forest product.

Every year, large quantities of American ginseng root are harvested across its native range, yet the majority is limited to a few states within the core of the range. From 2000 to 2007 more than 500,000 pounds of American ginseng root were harvested from natural forests (figure 2.2; see also table 6.3). Seven states accounted for approximately 70 percent of the total American ginseng harvest for the period. Kentucky's harvest was more than 25 percent of the total, followed by Tennessee (14 percent), North Carolina (12 percent), West Virginia (9 percent), and Indiana (8 percent). The average annual harvest across all States during these years was 63,200 lbs (Chamberlain et al. 2013b), though there has been a general decline in harvest volumes.

Harvesting of wild American ginseng and hardwood timber has been occurring in the same forests throughout this country's history. There is a positive correlation between ginseng harvest and hardwood growing-stock volume, and hardwood growing-stock volume on public lands (Chamberlain et al. 2013b). More ginseng harvest occurs in hardwood forests with greater growing-stock volume and, as the proportion of public forest land base increases, there is an associated increase in reported ginseng harvest. However, to reiterate, harvesting of eastern forests for timber has impacted the survival, growth, and reproduction of American ginseng (Chandler and McGraw 2015). These findings imply that forest management (see section 2.2) of this NTFP and timber is possible and warranted.

Beargrass—This decorative forest product grows in the Western United States and Canada. In its U.S. range there are two distinct distributions (Hummel et al. 2012)—one in west-central California, north through Oregon to the Cascade Mountains in northwest Washington, and the other ranging from western Wyoming through Idaho and Montana, along the Rocky Mountains. The species is an early- to late-successional pioneer that grows in a variety of forest types. It is found in the understory of dry, mixed-coniferous forests to subalpine meadows. The greatest densities of beargrass are in forests with sparse canopies (figure 2.3).

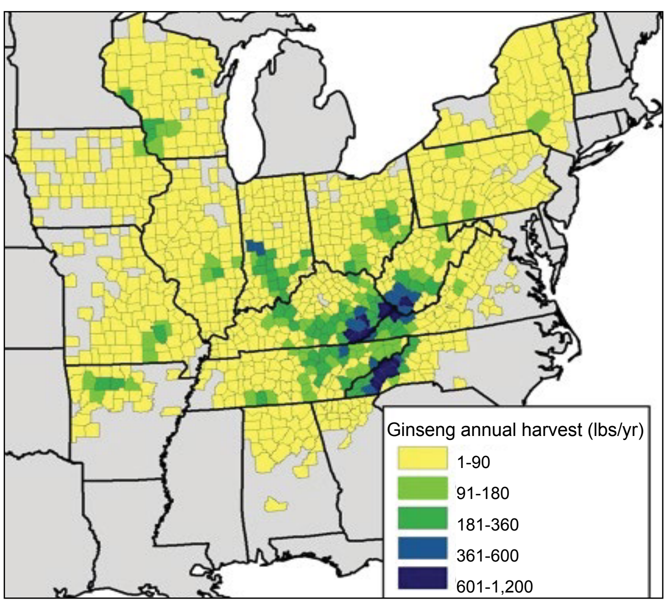

Figure 2.2—Average annual reported American ginseng harvest by county across 19 states certified by the U.S. Fish and Wildlife Service for the years 2000-2007. (Source: Chamberlain et al. 2013.)

Figure 2.3—Many nontimber forest species, such as this patch of beargrass (*Xerophyllum tenax*), live below the trees. Integrating these understory species into forest management increases the complexity, yet critical to forest health. (Photo credit: Frank K. Lake, U.S. Department of Agriculture, Forest Service.)

Beargrass is harvested for making traditional baskets and for the commercial floral industry (Hummel et al. 2012). The plant did not enter the floral greens industry in commercial volumes until the late 1980s, although American Indians have been harvesting beargrass for spiritual and cultural purposes for generations (Lynch and McLain 2003, Weigand 2002). Beargrass was reportedly the most harvested NTFP for the floral industry in the Pacific Northwest (Schlosser and Blatner 1997, Schlosser et al. 1992). They estimated the commercial value of beargrass to be over $1 million in 1997. Draffan (2006) estimated 10 years later the value of beargrass and salal (another wild-harvested Pacific Northwest floral green) at $54 million. These analyses illustrate the tremendous value of NTFPs and inconsistencies between studies that need reconciliation for a better understanding of the overall market values.

Different groups have preferences for harvest timing and locations as well as plant characteristics. American Indians have traditional ecological knowledge that influences decision making of preferred harvest sites and practices (Hummel and Lake 2015). American Indians harvest after the snow has melted, primarily during the spring and summer. Sites that have experienced low-intensity and frequent fire incidents are preferred by American Indians (Charnley and Hummel 2011, Hummel et al. 2012, Shebitz et al. 2009). Accordingly, American Indian harvesters prefer long, strong, and pliable leaves for basket making. For ceremonial purposes, they want plants with flowers, along with the preferred leaf structure.

Commercial harvesters have different preferences for harvest sites and practices. They bring personal experience that may have been handed down through generations of harvesting NTFPs from their native lands, or that personal experience is new and lacking a full appreciation and understanding of plant. Generally, they look for large populations with plants that have the desired leaf qualities. Commercial harvesters use various techniques to remove leaves, which may result in overharvesting and threaten plant populations (Charnley and Hummel 2011). The preferred leaf characteristics for commercial markets are deep green color, with long, wide, and firm leaves from the center of the plant. These are best found in conifer forests with 60 to 90 percent canopy cover, at higher elevations (Charnley and Hummel 2011, Hummel et al. 2012) According to Schlosser and Blatner (1997), beargrass leaf quality is maximized during the later stages of mid-successional forest development.

Managing beargrass for tribal weaving requires blending traditional and scientific ecological knowledge to craft and implement adaptive management strategies (Hummel and Lake 2015). This will be accomplished by embracing the social and cultural dynamics and working with the community of interested people who want to benefit from the harvest of beargrass. The scale of harvest volumes (commercial versus noncommercial) affects management decisions and potential silvicultural treatments (Hummel and Lake 2015, Hummel et al. 2012). Management strategies for beargrass need to be adapted to different market demands, cultures and ethnicities, as well as climate variations.

Fiddlehead ferns—An edible forest product, fiddleheads, are the tightly coiled, vegetative fronds of the ostrich fern (*Matteuccia struthiopteris* (L.) Todaro). Ostrich ferns have a wide distribution in the United States, from Maine, south to Virginia, west to Nebraska, and north to Minnesota and in warmer areas of Alaska. Ostrich ferns are adapted to USDA plant hardiness zones 3 to 7 (USDA 2012). Their preferred growth habitat is along stream and river floodplains in sandy loam soils under the high canopy of maple, ash, and other hardwoods.

Fiddleheads are culturally important as a harbinger of spring and as a healthy, welcome addition to local diets. Fiddleheads also are an important part of rural economies and sold in neighborhood markets, roadside stands, and large grocery store chains (Fuller 2012). Accurate figures are lacking for total yields but are estimated to be about 100,000 lbs, annually.

Fiddleheads are harvested in the spring as they emerge from the plant's crown with a short piece of the stem. Harvesting is done primarily from wild, unmanaged populations, though some forest farming of this product is known to occur. Proper identification of the fern, sustainable harvesting practices, and proper preparation of ostrich fern is important. For example, misidentifying brackenferns (*Pteridium aquilinum* (L.) Kuhn), which may be carcinogenic, for ostrich fern and improper cooking of ostrich fern has been related to cases of foodborne-related illness (Bolton and Fuller 2013).

Maple syrup—Maple syrup (figure 2.4) is one of the most prominent edible NTFPs in eastern United States (Farrell and Chabot 2012). It is produced primarily from

Figure 2.4—Maple syrup from Vermont, the major producer of this delicacy, and other New England states is an iconic nontimber forest product from trees. In 2013, the United States produced approximately 3.25 million gallons, and annually the sale of syrup adds over $100 million to the Nation's economy. (Photo credit: Cornell University, Uihlein Maple Research Forest.)

the sap of sugar maple (*Acer saccharum* Marshall), but black maple (*A. nigrum* Michx. f.) and red maple (*A. rubrum* L.) also can be tapped. In the United States, sugar maple grows in several eastern States, although commercial production of maple syrup occurs primarily in the Northeastern States. Trees must be at least 10 inches in diameter before they can be tapped without damage to the tree and should occur in fairly dense forest stands to make sap collection economically efficient.

Maple syrup is produced in late winter and early spring when weather conditions fluctuate above and below freezing, stimulating sap movement within the trees. The annual value of U.S. maple syrup production is well over $100 million, distributed across 10 states (Farrell and Chabot 2012). Vermont leads production whereas New York, Michigan, and Pennsylvania have the greatest potential to increase production. Overall, there is tremendous potential to increase maple syrup production as less than 1 percent of more than 2 billion tappable-size maple trees are utilized (Farrell and Chabot 2012).

Pine nuts—In the United States, pine nut production is from primarily natural stands of pinyon trees on public forest lands in western United States, which are not managed specifically for nut production. Pine nuts are harvested from singleleaf pinyon pine (*Pinus monophylla* Torr. & Frém.), found primarily in the Great Basin, and two-needle pinyon pine (*P. edulis* Engelm) on the Colorado Plateau. Both species produce large, highly prized nutritious nuts.

Pine nuts were a staple food of many American Indian tribes in western United States. Today, they are collected and sold in local markets. In 2007, the United States exported pine nuts valued at about $20,000, and imported about $54 million worth of pine nuts (Alexander et al. 2011). This indicates that the United States pine nut market has potential for development with concomitant management considerations.

In the United States, pinyon pine grows with a number of juniper species (*Juniperus* spp. L.) in a forest type known as pinyon-juniper (Eyre 1980). This forest type is the most extensive in Southwest States and dominates 47 million acres (ac) in five states (Intermountain Society of American Foresters 2013). The pinyon-juniper forests are typically unmanaged and are commonly eradicated in favor of rangeland species deemed more favorable to livestock and some wildlife species. Healthy stands of pinyon-juniper can be maintained by thinning and uneven-aged silviculture management. It is possible to comanage pinyon stands for food, livestock, and wildlife.

Management prescriptions (some of which were used by American Indian tribes) may include identifying mixed-aged stands of pinyon pines located on gentle slopes with deep soils, which are more productive sites (Mclain and Frazier 2008). Thinning stands to reduce the non-pinyon tree component will release good nut trees. Pinyon trees with large spreading crowns are typically the most prolific nut bearers and can be retained through selective thinning. Pruning lower branches decreases the risk of crown fires and makes trees less susceptible to infections and pests. Pruning and light thinning results in increased cone production on residual trees. Integrating this NTFP into forest management requires balancing multiple land use objectives that may conflict.

Ramps—A spring ephemeral, ramps (wild leeks) are native to rich, moist hardwood forests of eastern North America (figure 2.5). Leaves of this forest herb begin to emerge when the soil temperatures increase, which usually occurs in late March and early April, depending on geographic location. Young plants produce smooth, broad leaves that die back as the overstory canopy closes and reduces the amount of sunlight that reaches the forest floor. Patches of ramps often can be located by their distinctive odor (Calvey et al. 1997). Before the plants lose their leaves, people forage the forests for this odiferous spring edible.

American Indians and early settlers ate ramps as the first green of the year. In the mid-20th century community groups began organizing ramp festivals to celebrate the arrival of spring and to raise money for local causes (Lohmann 2005, Simmons 2006). An early study documented harvest levels for 10 ramp festivals in western North Carolina to be in excess of 3,000 lbs, annually (Greenfield and Davis 2003), yet total annual harvest volumes have not been documented. More than 50 festivals have been identified from North Carolina to New York. Harvesting intensity increased with development of markets at roadside vegetable stands, farmers' markets, and even to local restaurants. In the late 1990s, the plant's popularity increased tremendously when culinary aficionados started promoting it as a luxury product (e.g., Geraghty 2005, Roach 2005, Sheffield 2005). Large-scale harvesting is supplying farmer's markets and other local food vendors (Levin 2006, Raisfeld and Patronite 2007, Wolcott 2006). Now, ramps are served at upscale restaurants and sold at natural food stores across the Nation and over the Internet (Ellison 2001, Feiring 2006). Expansion of market demand has generated concern for the plant's conservation (Associated Press 2005, Clabby 2005, Ostendorff 2005, Sheffield 2005).

The impact of harvesting and other disturbances on natural populations of ramps is not well understood. Understory herbaceous plant communities may take

Figure 2.5—Ramps (*Allium tricoccum*), a spring ephemeral forest species, are only available for about 10 weeks each year. During that time, people harvest large volumes of this odiferous onion for personal consumption and for sale in a burgeoning market. The increased interest in foods foraged from forests is putting tremendous pressures on natural populations of this and other edible forest products. (Photo credit: Michelle J. Baumflek, U.S. Department of Agriculture, Forest Service.)

longer to recover from harvest disturbance than overstory trees (McLachlan and Bazely 2001). Rock et al. (2004) estimated that a 10-percent harvest once every 10 years from a patch may be sustainable, but a 25-percent harvest was clearly detrimental to natural populations. On the other hand, Walker and Knapp (2010)[2] monitored 22 populations of ramps, with varying degrees of disturbance, and found them to be "remarkably stable" through a decade of analysis. Recolonization may be prohibited by dense vegetation cover of more aggressive plants. Nantel et al. (1996) concluded that the only measure to conserve ramp populations would be to delay bulb harvest until the end of the photosynthetic season when the bulbs are fully developed.

Forest herbs, such as ramps, are recognized as indicators of forest health (McLachlan and Bazely 2001). Slow annual growth and small-sized plants lead to a long preproductive stage (Nantel et al. 1996). Population growth and maintenance is due to vegetative propagation more than seed production. Changes in soil moisture and temperature due to climate variations could impact growth and maintenance of natural populations of spring ephemerals, such as ramps.

2.2 Silviculture for Temperate U.S. Nontimber Forest Products

Most NTFPs are harvested from natural populations in forests. In general there is little professional management of nontimber forest resources, yet as discussed in this section silvicultural practices could be used to integrate NTFPs into forest management to promote sustainable harvesting of natural populations. Opportunities abound for silviculture to address the complexities presented when forest management integrates nontimber plant and fungi species into strategies and prescriptions.

Silvicultural practices for naturally regenerated forest stands provide multiple goods and services for society while protecting and maintaining ecosystem function (Coates and Burton 1997, Curtis et al. 2007, Smith et al. 1997). The integration of NTFPs into timber-focused forest management regimes provides a means for attaining both objectives. The diversity of species and functional groups in forests necessitates the need for management plans that consider a broad range of biotic, abiotic, and social factors for successful outcomes. Balance between spatial, temporal, and economic scales must be maintained with the inclusion of NTFPs, and an increase in management complexity should be expected (Filotas et al. 2014, Hummel 2003, Schmidt and Lotan 1980). The added complexity should be considered not as a deterrent, but as an impetus for better understanding how to increase the utility and health of forest ecosystems. Managing for complexity increases resiliency and adaptive capacity of forests, which is particularly important under increasingly variable climate scenarios (Puettmann et al. 2009).

Plants and fungi that produce NTFPs help facilitate the maintenance of ecosystem processes, contributing to the structural, compositional, and functional diversity of forest systems. The inclusion of these plants in management can lead to economically and ecologically healthy forests. For example, spring ephemeral herbs contribute to nitrogen cycling pathways in eastern deciduous forests, meaning NTFP species with similar life history traits have the potential for ecological as well as economic value (Muller 2003). Similarly, economically valuable fungi are well known for their importance in nutrient cycling (oyster mushrooms, *Pleurotus* spp. (Fr.) P. Kumm.) and mycorrhizal associations (chanterelles, *Cantharellus* spp. Adans. ex Fr.).

Many hard mast (e.g., American hazelnut, *Corylus americana* Walt.; oak, *Quercus*, spp.) and soft mast (e.g., elderberry, *Sambucus canadensis* L., eastern redcedar, *Juniperus virginiana* L.) producing NTFP species provide valuable food and cover for wildlife. Some NTFP species may provide critical resources for invertebrate species (stone root, *Collinsonia canadensis* L.) and may serve as important pollination vectors (mountainmint, *Pycnanthemum* spp.). Similarly, understory species act as filters for guiding regeneration pathways of forest canopy trees, and the same may be true for important NTFP species (George and Bazzaz 1999, Maguire and Foreman 1983).

2.2.1 Treatments and Site Conditions

The compatibility of silvicultural treatments with NTFP production depends on a number of things, most

[2] Walker, J.; Knapp, B. 2010. Wild leek (*Allium tricoccum*) populations in Southern Appalachians: 1999–2009. Presentation at the 2010 Ecological Society of America Annual Meeting. 1–6 August. Pittsburg, PA.

noticeably resource availability. Light is the principal resource manipulated by silvicultural treatments, and will vary based on the type and intensity of treatment, site conditions, and species composition. Many NTFP species are understory herbs that are shade tolerant and associated with later successional stages (e.g., American ginseng, black and blue cohosh). Shade-intolerant NTFP species are associated with open areas or early successional stages and can be herbs (e.g., beargrass), shrubs (e.g., red raspberry, *Rubus ideaus* L.), and trees (e.g., paper birch). Silvicultural treatments fall into two core groups—intermediate treatments promote development of the existing stand, while regeneration treatments create favorable conditions for establishment of a new tree cohort (Curtis et al. 2007, Nyland 2002, Smith et al. 1997).

Intermediate treatments focus on increasing the timber value of canopy trees and can be used to maintain or promote NTFP production. The effects of an intermediate treatment can be manipulated through the amount of basal area removed, types of residual trees retained, and canopy strata targeted. By targeting the lowest canopy class and simulating the mortality of suppressed trees that would be removed naturally through self-thinning processes, low thinnings may be used to manipulate light and soil moisture within the stand to the benefit of NTFP species. Removal of the subordinate strata also may increase the soil moisture available to ground-story vegetation, although the amount of leaf area removed may have more influence on moisture than the thinning method (Smith et al. 1997). In mixed hardwood-conifer stands, low thinnings can maintain shade conditions that are conducive to mushroom production such as shiitake (*Lentinula edodes* (Berk) Pegler), while creating the physical space in the understory for cultivation.

Crown thinning improves incremental growth of target trees by increasing light levels to codominant and sometimes dominant trees. In the case of sugar maple, this increases tree vigor, size, and sap production of residual trees (Lancaster et al. 1974). Crown thinning has the potential to increase trees' surface areas and therefore the value of bark harvested from species such as tulip poplar (*Liriodendron tulipifera* L.). When thinned hardwood stems are of precommercial diameter, they may be used for mushroom production. In the case of species such as oaks, the value of the stems as a mushroom substrate should be weighed against the potential future timber value of the tree. Selection thinning in conifer stands may create favorable conditions for very shade-tolerant understory species that rely on single tree gaps, but the need for multiple entries into a forest stand may create disturbance regimes that negate these benefits. Geometric thinnings, which remove trees at intervals, usually in rows or strips, may have potential in forest farming systems where the intercropping of canopy trees and NTFPs is a goal. Variable density thinning treatments early in stand development can increase structural complexity within stands (Hummel 2003), which may increase opportunities for NTFP production.

Regeneration treatments are designed to initiate new forest stands by removing mature forest canopies and can complement certain NTFP resources in naturally regenerated forests. The size of gaps in the canopy, their orientation, and the length of time over which the canopy is removed as well as retention of previous stand structure by retaining group reserves all can influence site conditions and NTFP growth. Clearcut systems release tremendous amounts of growing space, creating open site conditions that benefit a broad suite of shade-intolerant species. Removal of the entire mature canopy strata over a relatively short period of time can result in full-sun conditions (Smith et al. 1997). This light environment can benefit shade-intolerant berry producing shrub species, however these benefits often are ephemeral without continued management as canopy species reestablish and shade the site (Reynolds-Hogland et al. 2006). Similarly, these conditions can promote establishment and growth of nonnative invasive plant species and/or aggressive native species that have potential to outcompete target NTFPs.

Clearcut openings can increase soil temperatures, change moisture regimes, and cause physiological stress and mortality to shade-tolerant NTFP species (Bazzaz 1979, Hicks and Chabot 1985, Meier et al. 1995). Populations of some species are restricted in their ability to reestablish once favorable conditions return (Meier et al. 1995) due to limited dispersal capabilities. Enrichment planting may be necessary to reestablish viable populations of economically important plants. In forest systems where artificial regeneration is practiced, planting density and competition control methods can influence understory structure and composition (Curtis et al. 2007, Hummel 2003, Jeffries et al. 2010, Knapp et al. 2014). Retaining elements of the previous stand (living and dead material) has implications for wildlife habitat and NTFPs (Hummel 2003, Nyland 2002, Smith et al. 1997). Specifically, group reserves or aggregated green-tree retention may provide refugia for certain dispersal-limited understory herb species to maintain populations. In addition, retaining or creating residual snags for wildlife may provide habitat to saprophytic fungi. Therefore, managing stands for complexity may provide nontarget benefits to NTFPs (Puettmann et al. 2009).

Group selection treatments also create open site conditions by removing the mature forest canopy, however gap size is typically smaller than clearcuts. Smaller gaps and associated smaller area-to-perimeter ratio create more diverse range of understory light conditions (Canham et al. 1990, Marquis 1965). By orienting selection gaps accordingly, timber value can be realized while protecting established populations of shade-tolerant understory NTFP species (Aikens et al. 2007). Multiple group selections create an uneven-age forest structure that closely resembles the natural gap phase dynamic and habitat heterogeneity that may support the life history traits of shade-tolerant NTFP species (Beatty 2003, Roberts and Gilliam 1995). Open conditions at the gap center, however, that would support shade-intolerant NTFP species may be more ephemeral than in clearcuts and thus less suitable for long-term production of NTFPs.

Shelterwood treatments are designed to produce single-age stands through a succession of canopy removals that promote establishment of more shade-tolerant canopy species. Evenly spaced mature canopy trees that are left as residual stand structure after the establishment cut mediate light and temperature environment that promote advance regeneration of more shade-tolerant timber species before overstory removal (Nyland 2002, Smith et al. 1997). The mediated environment of shelterwoods could be used to maintain existing populations of shade-tolerant NTFP species by reducing physiological stress and facilitating natural dispersal mechanisms. Care would have to be taken to protect populations of NTFP species, as shelterwood treatments often include a preparatory cut to remove competing vegetation and site preparation.

As with clearcuts, seed-tree treatments generally retain canopy tree densities at low levels, resulting in open site conditions, and NTFP considerations would be similar (Nyland 2002). There may be potential to focus seed-tree treatments on hard mast producing species such as oak to increase acorn production. This approach, however, may be more appropriate for a silvopasture system than a closed canopy timber production system. Single tree selection treatments would have challenges and benefits similar to selection thinning treatments.

2.2.2 Integrating Understory Nontimber Forest Products and Forest Management

Forest understories are complex ecological communities consisting of transient members (i.e., regenerating tree species) and permanent members (e.g., herbs, mosses, mushrooms, and shrubs; Gilliam and Roberts 2003a). Many important NTFPs are permanent members of understory forest communities and have different ecological requirements than associated tree canopy species. The forest understory is a stressful environment where light and moisture are limited. To deal with this, understory NTFP species employ an array of adaptations and life-history characteristics. Abiotic conditions are spatially and temporally variable, and stand-level measurements used to monitor canopy species may not be sufficiently informative or accurate when managing for understory NTFP species (Canham et al. 1990, Muller 2003, Neufeld and Young 2003, Reifsnyder et al. 1971).

Understanding the autecology of understory nontimber forest species is important for successful management. For example, the understory forest species ramps (leeks) and American ginseng have different phenological strategies for dealing with low light levels inherent on the forest floor. Ramps are spring ephemerals and do most of their photosynthesis, growth, and carbohydrate storage before canopy leaf out (Givnish 1987). In contrast, American ginseng is a summer green species (as defined by Uemura 1994) and associated with high leaf area index[3] canopies. Ginseng plants leaf out in spring and photosynthesize throughout the summer, and they produce flowers and fruit under high shade (Proctor 1981). While both species are "woodland herbs," these phenological traits reveal a great deal about their abiotic preferences, and therefore management. Ramps are not shade tolerant, but shade avoiders, while ginseng may be damaged under full-sun conditions (Nadeau et al. 1998, Proctor 1981). Management

[3] Leaf area index (LAI) is a dimensionless quantity that describes plant canopies and is estimated by the one-sided green leaf area per unit of ground surface area (LAI = leaf area / ground area).

decisions therefore need to consider canopy species composition and interactions with understory plants.

The forest understory is a dynamic community, with each species constantly interacting with biotic and abiotic components of the environment. While abiotic factors have been used to explain vegetation patterns, physiological tolerances are a small part of the story (Tilman 1988, Whittaker and Klomp 1975). Emerging soil biology and community ecology research suggests that biotic interactions may be just as influential in shaping plant community composition (Reynolds et al. 2003, Warren and Bradford 2011). These biotic interactions shape spatial patterns and demographics of plant species and may be even more important for fungal communities (Crowther et al. 2014). In addition, some understory herb species may be more limited by the abundance of mutualist partners (e.g., mycorrhizal fungi, ants for myrmecochorous plant species) than physiological tolerances (McCormick et al. 2012, Warren et al. 2011).

Understory NTFP species are influenced by disturbance as well as resource availability and biotic interaction (Neufeld and Young 2003, Roberts and Gilliam 2003). Forests that are managed for timber inherently deviate from natural disturbance regimes. Timber harvesting should be considered as two separate, interacting types of disturbance in respect to understory plant species. The first is the intensity of canopy removal, which alters edaphic and microclimate conditions (Bhatti et al. 2002, Gilliam 2002, Gilliam and Roberts 2003b). Second is the severity of ground disturbance, which can destroy propagules and expose bare mineral soil, giving competitive advantage to early successional colonizers from outside the stand (Ramovs and Roberts 2003, Roberts and Gilliam 2003).

Interaction effects between canopy and ground disturbance also may be present and are dependent on site conditions (Duguid et al. 2013). Furthermore, the long-term effects on the understory resulting from successional changes and competitive interactions also should be considered (Halpern and Spies 1995). The NTFP species life-history traits, especially the organ harvested, life cycle, and reproductive strategy, define how they respond to disturbances. Ground disturbance and site preparation treatments can be tailored to the NTFP species. For example, forest management with high levels of ground disturbance would not be conducive with perennial herbs whose roots are the desired product, while annual and biennial herbs thrive on high levels of ground disturbance.

Plant and fungi communities or the relative success of an individual understory NTFP species is driven by life-history traits responding to resources availability, disturbance, and biotic interactions. While information on some high-value NTFP species is available, we know very little about the demographics and life-history traits of most understory plants (Bierzychudek 1982, Whigham 2004). The processes driving demographic patterns of fungal communities, and the effects of forest harvesting on those communities, is even less well understood (Crowther et al. 2014, Dahlberg 2001). Additionally, fungal NTFPs belong to distinct functional groups—saprotrophic fungi (e.g., oyster mushrooms, *Pleurotus ostreatus* (Jacq. ex Fr.) P.Kumm.) and ectomycorrhizal fungi (e.g., matsutake, *Tricholoma magnivelare* (Peck) Redhead)—with differing environmental preferences, further making broad generalizations about management difficult.

2.2.3 Integrating Production of Timber and Nontimber Products

The timing of timber harvesting is an important consideration for successful integrated management that occurs when forest stands are managed with multiple objectives that include timber and nontimber products. For example, managing a stand of maple trees for timber and syrup requires integrating these objectives into silviculture prescriptions. Management decisions consider interactions between the timber and nontimber resources. Timber harvesting in mid-summer may stress and damage foliage of understory NTFP species that are challenged in adapting to abrupt changes in solar radiation. Winter timber harvesting, conversely, allows plants to develop under full-sun conditions and acclimate to the new light regime (Ellum 2007).

Rotation length is another consideration when comanaging for NTFPs and timber. Some NTFPs, such as many ectomycorrhizal mushrooms, are only associated with later successional stages. Since commercial rotation cycles are generally shorter than natural disturbance regimes, populations of some valuable NTFPs (e.g., matsutake) may be reduced or even eliminated under short rotation times (Kranabetter et al. 2005).

Three basic classes describe management of forests for timber and nontimber products. Passive management includes timber or other objectives, such as wildlife, water, or recreation that are the primary stand objective. In these cases, NTFPs may provide inconsequential revenue and do not justify large management investments, or the product is ubiquitous and does not warrant management. Floral greens, such as salal, Oregon grape (*Mahonia* spp. Nutt.), and sword fern (*Polystichum munitum* (Kaulf.) C. Presl) harvested from Pacific Northwest forests, provide an example of passive NTFP management. Cuttings of these native plants may be harvested for personal use with a free permit (USDA Forest Service 2013), and these provide no additional revenues to the Government agencies. While permits for commercial harvest are available, salal is an aggressive groundcover, and management objectives are usually associated with reducing salal populations to aid in regeneration of more favorable species (Tirmenstein 1990). Most wild-collected mushroom permits on public lands are considered passive management, since little is known about cultivation and management for most species (Yun and Hall 2004). Other examples of passive management include burls and twigs for floral crafts (e.g., winterberry, *Ilex verticillata* (L.) A. Gray; willow, *Salix* spp. L.; paper birch, *Betula papyrifera* Marshall).

Active management is more common where there is potential for enough additional revenue to invest in research and management operations. One example is Canada yew (*Taxus canadensis* Marshall); after widespread overharvesting in the 1990s the Canadian Forest Service invested time and resources in establishing sustainable management practices to ensure long-term harvest and profits from this resource (Smith et al. 2003). Some provinces even implemented education and training programs along with the issuing permits to collectors and landowners (Prince Edward Island 2013).

Successful and rewarding integrated management of forests includes production of culinary mushrooms (Weigand 1998), balsam boughs (Krantz 2001, Titus et al. 2004), and pine straw (Demchik et al. 2005, Feldhake et al. 2010, Garrett et al. 2004). Foresters working with private landowners on high-value forest lands actively comanage for timber and shiitakes to maintain the property's agricultural status. The balsam fir boughs partnership in Minnesota is centered on sustainable harvesting practices and training (Krantz 2001, Titus et al. 2004). Silvopasture systems in pine forests are integrated approaches where objectives include forage, pine straw, and timber. These examples demonstrate that managing for the NTFP is feasible, though the exception in forest management.

Integrated management practices can be intensive for NTFP resources with extremely high values. Micropropagation, inoculation, and even bioengineering are being applied for management of truffles (*Tuber* spp. P. Micheli ex F.H. Wigg.) and timber (Mycorrhiza Biotech 2013, Symbios 2014, Titus et al. 2004). For instance in sugarbushes, silviculture is targeted at growth and regeneration of sugar maple trees for long-term sustainable yield (Cope 1946, Lancaster et al. 1974), timber harvesting is tailored to support these goals and additional revenue is secondary.

The third class of integrated management is applying silvicultural prescriptions to NTFP resources. In these cases foresters serve as NTFP harvesters or work closely with harvesters to integrate silvicultural treatments to improve NTFP resources. Extracting small-diameter trees for rustic furniture or shiitake logs in low thinnings (Titus et al. 2004) is an example of this type of management. While sections of birch bark can be harvested without harming the standing trees, harvesting large sections of bark for canoes and other crafts might be more efficient from felled trees following crown thinnings (Zasada 2002). Site preparations for stand regeneration can be paired with NTFP collection, such as targeted cutting of aggressive understory shrubs that have value during the preparatory or establishment cuts of a shelterwood, or as timber stand improvement. Witch hazel (*Hamamelis virginiana* L.) harvesting is permitted from Connecticut's state forests to enhance oak regeneration and growth (Associated Press 2009). Whole plants of shade-tolerant evergreen shrubs (e.g., Rosebay, *Rhododendron maximum* L. and mountain laurel) are dug and sold as nursery stock from forest lands in the Southeast. Targeted pruning or thinning of crop trees could be done on species that have potential for essential oil extraction such as eastern and western redcedar (*Thuja plicata* Donn ex D. Don Ciesla 1998; Titus et al. 2004), or for pine oil in the Southeast (Alexander 2003).

Finally, invasive species management has the potential to be paired with NTFPs collection. Blue gum (*Eucalyptus globulus* Labill.) is a problem invasive in California but can be used to produce valued essential oils (Ciesla 1998). While the planting of invasive plant species (e.g., Japanese knotweed, *Polygonum cuspidatum* Siebold & Zucc.; garlic mustard, *Alliaria petiolata*

(M. Bieb.) Cavara & Grande) is not advocated, these have emerged as potential food crops through the permaculture and wild foods movements. To help control invasive species, land managers can provide incentives for their harvest (Pasko et al. 2014).

2.2.4 Considerations and Concerns for Integrating Timber and Nontimber Products

To assure forest health, sustainable harvest, and resilience in a changing climate, there are a number of considerations regarding the integration of NTFP production into forest management. A primary consideration is the phenology of harvest opportunity, which addresses the fact that the majority of NTFPs only can be harvested at a specific time during the species growth cycle. For example, the quality of the outer bark of paper birch trees varies with the season. At the very beginning of the harvest period, the cork cambium is still dormant and more difficult to remove, rougher in texture, and darker color than "summer bark" harvested later in the season, during the active cambial growth of the tree (North House Folk School 2009, Stewart 1995). In addition, many plant species have more than one product, such as paper birch that is valued for sap, outer bark, whole bark layer, small-diameter saplings, roots, leaves, and character wood (Emery and Zasada 2001). There may be distinct harvest times for different products within a single species.

Coordination of harvest activities is another consideration. While harvesting NTFPs prior to cutting timber often produces higher quality products and more efficient harvesting, modern logging equipment has made it possible to reduce soil and understory damage. For some products (specifically from tree species) intensity and sensitivity of the harvest operation may differ based on timber harvesting. NTFP harvests in areas slated for logging may be able to remove entire plants or larger quantities of bark or sap. In contrast, if the goal is long-term sustainable harvest, care must be taken to leave the individual plant or population in a condition from which it can recover to supply future harvest. Of primary concern is protecting individual plants and plant populations, which includes protection of the cambium for healing wounds and adding new bark, protection of aerial and soil bud banks, and maintaining the potential for sexual reproduction.

While there are many opportunities to increase management of timber and NTFPs, there also are challenges to consider. Foremost are logistics, including permitting, enforcement, access, and jurisdiction on public and private lands. NTFP harvesting has the potential to increase ground disturbance and the risk of fire, depending on the number of additional stand entries, season of collection, type of crop, and mode of transportation by harvesters. Decisions must be made whether to allow harvesters access to the resource. These decisions might be based on profit, as some products may give higher returns from multiple small collector permits than one large commercial collector. They may, however, be based on other considerations; for instance, multiple local collectors may increase investment and stewardship of the forest by the community (Emery and Zasada 2001, Titus et al. 2004). Interactions between multiple and different types (e.g., loggers and NTFP gatherers) of harvesters as well as open access scenarios increase the potential for conflicts.

Communication about active logging jobs or other concerns may be easier to maintain between a single commercial harvester and landowner than with multiple parties. In addition, there may be liability concerns for private landowners if they allow harvesters access. Clear communication and easy passage to acceptable harvest areas is necessary; trampling alone has potential to damage sensitive communities. There also is the potential harvesting of additional nontarget species when lands are open to foragers. Most of these concerns can be mitigated with open and frequent communication between landowners, foresters, and collectors. Embarking on the decision to manage for NTFPs should be approached with careful planning and written guidelines.

2.2.5 Challenges to Managing for Nontimber Forest Products

There are inherent ecological and environmental challenges to managing for NTFPs. Forest cover change, invasive species, and a changing climate all contribute to an environment of uncertainty. While most forest management is based on historical conditions, we cannot be sure that the past is an appropriate analog to future forest conditions. Managing for resiliency is one way that ecologists and forest managers seek to mitigate the risks associated with uncertainty (Drever et al. 2006). Resiliency buffers forest ecosystems from large changes in composition and function, and it protects markets and ecosystem services (Millar et al. 2007). High species diversity increases ecological resiliency (Tilman and Downing 1996) and may contribute functional redundancy (Peterson et al. 1998). Intensely managing for one or a few high value NTFPs, especially in forest understories, may decrease diversity and resiliency and increase forest vulnerability.

Invasive species have ecological and economic consequences in managed forests (Pimentel et al. 2005) and can affect NTFP management. For example, invasive feral hogs in many parts of the United States destroy the understory and significantly change plant communities (Aplet et al. 1991, Bratton 1975), which is specifically relevant for many medicinal herbs. Some invasive plant species directly compete with understory NTFP species or employ novel phytochemicals with allelopathic effects (Wixted and McGraw 2010). Garlic mustard, for example, disrupts arbuscular mycorrhizal networks, which is critical for most understory herbs (Barto et al. 2010, Roberts and Anderson 2001, Whigham 2004). Non-native invasive earthworms can impact regeneration and establishment of forest herbs through predation or changing the physical properties of the forest floor (Frelich et al. 2006, Gundale 2002, McCormick et al. 2013). Furthermore, earthworms can have indirect effects on understory plant communities by altering mycorrhizal fungal communities (Lawrence et al. 2003, McLean and Parkinson 1997). Invasive insects and pathogens have reshaped American forests for more than a century (e.g., hemlock woolly adelgid [*Adelges tsugae* Annand], chestnut blight [*Cryphonectria parasitica* (Murrill) Barr]) and interactions between them have unintended consequences for forest understories. For example, gypsy moth (*Lymantria dispar* L.) outbreaks may be responsible for increased garlic mustard and Japanese stiltgrass (*Microstegium vimineum* (Trin.) A. Camus) abundance in eastern forests stands (Eschtruth and Battles 2014).

Unsustainable populations of animals and native plants, such as white-tailed deer (*Odocoileus virginianus* Zimmermann) and eastern hayscented fern (*Dennstaedtia punctilobula* (Michx.) T. Moore) in the eastern deciduous forest, can severely impact management of many understory NTFP species (Avril and Kelty 1999, Horsley et al. 2003, Webster et al. 2005). Diverse forest systems generally are more resilient to invasion of pests or disease outbreaks than more intensive management systems. Moving toward more intense NTFP production, such as forest farming, may increase impacts of pathogens.

2.3 Forest Farming in Temperate United States

Some NTFPs are cultivated under forest trees in a farm setting. Forest farming involves the cultivation or management of understory plants within an established or developing forest (Chamberlain et al. 2009). NTFPs produced in a forest where soils and competing vegetation are manipulated are considered woods grown, while wild-simulated NTFPs are grown in forests with little site disturbance and few inputs. Some NTFP species, particularly American ginseng, have been cultivated under shade-cloth in north-central United States for many years. This section details forest farming practices, challenges, and opportunities.

Forest farming, the cultivation of crops (e.g., decorative ferns, medicinal herbs, and mushrooms) within a forest, is one of five categories of agroforestry recognized in the United States (Chamberlain et al. 2009, Gold and Garrett 2009). Simply harvesting plants or fungi from natural populations without any management is not forest farming. The fundamental criteria that define forest farming are that the crop-forest system is intentionally established, intensively managed, integrated, and interactive, which provides mutual benefits to the understory crops and trees (Gold and Garrett 2009). A naturally occurring population of a plant or fungus, however, can be brought into a forest farming system through propagation and management. Forest farming is designed to provide multiple income streams from the forest and create a more ecologically stable forest ecosystem. Forest farming may be done in a natural forest or in a deliberate planting of trees (Chamberlain et al. 2009). The overstory trees may be managed for timber production, which can allow for several rotations of understory crops to be grown and harvested before the timber is harvested. Forest farming of NTFPs has potential to increase conservation of NTFPs while providing innovative economic opportunities for rural America.

2.3.1 Approaches to Forest Farming

Forest farming ranges from intensive cultivation where seeds are planted in the forest understory to extensive approaches that modify forest stands to enhance production of existing plants. There are three widely recognized methods of forest farming: woods-grown, wild-simulated, and managed populations (Munsell et al. 2013).

In a woods-grown production system, the objective is the highest yields of the products in the shortest period of time (Davis and Persons 2014). It is an intensive system with generally high inputs, including the clearing of understory plants, tilling, and possibly establishment of raised beds. Planting may be done mechanically, resulting in high plant populations in closely spaced rows. Fertilizers, pesticides, and herbicides are used to enhance growth and protect the plants. Pests such as deer, rodents, and other wildlife may be controlled with fences, baits, or traps. Woods-grown production also can refer to the intentional planting of trees for production of a NTFP from the trees such as nuts, berries, or syrup.

In a wild-simulated production system, the objective is to grow the NTFP resource as naturally as possible with few inputs (Davis and Persons 2014). Wild-simulated production is less intensive and less expensive than woods-grown. The plants usually take longer to reach harvestable size and yields often are lower. The site is minimally disturbed and if soil amendments are used, they are done so sparingly. In general, no fertilizers or pesticides are employed after planting, although efforts are often made to protect the planting from thieves and herbivores. In wild-simulated production little if any maintenance may be needed after planting.

Wild-managed natural populations of NTFP species can lead to sustainable production of wild-managed NTFPs. Typically, the wild-managed method is based on the local ecological knowledge (LEK) of harvesters. Activities may involve removing competing vegetation from within and around the population and includes propagation by seed collected from that population or vegetative propagation by cuttings or division of roots and rhizomes. Managed populations can be treated as wild-simulated production systems, with little disturbance and few inputs. Silvicultural treatments, discussed in section 2.2, can facilitate wild-managed NTFPs and improve upon local practices. Nurturing of an existing population of an understory plant, fungus, or trees for NTFP collection, such as maple trees for syrup, is a time-honored method that harvesters have used to ensure the future availability of the product (Chamberlain et al. 2009).

2.3.2 Common Forest Farmed Products

Common NTFPs grown in forest farming systems include medicinal herbs, food (e.g., mushrooms, fruit, honey, nuts, and vegetables), decorative products, and native ornamentals (USDA Forest Service 2012). Shiitake mushrooms are perhaps the most popular edible forest product that is forest farmed, though forest farming of other edible forests products, such as ramps, is becoming common. American ginseng and goldenseal are prominent forest farmed NTFPs that provide insight into opportunities to expand this approach to production and conservation.

The most popular and valuable forest farmed NTFP is the native plant, American ginseng. Nearly 95 percent of the American ginseng produced in the United States is exported to China and other Asian countries (Davis and Persons 2014). In the early 1700s, ginseng was extensively wild-harvested from the forests in North America and exported to China. Cultivation of ginseng started in the 1800s after native populations had diminished (Davis and Persons 2014). Early on, most ginseng was grown under artificial shade, and there was little distinction in price between wild and cultivated ginseng. Ginseng grown in tilled, fertilized soil produces a big smooth root, while ginseng grown in undisturbed soil produces a more wrinkled root with a long “neck” composed of bud scars each representing a year’s growth. Today, the latter is preferred and fetches a higher price.

Field grown under artificial shade structures is the most intensive production system, which results in high yields of smooth ginseng roots in a few years (Davis and Persons 2014). Woods-grown ginseng may take 5 to 7 years to produce marketable roots, while wild-simulated ginseng takes 9 years or more to reach marketable sized roots. Wild ginseng roots, or roots that look wild, are much more valuable than cultivated roots. In 2012 and 2013, the price of wild ginseng ranged from $400 to $1,250 per dried pound, while ginseng grown under artificial shade was valued at $12 to $42 per dried pound (Davis and Persons 2014). Since the mid-1990s, buyer interest in woods-grown and wild-simulated ginseng has increased dramatically. Because of the high value, loss due to theft is a major threat to forest farmed ginseng in areas where ginseng is also wild-harvested.

Goldenseal, another native medicinal herb in high demand, is destined for markets in North America and Europe (Davis and Persons 2014). Goldenseal was wild-harvested throughout its native range in the 1700s and by the 1880s there was concern about the impact harvesting was having on wild populations (Lloyd 1912). Forest farming of goldenseal was practiced across the country throughout the first half of the 20th century, but disease and falling prices reduced production to about 100 acres nationwide by the mid-1970s (Veninga and Zaricor 1976). In the mid-1990s, demand increased once again and due to concern about the pressure on wild populations, there were renewed efforts to encourage forest landowners to grow goldenseal (Davis and Persons 2014).

In contrast to ginseng, there is no difference in prices paid for goldenseal root grown under artificial shade or on the forest. Goldenseal certified as organic or grown sustainably, however, can provide a premium price for producers. In 2013, goldenseal root sold for between $16 and $35 per dried pound, while certified organic root was valued at $67 to $70 per dried pound (Davis and Persons 2014). This pricing structure is typical of other medicinal forest products.

Several other popular NTFPs grown in a forest-farming system include ramps, bloodroot (*Sanguinaria canadensis* L.), and black cohosh. Shiitake mushroom forest farming is increasing across the country. In southern United States, pine straw production through silvopasture also provides forest-based income. Other NTFPs are forest farmed on a very small scale. Growers often cultivate 0.25 acres or less of many native herbs to supply local herbalists, raw material buyers, and crafters. There are plants native to every region of the United States that may be forest farmed. Forest farming of NTFPs is attracting widespread interest among landowners wanting to diversify their income sources.

2.4 Market and Economic Considerations

Many private landowners adopt forest farming as a way to generate income from their forests without having to cut timber (Chamberlain et al. 2009). For others, production of NTFPs is a very deliberate method of generating income while timber matures before harvest. For whatever reason landowners decide to forest farm NTFPs, there are market and economic factors that must be considered in management decisions.

A few enterprise budgets for common forest farmed nontimber forest products have been developed (Burkhart and Jacobson 2009, Kays and Drohan 2003). Ginseng appears profitable on most budgets, while the profitability of other NTFPs is less attractive. Davis and Persons (2014) estimated that a forest landowner could net a profit of about $43,000 from 0.5 acres of wild-simulated ginseng after 9 years, at a per-pound price of $675 for dried roots. Jacobson and Burkhart (2005) estimated that 0.5 acres of wild-simulated ginseng would yield a profit after 10 years of $22,000 with the ginseng valued at $349 per dried pound. Accounting for the difference in price per pound, the estimated net profits on these two budgets would be nearly identical.

Using these studies to compare estimated profits for goldenseal, however, reveal substantial differences. Davis and Persons (2014) estimated that 0.5 acres of woods-grown goldenseal would yield a profit ranging from $300 (low root yields) to $41,000 (high root yields) with the goldenseal priced at $70 per dried pound, after 4 years. In contrast, Jacobson and Burkhart (2005) estimated that profits for a similar scenario with goldenseal would be about $15,000 at $17.69 per dried pound. Inconsistencies between analyses could be addressed through additional research to develop standard production budgets and cost-benefit and profit analysis.

Commercial markets for many raw materials of NTFPs (e.g., medicinal herbs, mosses) are well-established (Greenfield and Davis 2003), yet finding them can be difficult because many of the markets are not highly visible and not easily found through regular channels (Davis and Persons 2014). To enter the market often requires personal contact with buyers. Raw materials are sold to wholesale buyers who consolidate products and may do some processing. In some communities, there are small manufacturers (e.g., herbalists, florists) that buy limited quantities direct from the producer. These markets often pay a higher price per unit compared to larger wholesale markets, but volumes are much less. Forest farmed products also are often in direct competition with wild-harvested products, meaning profit margins for forest farmed products may be small or nonexistent (Chamberlain et al. 2009).

Product branding or certification are ways to add value to the forest farmed products, and efforts are underway to accomplish this using third party verification programs that guarantee product quality or regional identification (Blue Ridge Naturally Program 2015). The USDA National Organic Program (2015) will certify wild crop harvested products for a number of forest farmed NTFPs, and some farmers are using this to distinguish their products. These programs are not for everyone, and the interested landowner should weigh costs and benefits of such.

2.5 Production in Alaska and Hawai‘i

The previous sections addressed production of NTFPs in temperate continental United States. There are many NTFPs produced in boreal and tropical forest ecosystems of this country and its insular territories. The contiguous states have different NTFPs than Alaska, Hawai‘i, and the island territories. Many people in Alaska rely on wild-harvested foods for subsistence and household nutritional needs. Hawai‘i and the island territories have hundreds of plants and fungi that provide NTFPs, and the products are embedded deep in traditional cultures of these tropical environments. Both states have strong cultural ties to NTFPs, as the products have been used by native people since they inhabited the places. Continued use and enjoyment of NTFPs is essential to the well-being of the people throughout the country. This section focuses on important NTFPs and their production outside the conterminous United States.

2.5.1 Alaska

A variety of NTFPs are important for Alaska Native and rural residents. Over 75 forest plants, used in various parts of Alaska, have historical documented use maintaining cultural identity including meeting nutritional needs, supplying arts and crafts materials, and medicinal and spiritual purposes (Garibaldi 1999). Subsistence harvesting provides food, opportunities for exercise, fresh air, and social activity with others. Subsistence typically is a communal activity with group harvest, preparation, and sharing (Thornton 1998, 2001).

Subsistence harvesting of wild plants is important in meeting rural household nutritional needs and maintaining cultural identity. Alaska Natives have a long harvest tradition and maintain subsistence use of wild blueberries (*Vaccinium alaskaense, V. ovalifolium*), bog cranberries (*V. oxycoccos*), high bush cranberries (*Viburnum edule*), salmonberries (*Rubus spectabilis*), raspberries (*Rubus leucodermis*), currants (*Ribes bracteosum, R. laxiflorum*), nagoonberries (*Rubus arcticus*), gooseberries (*Ribes lacustre*), and watermelon berry (*Streptopus amplexifolius, S. roseus*). Syrup is produced from berries and also from the sap of paper birch (*Betula papyrifera*) and Sitka spruce bud tips (*Picea sitchensis*). Tea is crafted using spruce bud tips along with the fruit, leaves, and flowers of edible plants.

Arts and crafts produced from forest plants are integral to native culture and are used to express and preserve culture and history. The fiber of birch, aspen (*Populus balsamifera*), juniper (*Juniperus communis*), hemlock (*Tsuga heterophylia*), spruce, and red and yellow cedar (*Thuja plicata, Callitropsis nootkatensis*), and other plant organs including bark, limbs, roots, cones, berries, and boughs, provide material for artisan products. Alaska Natives have used wild forest products to craft totems, canoes, basketry, paintings, carvings, floral arrangements, and wreaths. NTFPs continue to be used to produce arts and crafts that convey Alaska Native history and cultural identity (Pilz et al. 2006).

Oral histories of Alaska Natives indicate plants have been used to treat a range of human injuries and ailments. Devil's club (*Oplopanax horridus*) is the most common and widely used medicinal plant used by coastal Alaska Natives (Garibaldi 1999). Skunk cabbage root (*Lysichiton americanus*) also is harvested and used for aches and pains, psoriasis, and other skin conditions (Garibaldi 1999). Labrador tea (*Ledum groenlandicum*) was used for colds, flu, stomach troubles, and tuberculosis (Garibaldi 1999).

2.5.2 Hawai‘i

NTFPs in Hawai‘i are used for food, decorations, construction, as well as landscaping (app. 4). Collection of NTFPs for hula and celebrations is a particularly important use of these products. Many of the NTFPs harvested from Hawaiian forests are indigenous or endemic to the islands and may require special attention. Some of the most valuable NTFPs come from trees that are harvested for their wood and used for specialty products. Descriptions of those are included here as the wood may not be of timber size or is used in production of fine arts and crafts.

The two most economically valuable trees in the Hawaiian forest are koa (*Acacia koa* A. Gray), and sandalwood (*Santalum* spp. L.). Koa is the largest tree in the Hawaiian forest and prized for its glossy, highly figured heartwood (Lowell et al. 2013). Sandalwood is harvested for the aromatic wood from which scented oil is derived. While neither koa nor the main commercial species of sandalwood (*Santalum paniculatum* Hook & Arn) are threatened with extinction, supplies of both will become rare unless conservation measures are improved.

Koa is a large, fast-growing legume tree that regenerates from seed or root suckers in forest gaps and is common in upland forests on all the islands (Baker et al. 2009, Friday 2010). Commercial koa stands today are limited mainly to the island of Hawai‘i, and harvesting is done by only a few small-scale operations. Nonetheless, in 2000, koa represented about 75 percent of the value of the Hawaiian forest industry (Friday et al. 2006). Some landowners restrict harvesting to dead and dying trees only. Browsing by cattle and feral ungulates, competition from invasive plant species, and wildfires continue to limit regeneration. Nontimber products from koa include stock for fine arts and crafts. As Hawai‘i's climate is expected to become drier and warmer (Giambelluca et al. 2008), koa is likely to retreat from the drier sides of the islands and become more vulnerable to wildfires, pests, and diseases.

Sandalwood is a slow-growing small tree of dryland forests. It was Hawai‘i's first commercial crop after Europeans discovered the islands. Over-harvesting in the early 1800s led to a boom and subsequent bust as natural populations of sandalwood were decimated (Merlin and VanRavenswaay 1990). While there are six native species of *Santalum* in Hawai‘i (Harbaugh et al. 2010), nearly all commercial harvest comes from *S. paniculatum*, the mountain sandalwood of Hawai‘i island. Unlike koa, sandalwood forests with commercial quantities of sandalwood are restricted to a narrow belt of a few thousand acres on Hawai‘i Island.

Because of the tree's scarcity, sandalwood harvesting in Hawai‘i is controversial and few harvesting operations exist. One firm extracts sandalwood oil and sells the residual wood for incense production. Other products from sandalwood include wood for carving and furniture and bark for medicinal tea. While *S. paniculatum* is not listed as a threatened or endangered species, these forests are vulnerable to livestock browsing, wildfires, and conversion to other uses. Landowners have had some success in encouraging natural regeneration from root suckers by controlling feral animals; however, no planted sandalwoods have reached harvestable size and rotation ages of Hawaiian sandalwoods are unknown.

2.6 Production in the Caribbean and Pacific Insular United States

The jurisdictions considered in this section refer to the insular areas of the United States. The term *insular area* refers to a jurisdiction that is a U.S. territory but is neither one of the 50 states nor a Federal district (DOI 2015). We restrict the term to include only insular areas that are inhabited and unincorporated island territories of the United States. These include the Caribbean islands of Puerto Rico and the U.S. Virgin Islands (USVI) and the Pacific islands of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI).

2.6.1 Environmental Setting

The insular areas share a tropical maritime climate characterized by little annual variation in temperature and a pronounced seasonal rainfall within a rugged topography that helps defines the biota. They represent a very wide geographical range from the Caribbean Sea to the northwest and southern Pacific Ocean (Donnegan et al. 2004a, 2004b, 2011; FAO 2001; Weaver 2006a, 2006b). Exposure to similar types of natural hazards such as hurricanes and potential impacts of climatic variability characterize the Caribbean region (Chakroff 2010, Lugo 2000, UNEP 2008), while past volcanic eruptions, frequent tropical storms, hurricanes, typhoons, and soil erosion characterize the major natural disturbances within the Pacific (Donnegan 2004a, 2004b; Donnegan et al. 2011; FAO 2001).

The forests in Puerto Rico and the USVI are mostly secondary stands of young structure, representing natural regeneration after abandonment of agricultural land and covering approximately 55 percent of the area (Brandeis et al. 2007; Brandeis and Turner 2013a, 2013b; Marcano-Vega et al. 2015; Weaver 2006a). Forest cover is approximately 42 percent in Guam, 67 percent in CNMI, and 90 percent in American Samoa (Donnegan et al. 2004b, 2011; FAO 2010a, 2010c; Government of Guam 2010; Neville 2014).

2.6.2 Caribbean, Puerto Rico, and the U.S. Virgin Islands

Many people within the insular Caribbean use NTFPs as sources of nutrition and medical care (van Andel 2006). The production of NTFPs in the insular Caribbean is said to reflect the "cultural history rooted in the use of the region's biodiversity" (John 2005). The major NTFPs (app. 4) can be divided into medicinal and aromatic, edible, and material for fine arts and crafts (FAO 2000, Kicliter 1997). Forero-Montaña (2015) revealed that Puerto Rican artisans made use of 127 types of wood, more than 30 seeds, bamboo (*Bambusa vulgaris* Schrad. ex J.C. Wendl.), coconut (*Cocos nucifera* L.), two calabashes, four vines, and two fibers.

Some species commonly used by Puerto Rican artisans for the wood includes the American muskwood (*Guarea guidonia* (L.) Sleumer), Spanish elm (*Cordia alliodora* (Ruiz & Pav.) Oken), lignumvitae (*Guaiacum officinale* L.), Spanish cedar (*Cedrela odorata* L.) and mahogany (*Swietenia mahagoni* (L.) Jacq. and *S. macrophylla* King) (Kicliter 1997, Mari Mut 2013). Other plant species widely used for NTFPs include the calabash tree (*Crescentia cujete* L.), which has medicinal uses and is used for containers and crafts (Benedetti and Negrón-Flores 2012). The coconut palm, used for food, fiber, and wood, is mainly cultivated for its fruit (Parrotta 2000). Shade-grown coffee (*Coffea arabica* L., *C. liberica* W. Bull ex Hiern.) is still a traditional crop from the western central mountains, while mango (*Mangifera indica* L.) and breadfruit (*Artocarpus altilis* (Parkinson) Fosberg) are abundant fruit trees within forests (Marcano-Vega et al. 2015). Other species such as soursop (*Annona muricata* L.), sour orange (*Citrus ×aurantium L. subsp. aurantium L*), key lime (*Citrus ×aurantiifolia* (Christm.), and cure for all (*Pluchea carolinensis* (Jacq.) G. Don) have been identified as frequently used to treat health conditions (Alvarado-Guzmán et al. 2009). The native soursop and naturalized sour orange and lime can be found in secondary forests (Brandeis and Turner 2013a, Francis 2004, Marcano-Vega et al. 2015, Nuñez Meléndez 1982).

The use of NTFPs in the USVI is mainly for the production of jewelry, bowls, spoons, and items made from locally grown wood, bamboo, and palm fronds (FAO 2010e). Mahogany (*Swietenia* spp.) and tibet (*Albizia lebbeck* (L.) Benth.) are tree species used for artisanal work (Chakroff 2010). Medicinal plants are important crops in the USVI and medicinal trees like neem (*Azadirachta indica* A. Juss.), moringa (*Moringa oleifera* Lam.), and noni (*Morinda citrifolia* L.) are grown in agroforestry systems (Palada et al. 2003, 2005). Herbal teas locally known as "bush medicine" are consumed for medicine or food (Palada et al. 2003, 2005). In the USVI farmers actively produce NTFPs on their land and the majority of the products are fruits, especially mango, avocado (*Persea americana* Mill.), coconut, mamee apple (*Mammea americana* L.), and lime (Workman et al. 2004). The leaves and berries from abandoned stands of bayrum trees (*Pimenta racemosa* (Mill.) J.W. Moore), planted to supply the cosmetic and perfume industry in the 1940s, remain productive today (Weaver 2006a). The nonnative genip tree (*Melicoccus bijugatus* Jacq.) is present within the secondary forests of the USVI, offering a favorite fruit, and its wood is used to make charcoal (Brandeis and Turner 2013b, Chakroff 2010).

2.6.3 Insular Pacific—American Samoa, Guam, Northern Mariana Islands

Traditional agricultural production in the insular Pacific consists of agroforestry systems of cocoa (*Theobroma cacao* L.), coconut, breadfruit, and various other fruit trees inter-planted with the nitrogen-fixing erythrina (*Erythrina subumbrans* (Hassk.) Merr.), bananas, cassava, and root crops (American Samoa Community College 2010). Further, the fruits, leaves, trunk, and roots of coconut palm are sources of copra oil and soap, baskets and brooms, construction materials, and material for rope (Wilkinson and Elevitch 2000), but plantations are being abandoned due to a decline in the copra market (FAO 2005a, 2010a). Native tree species are harvested to create traditional handicrafts, traditional clothing, oils, and mats (FAO 2010a), as the flora has always been an integral part of the insular Pacific culture. In American Samoa, noni is used for medicinal purposes and moso'oi (*Cananga odorata* (Lam.) Hook. f. & Thomson) and laga'ali (*Aglaia samoensis* A. Gray) for making of perfume and cosmetics. Moso'oi and laga'ali are used as ornamentals (FAO 2000). Other species used in American Samoa include ifil (*Intsia bijuga* (Colebr.) Kuntze), reported to generate more than $400,000 per year in revenues for the national economy. Other trees used for the nontimber products include Javanese bishopwood (*Bischofia javanica* Blume) for dying and thatch screwpine (*Pandanus tectorius* Parkinson ex Zucc.) for utensils (FAO 2000). In Guam, the fruit of the betel nut palm (*Areca catechu* L.) is regularly collected (FAO 2005b, 2010b) and used as an astringent and stimulant. Fruits of breadfruit (*Artocarpus altilis*) and dokdok (*A. mariannensis* Trécul) are food sources as well. Some fruits and medicines are also collected within the forests of CNMI, and agroforestry systems include the coconut palm and a mix of native and introduced species used for sustenance (FAO 2010c).

2.6.4 Opportunities

The prospects for NTFPs to be more integrated into forest management are encouraging. NTFPs present alternatives for utilization of local forest resource and encourage rural economic growth. Promotion of sustainable forestry practices on private and communal lands can lead to better NTFP management and conservation. Integrating NTFPs into forest inventory and monitoring presents challenges that require additional research and investments.

Interest in traditional use of medicinal plants persists within the insular areas of the Caribbean (Alvarado-Guzmán et al. 2009, Benedetti 2009, Chakroff 2010, Weaver 2006b). An ethnopharmacological survey in the southeastern region of Puerto Rico revealed that 58 medicinal plant species, some of which are obtained from the forest, were used as remedies for ailments mostly affecting the respiratory and gastrointestinal systems (Alvarado-Guzmán et al. 2009). Medicinal plants from the USVI include 35 herbaceous, 11 tree, 12 shrub, and 10 vine species (Weaver 2006b). This interest offers opportunities to promote production of NTFPs as economic alternatives.

Integrating NTFPs into forest inventory and analysis is needed to ensure sustainable sourcing of products. Since the 1990s, there has been a call to integrate NTFPs in forest assessments within the Pacific islands to provide useful baseline data regarding sound management of forests (DeBell and Whitesell 1993). On the other hand, the Food and Agriculture Organization (FAO) of the United Nations global forest resource assessment highlighted the important role of NTFPs in the well-being of people worldwide but lacks assessment and monitoring of resources and utilization (FAO 2001). Major research opportunities include the need for inventorying NTFP resources and their habitat requirements. Also, there is a need to monitor markets and the amount of NTFPs traded as well as the sources of raw materials. Finally, research is needed to assess impacts of introduced animals and invasive species on NTFP resources.

2.7 Inventory and Analysis

The inventory and analysis of trees in forests are well embedded in forestry and forest health assessments. Methods to inventory trees harvested for timber are well developed and integrated into forest management. Information is available for some trees that provide NTFPs, but the data must be examined from an NTFP perspective. While the Forest Inventory and Analysis (FIA) program of the Forest Service (USDA Forest Service 2015) can provide data on some NTFPs, there are opportunities to expand research investments and data collection to improve information about these products.

2.7.1 Current Approach to Forest Inventory

Management and planning for sustainable production of all forest products requires knowledge of their spatial distribution, abundance, and change over time. Collection of this information for resources as biologically diverse and geographically dispersed as NTFPs presents challenges. Fortunately, much can be learned about NTFPs from conventional forest inventory, and there are opportunities to leverage existing data with additional information to gain insights about the status and expected trends of many NTFPs. A distinction can be made between national-scale inventories that are consistent, comprehensive, and repeated, versus inventories for specific purposes, places, and/or times.

The FIA program collects information on the status and trends of forest resources of the United States. The program is a national-scale inventory that collects data across all ownerships, across the entire United States, using standard sampling schemes and data collection protocols (Bechtold and Patterson 2005, Reams et al. 2005). Plots are remeasured in cycles; in eastern states, every 5-7 years and in the West every 10 years. At each forested sample plot, information about the site (i.e., location, physiographic condition, ownership, forest type, and stand age class) and individual trees (species, diameter, height, and condition) are recorded (USDA Forest Service 2014). These data, related to specific location by plot coordinates, enable spatial analysis of abundance and status of individual tree species.

Non-tree vegetation profile information may be collected from plots and, if collected, consists of percentage canopy cover of growth habit (tree, woody shrub/vine, forb, graminoid) and canopy layer. Also, up to four of the most abundant species per growth habit may be recorded. The FIA program produces summary reports and analyses from the plot data and also provides data and tools with which users can perform their own analyses of populations of specific interest.

2.7.2 Status of Nontimber Forest Product Inventory

Inventory protocols for commonly harvested timber and wildlife species are fully integrated into forest management. Wong et al. (2001) summarized much of the body of knowledge concerning inventory and resource assessments of nontimber forest resources and associated products in a seminal document. Vegetation inventories are used for biodiversity conservation (Elzinga et al. 1998). Market and economic inventories have been used to assess current and potential contributions to community development (Greene et al. 2000, Greenfield and Davis 2003). Inventory and monitoring NTFPs are essential activities in the sustainable management of these resources (Kerns et al. 2002) yet they have not been integrated into current programs.

Approaches and methodologies differ for the various products and desired information. Permanent plots have been used for mushrooms in the Pacific Northwest (Pilz et al. 1996) and medicinal plants in southern Appalachia (Chamberlain et al. 2013a, McGraw et al. 2003, Small et al. 2011). Protocols to inventory salal and other understory plants in the Pacific Northwest forests, which are harvested for the floral industry, have been tested (Barnes and Musselman 1996). Inventory and monitoring protocols have been developed for American ginseng and goldenseal (Gagnon 1999a, 1999b). A challenge with these is scaling up from research to production levels.

For NTFP resources where the desired products are belowground, such as tubers and roots, inventories are especially problematic as there is little or no way to correlate aboveground biomass to belowground yield. Chamberlain et al. (2013a) developed a method to model belowground biomass for black cohosh based on measurements of aboveground vegetation. The model serves as a tool to inventory NTFPs that are harvested for their roots. Efforts are under way to adapt this model to other medicinal NTFPs, such as blue cohosh (*Caulophyllum thalictroides* (L.) Michx.).

In general, FIA does not inventory specifically for NTFPs, although fortuitously information can be extracted from FIA data that are relevant to monitoring NTFPs derived from forest trees. Because tree records in the FIA database can be selected for a species of interest, a great deal can be learned about the abundance, distribution, and trends for a single forest tree species. FIA data have been used to estimate potential production of maple syrup from American forests (Collins 2001; Farrell 2009, 2013). The most recent of these studies used plot information on stand density (number of potential maple tree taps per hectare) as well as distance to nearest access road to include only those sites with potential for commercial production (Farrell 2013).

Slippery elm (*Ulmus rubra* Muhl.) illustrates what can be deduced from FIA inventory data on NTFPs from trees (Kauffman et al. 2015). Slippery elm is a tree species native to eastern North America from which bark is harvested for herbal remedies. FIA data enable the analysis of the abundance (numbers of trees), spatial distribution, and components of change (growth, harvest removals, and mortality) and to evaluate the change in inventory measures over time (figure 2.6). Tabular presentations of slippery elm inventory, growth, mortality, and removals indicated a net volume decrease of living slippery elm trees from 2007 to 2012, with annual mortality approximately equal to annual gross growth. At the same time, removals of slippery elm increased. Thus, the inventory data indicate there is cause for concern for the sustainability of slippery elm, with high levels of mortality (possibly related to Dutch elm disease) and increasing removals.

2.7.3 Using Forest Inventory and Analysis Data for Nontimber Forest Product Inventory

The FIA program has a broad user community, and many scientists are involved in improving and leveraging the information collected by FIA. Remote sensing data are being used to develop more spatial precision in estimates of FIA forest and tree species distributions. Substantial research efforts tied to FIA plot data can

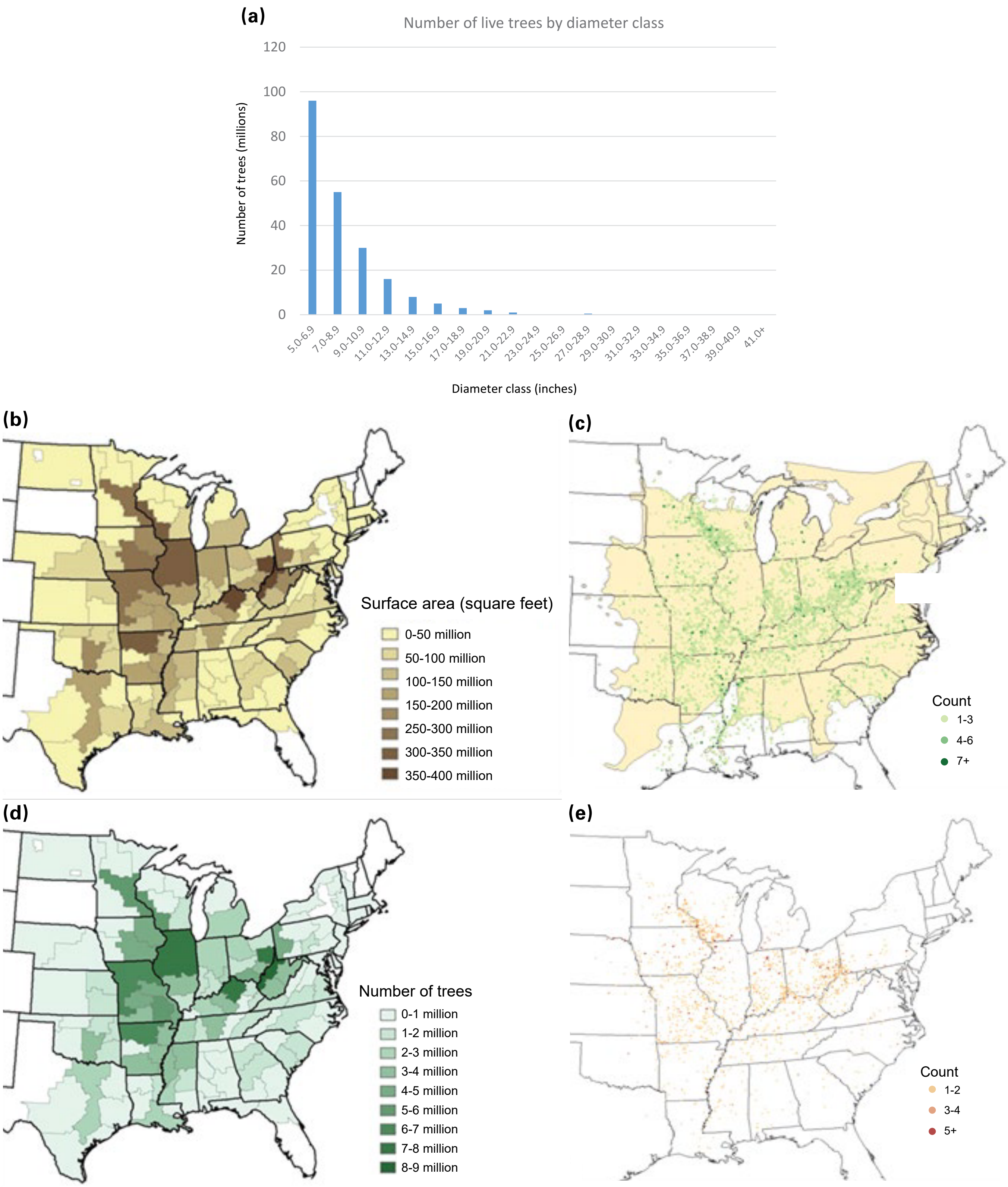

Figure 2.6—Slippery elm inventory. (a) Number of live slippery elm (*Ulmus rubra* Muhl.) trees (diameter 5 inches and greater) by diameter class in eastern United States. (b) Surface area of slippery elm boles by Forest Inventory and Analysis (FIA) inventory unit, 2012. (c) Approximate locations of FIA plots on which slippery elm trees were measured, 2012. Dot colors represent numbers of trees observed on the plot; the shaded region is the natural range of slippery elm (Little 1971). (d) Number of slippery elm trees by FIA inventory unit, 2012. (e) Approximate locations of FIA plots on which slippery elm mortality was observed, 2012. Dot colors represent number of dead trees observed on the plot. (Maps rendered by J. Kauffman, Virginia Tech.)

be immediately applied to NTFPs derived from trees. For example, modeling of the spatial distribution of tree species under a variety of future climate scenarios has been conducted for over 100 tree species, including some of NTFP importance (Iverson et al. 2008).

FIA data can be integrated with other datasets to gain insights into certain NTFPs. For example, Chamberlain et al. (2013b) combined FIA data with American ginseng harvest data obtained from the FWS to assess the relationships between ginseng harvest and timber inventory and harvest. Because FIA plot data and ginseng harvest data could be resolved to a county level, it was possible to examine correlations between the two datasets. They found ginseng harvest levels correlated with hardwood forest area, hardwood growing-stock volume, and timber removals.

Another approach to extending the value of FIA data for NTFPs involved augmenting FIA data with field inventory specifically designed for assessing paper birch bark resources for baskets and other fine arts (Emery et al. 2014). Integrating standard FIA data with a custom inventory and traditional ecological knowledge (TEK) yielded new information on the resource. Experts in bark harvest identified bark characteristics related to the potential utility of harvested bark for fine arts. Measurable features associated with these characteristics were then identified by ecological experts with extensive cultural expertise. FIA field crews collected data on these features when measuring paper birch trees. The variables, combined with traditional tree measurements such as diameter and height, enabled computation of estimates of harvestable bark and change over time.

Finally, often FIA plot measurements can be used to develop models that predict parameters of interest, but this may require more intense data collection from plots across the landscape. For example, modeling ginseng distribution is possible and requires extensive data on topography, soils, forest cover parameters, and other geographic variables such as aspect, slope, elevation, and soil acidity (McGraw et al. 2013). Research investments have improved the mathematical techniques for computing the inventory parameters of interest (e.g., biomass, growth, removals, and mortality). Similar efforts could lead to the ability to predict other parameters of interest for NTFPs, such as predicting fruit or seed yield from tree or site conditions.

In summary, while a great deal of information on NTFPs from trees can be derived from FIA data, there are opportunities to leverage investments in research and field data collection to improve the information on NTFPs. The FIA program has active support and interest from a broad user community, and expanding data collection to include more information on NTFPs will likely require similar strong support from the NTFP science and broader user communities.

Fundamentally, there is a strong and growing body of knowledge to build an inventory program for NTFP resources. Globally, there are insufficient data and a lack of common reporting methods to fully integrate NTFP inventories into forest management. Efforts are constrained by a lack of field skills, time, personnel and fiscal resources. Until these issues are addressed, the inventory and assessment of nontimber forest resources will be under-utilized in forest management in the United States.

2.8 Tracking Nontimber Forest Products

One of the greatest obstacles to creating effective NTFP policy is the lack of knowledge about the size and structure of the NTFP industry. These products have a great deal of cultural and economic value, but there are little consistent data on how much is harvested and where it originates (Vaughan et al. 2013). To effectively allocate resources for sustainable utilization of NTFPs, a better understanding of their economic impact and the impact of harvest on wild populations is necessary. This requires systems that track how NTFP resources get from forests to consumers. For the purpose of this section, *tracking* refers to methods for collecting data on NTFPs including estimates of harvest volumes and distribution and measurements of how production changes over time. Knowing the context of tracking data is vital for effective management decisions. This includes the structure of NTFP supply chains, the practice of harvesting and trading, and changes in price and consumer demand. NTFP economies vary from region to region, and within one sector there may be a multitude of species being harvested. Tracking programs should be efficient and focus on products that have high economic value, are harvested heavily, or that are rare or rapidly declining. This means that tracking is most effective when it is part of a system that also monitors plant populations and engages market participants.

A tracking program can benefit many stakeholders affected by NTFP production. Market participants, forest managers, and conservation organizations share an interest in ensuring the sustainable management of natural populations. For consumers, a more open supply chain can provide confidence in the quality and safety of products and whether the products are sustainably sourced. Tracking programs can be burdensome for harvesters and producers, but such programs can benefit them as well. Tracking programs that reveal the economic impact of NTFPs on what are often marginalized communities can help make an argument for greater institutional support for production. Unlike most businesses, NTFP market participants lack access to data on product supply and demand. Fluctuations in price and demand cause general instability within the market, resulting in greater risk for those involved. The lack of available market research is often cited as a barrier to entry for farmers, landowners, community organizers, and professionals interested in cultivating or managing their woodlands for NTFPs (Chamberlain et al. 1998, Gold et al. 2004). This section explores how NTFPs are tracked and the challenge of designing and implementing tracking programs.

2.8.1 Approaches, Methods, and Programs

Few institutions track NTFPs to any extent, and they employ different strategies including sales of harvesting permits (e.g., national forests), mandatory reporting (e.g., CITES), and voluntary surveys (e.g., AHPA). This section gives a brief summary of various tracking methods. All have advantages and disadvantages. They are tailored to certain products, markets, and land classes. A comprehensive large-scale tracking program would have to integrate multiple methods.

Permit programs—Permitting provides collectors with access to NTFP resources and landowners with an opportunity to manage NTFPs over large areas. The Forest Service and BLM issue permits to harvest NTFPs (USDA Forest Service 2015a). Permits typically are issued for specific volumes and time limits. Permit prices are based on estimated fair market value of the product and, in some cases, different permit prices are available for commercial and recreational harvesters (USDA Forest Service 2015a). The granting office assumes that the entire permitted amount, and only the permitted amount, is harvested. Permitted harvest volumes are totaled by district and by forest to achieve an estimate with a degree of regional distribution (Alexander et al. 2011). Permitted harvest volumes, as reported by the Forest Service and BLM, do not include private lands and are an imperfect measure of actual harvest volumes (Alexander et al. 2011, Muir et al. 2006). Table 2.1 summarizes the volumes of permitted harvest in 2013 from national forests and BLM lands. Enforcing permitting regulations requires significant resources, and given the expansive areas involved, it is unlikely effective. Income from permit fees can support enforcement, but because of slim profit margins for harvesters, the cost of permit fees can discourage their purchase and lead to illegal harvesting (Charnley et al. 2007). Permitted harvest data may provide a better description of harvest volumes in the West, where public ownership dominates, but is less useful in the East, where private lands dominate. Private landowners may grant leases to harvest, but data are not available.

Mandatory reporting and export data—In the United States, American ginseng may be the NTFP that has been tracked the longest and with the most detail because of its inclusion in CITES (Chamberlain et al. 2013b). Buyers of American ginseng root, who want to sell outside of the State in which they reside, are required to register with the appropriate state agency, keep records of each transaction, and have ginseng roots inspected and certified by the state agency before the roots can leave the state. The system was established to ensure that ginseng is legally harvested and allows the FWS to determine nondetrimental status of the harvest.

This mandatory reporting achieves high participation and has provided the most detailed data on volume and harvest distribution of any NTFP in the United States. Tables 6.2 and 6.3 (chapter 6) summarize the ginseng harvest volumes by state, year, and amounts. It is burdensome, however, for harvesters and buyers who use ginseng sales to supplement income. The tracking program is directly tied to regulations that are perceived by many buyers and harvesters as overly restrictive, ineffective, and created without their input (Blumenthal 2006). Negative associations with mandatory reporting may hinder future voluntary collaboration on efforts to track other NTFPs (Love and Jones 1997, McLain 2008). The ginseng program requires substantial resources for enforcement and administration in the respective state programs. Mandatory reporting should not be undertaken without exploring other possibilities and assessing the impact on participants (Robbins 2000).

Some NTFPs are exported and assigned an international export code under the Harmonized Tariff Schedule that is used by the U.S. International Trade Commission (ITC 2014) to track products. In most cases, wild-harvest products are lumped into broad categories such as "foliage," which also can include cultivated products (Alexander et al. 2011). Three exceptions to this are wild blueberries, wild ginseng, and mosses. Data from the ITC can be used to estimate harvest volumes at a national level, but do not allow for assessment of harvest distribution.

Industry tracking—Trade associations generate estimates of some NTFP sectors. Some are single-product oriented, such as the National Christmas Tree Association, which surveys its members (NCTA 2012). AHPA and the American Botanicals Council (ABC) publish quantitative data on wild-harvested medicinal plants. The ABC collects and summarizes data on retail sales of herbal products in its publication HerbalGram. Data derived from retail sales can provide estimates of the monetary value or economic impact of particular species or a category of nontimber forest end-products such as herbal supplements (Blumenthal et al. 2012). Retail data also can show trends in demand for NTFPs but are not effective at tracking actual product volume because manufactured goods containing NTFPs vary in price and the amount of raw plant material they contain. Presentations of these data also are one-time windows of dynamic markets that change with supply and demand.

AHPA surveys its members, some of which are the largest herbal companies in the United States, as well as primarily buyers of raw materials and publishes total volume for approximately 20 medicinal plants (table 2.2; AHPA 2012). The AHPA survey provides baseline estimates available for several species. The survey is repeated biannually, making it extremely valuable in providing insight into harvest and market trends. The AHPA data show dramatic fluctuations in volume of certain products from year to year, something that cannot be accounted for in a one-time study.

Household and voluntary surveys—Surveys have the potential for being an effective method for tracking NTFPs and can provide quantitative and qualitative data needed for management decisions. They are typically voluntary and confidential and can cover products harvested from public and private lands. The few surveys that have aimed at tracking NTFPs were directed at specific commercial product sectors, such as floral products in the Northwest (Schlosser et al. 1991), mushrooms in the Northwest (Schlosser and Blatner 1995), and moss in the Northwest and Appalachia (Muir et al. 2006). Surveying NTFPs from different market segments from the same region is another approach (Greenfield and Davis 2003). These were undertaken for research purposes and were not intended to track for long-term analysis.

Surveys are designed to target a point in the supply chain at which respondents are likely to know how and where their products are harvested. Some surveys have aimed to estimate the economic impact of NTFP markets by asking participants about prices for products. This makes it possible to describe economic value and volume of harvest, which is helpful when products have different physical properties (e.g., bark versus foliage). Surveys that are voluntary eliminate the need for enforcement, reduce cost, and are less burdensome to the participants. They, however, suffer from low response rates and nonresponse issues. Although surveys can be replicated, NTFP surveys in the United States have been short term, usually just covering one year. NTFP markets can be highly volatile, and new products are always emerging, meaning that to be effective, tracking systems including surveys should be updated and readministered.

Muir et al. (2006) used several data sources to project total estimates of product volume for mosses harvested from the Pacific Northwest and Appalachia. The authors found that export data indicated a much larger moss harvest than reported from permits. Moss dealers provided information on the proportion of their products for international versus domestic markets. To get a total estimate, they combined export data with a projection based on those percentages, demonstrating that using data collected from multiple sources can improve estimates.

2.8.2 Other Product Tracking Models

Other similar products are tracked effectively and provide insights into approaches that may be appropriate for NTFPs. As an example, the Forest Service FIA program has tracked timber production for more than 70 years. Other institutions track products sold through more informal markets, such as roadside stands and farmers' markets (e.g., USDA Agricultural Marketing Service [AMS]). Other countries have established systems for tracking some NTFPs. The methods used to track these products can provide valuable lessons for developing approaches for NTFPs.

Forest Service—Since the 1930s, the Forest Service has tracked timber production through the Timber Product Output (TPO) assessments, which are voluntary and confidential surveys of primary timber processors (USDA Forest Service 2015c). The TPO assessments collect data on the size, location, product, and production volume of each mill. TPO surveys also inquire about the origin of the raw material and if it came from public or private land. Data are collected at the county level and can be aggregated into multiple counties to preserve confidentiality if there are only a few operators that could be identified, which is often the case for NTFP buyers.

Designers of NTFP tracking systems can learn from the TPO assessments. The TPO collects data on harvest distribution, which can be correlated with data from FIA inventory plots such as measurements of timber removal and growing stock (Chamberlain et al. 2013b, Piva and Cook 2011). This ability to seamlessly integrate data from the industry and the forest makes the TPO a powerful tool for managers and policymakers analyzing the relationship between commerce, harvesting practices, and forest health. TPO assessments are done regularly, which allows for an ongoing analysis of trends and changes over time.

The TPO achieves response rates as high as 100 percent (Piva and Cook 2011), much higher than most surveys. When responses are missing, and the size and location of the mill is known, data are substituted from another comparable facility (Johnson et al. 2008). Part of the reason for the TPO's high response rates may be that the results are useful to participants. Reports are summarized by region and state and published in an easily accessible format. The public also can search and retrieve customized data through an interactive online database.

Other USDA programs—Farmers' markets share some of the informal characteristics of the NTFP economy. Cash transactions are common, and recordkeeping is inconsistent, making it difficult to create nationwide estimates of farmers' market sales and their economic impacts. The AMS commissioned a nationwide survey of farmers' market managers in 2006 (Ragland and Tropp 2009). The AMS maintains a directory of farmers' markets with the contact information of market managers, which serves as a sample frame, while a Web-based version allows market managers not in the directory to participate (Ragland and Tropp 2009).

This tracking method has the advantage of emerging from a larger institutional framework that provides resources for local food infrastructure, meaning the respondents were likely to benefit from participating. The lack of such a perceived benefit is a major obstacle for NTFP data collection. Finally, an important element of the farmers' market survey is that, like the TPO, it was designed to be repeated.

In addition to the AMS, the USDA National Agriculture Statistics Service includes NTFPs such as tree nuts, berries, and maple syrup in its annual reporting, which presents data on production volumes, prices, and producer demographics (e.g., NASS 2013).

NTFPs tracking in other countries—Looking at how NTFPs are tracked around the world can be instructive for assessing U.S. tracking methods. These programs face many of the same challenges that exist in the United States. In discussing the need to compile statistics on NTFPs for nations to use for policy decisionmaking, Vantomme (2003) argued that comprehensive data on product volume and origin is sparse and markets are informal and volatile.

One way Europe tracks NTFPs is through "The State of Europe's Forests" (SEF), a periodic report prepared by the Ministerial Conference on the Protection of Forests in Europe (MCPFE 2007). In the SEF, signatory countries report on indicators of sustainability to assess the overall condition of European forests. One criterion is the measurement of NTFPs quantity and value. In 2007, 32 European countries reported on marketable NTFPs and the quality of assessments varied greatly between countries. There is no standardized, overarching method used by all countries, but the SEF is still able to publish information on total NTFP quantity and value (MCPFE 2007). The report breaks down that value by country and also by product categories such as mushrooms, berries, and medicinal or colorant products. One limitation of this approach is that it provides national-level statistics and not local data.

Finland has some of the most detailed NTFPs tracking. Since the 1980s, Finnish researchers periodically survey households about NTFP harvesting activities (Saastamoinen et al. 2000, Turtiainen et al. 2012). Surveys are distributed to households throughout the country, with special emphasis on communities close to known harvesting areas (Turtiainen et al. 2012). Respondents are asked what species they harvest and the proportions for personal and commercial use. While these surveys do not collect data on harvest location, the studies do look at distribution based on harvester location.

Household surveys are effective in Finland, where an estimated 60 to 90 percent of people collect berries (Saastamoinen et al. 2000). More than 40 percent harvest mushrooms (Turtiainen et al. 2012). The low population of Finland and small size of the country support this type of analysis. In the United States, this would be challenging due to the size of the country, the dispersed nature of NTFP harvesting communities, and divisions between recreational and commercial harvesters. However, by targeting clusters of the population with higher probability of NTFP participation, it may be possible to assess the rate of harvest for some products in the United States. This can be done by targeting populations who live close to forests, common users of public lands, or cultural communities with strong NTFP harvesting traditions. The National Survey on Recreation and the Environment and the National Woodland Owners Survey collect data on gathering natural products from forests for personal and economic use, including mushrooms, berries, and plants and flowers (Butler 2008, Butler et al. 2016, Cordell and Tarrant 2002). The demographic data collected for natural product gatherers could help more detailed survey programs target likely NTFP harvesters.

Finnish researchers also work with volunteers to actively monitor NTFPs in the wild. They create annual yield estimates for berries based on inventory and climate data (Wong et al. 2001) and survey NTFP buyers about market conditions (Paassilta et al. 2009). The approach indicates that having repeated periodic surveys of NTFP harvest combined with monitoring and production support can improve NTFP tracking.

2.8.3 Challenges and Considerations for Tracking Products

NTFP production systems have characteristics that should be considered in the design of programs to track product movement. The diversity of NTFP markets complicates these efforts. In one forest district in the national forests of North Carolina, products are harvested for the floral industry, craft industry, medicinal products, nursery stock, and edibles (USDA Forest Service 2015b). Many products are collected for personal use, some make their way to regional markets as specialty or niche products, and others, such as American ginseng, are commodities that may be bought and sold several times and end up in distant domestic or international markets. Tracking programs should prioritize products based on some metric such as amount of volume harvested, monetary value, and scarcity of the plant.

The informal nature of the NTFP economy is another obstacle to effective tracking of the volumes of products harvested. Many NTFP markets are seasonal, and harvesters may be difficult to identify or contact, or they may not want to be identified as their work provides undocumented or untaxed income (Alexander et al. 2002). At the primary point of sale, cash transactions are common, and the extent of accurate record keeping by market participants is unknown. Primary buyers may not advertise and rely instead on a large network of suppliers. Identifying participants and key products can be difficult. When buyers or harvesters are not publicly listed, chain referrals, or the *snowball method*, can help locate participants (Greenfield and Davis 2003, Schlosser et al. 1991).

Identifying the optimal place in the supply chain to concentrate tracking efforts is another difficult task. While some NTFPs are sold directly from harvesters to consumers, there is a great deal of variation from product to product. An hourglass may best describe the shape of the typical NTFP market. At the bottom, a large number of harvesters sell to local buyers, who in turn sell the raw product to a few regional aggregators. Depending on the product, aggregators may process the product themselves, export the raw material, or sell to domestic processors such as herbal supplement manufacturers. Products then reach a large number of consumers through numerous outlets such as grocery or health food stores, craft shops, florists, or restaurants (Greene et al. 2000).

Tracking programs that collect data on where products are harvested must be conducted close to the point of harvest. Harvesters have the most accurate information about where products come from but may be difficult to locate and less likely to participate. Primary buyers are easier to locate and likely to know the general location where products were harvested (at the county level, for instance), but they may not keep accurate records of transactions. Large regional aggregators have varying levels of familiarity with product origin, and they may be easier to locate, but at this level, raw materials often have been consolidated into large lots, making it difficult to identify harvest locations. There also may be trade between participants, meaning products could be counted twice. At the other end of the supply chain there may be more record keeping, but even less knowledge about where the raw materials originated. By choosing any point on the supply chain, a tracking system may miss outliers, such as harvesters who make their own value-added products, but this is likely a small portion of what moves through the supply chain. With the exception of permitting programs, which target harvesters, the tracking systems that collect geographic data rely on primary buyers.

Low participation in tracking programs is possibly the greatest challenge in creating effective methodologies. The NTFP community often is described as secretive or having a closed culture, but there are practical reasons some people choose not to participate and practical reasons for maintaining confidentiality for those who do. Some concerns may be rooted in the potential legal ramifications for under-reporting cash transactions or trading in products harvested illegally. Competition within the industry, where personal relationships in the supply chain form a currency, can heighten the desire to protect information and increase reluctance to participate. In marginalized NTFP communities, there may be linguistic or cultural barriers to participation.

Often, NTFP producers choose not to participate simply because they see no benefit, or none that outweigh the burden and perceived consequences of participation. Communities engaged with NTFPs often have a history of negative experiences with Government agencies and other institutions (McLain 2008). These are exacerbated when policies are made without input from market participants, by people who generally do not understand how NTFPs are harvested and sold, or other nonenvironmental forces such as land use changes and local economic conditions. There is concern that this lack of contextual knowledge will lead to data being misinterpreted.

Affiliation with a university or nongovernmental organization might make it easier to work with NTFP groups (Greenfield and Davis 2003), but as Love and Jones (1997) observed, regulation and research often go hand in hand. Unlike timber, which has a great deal of research and management resources devoted to its production, NTFP management strategies often are limited to restricting harvest. Giving up hard-earned knowledge about their livelihood can mean participants are relinquishing control over it, and may lose access to valuable resources (McLain et al. 2008).

To successfully track NTFP harvest volumes will require participation of stakeholders, who must feel that the program is effective, fairly applied, and beneficial. Knowing the context of tracking data is vital for effective management decisions. This includes the structure of supply chains, the practice of harvesting and trading, and changes in price and consumer demand. NTFP economies vary across regions and within sectors there may be a multitude of species. Effective tracking programs will focus on products that have high economic value, are heavily harvested, or that are threatened or declining. Tracking programs will be most effective when part of a system that also monitors plant populations and engages market participants.

2.9 Knowledge Gaps

Nontimber forests products are many and diverse. Our knowledge of them is basic and developing. Gaps in knowledge about the products and management are similar through the United States and insular territories. Silvicultural practices abound for timber and may be applicable to nontimber but need to develop further to deal with complexities created when NTFPs are integrated into management strategies. Forest farming these products is becoming attractive to landowners as an innovative income stream, yet research-based knowledge about growing and the profitability of NTFPs under trees is lacking.

NTFP science is rudimentary, at best. With some products, little more is known than basic ecology and botany of the plant or fungus whence the product originates. With others, such as American ginseng, our knowledge is more developed. There is a great deal of traditional and local ecological knowledge that guides stewardship and use of NTFPs. The science-based knowledge regarding these products, however, is wanting. Research that respects and integrates traditional and local knowledge with scientific analysis is warranted.

The species discussed in this document represent a collection of expert knowledge but not a complete list of NTFPs. The list will change with time as many products have yet to be identified or documented. The many uses of these products have to be explored. The volumes and values of these products are not fully defined, nor are the methods developed to collect these data. More important, there is a lack of knowledge on how to manage the resources whence the products originate to ensure that the resources are available in perpetuity.

The integration of NTFPs with established silvicultural practices can increase economic benefits for landowners and ecological benefits for forests. More information is needed on the ecology, life history, and demography of target NTFP species, across a variety of silvicultural treatments and site types with close attention to species responses to disturbance regimes resulting from timber management. The role of biotic and abiotic factors on regulating the growth of NTFP species could be better understood. There is an increasing body of knowledge related to microbial and fungal communities that needs consideration to apply these lines of inquiry to better elucidate the role they have in regulating the ecology and economies of managed forests. With the growing interest in NTFPs, research is needed to determine sustainable harvest levels for specific species, particularly when harvest kills the plant, across a variety of habitats, environmental conditions, and climates.

With changing climates, research must consider current data in the context of projected future conditions in an effort to add some level of confidence to long-term management scenarios. This is especially true in the cases of shifts in species phenology and asynchrony of pollinators and dispersers, reorganization of novel communities, and the expansion/contraction of climate envelopes. Silviculture should continue to move toward managing for increasing complexity and diversity (Puettmann et al. 2009). Managing forests as complex adaptive systems will benefit integration of NTFPs in silvicultural systems and increase resiliency in the face of climate change.

Much of the information available on how to forest farm NTFPs is based on experiences in specific parts of the country. Applied research is limited and has been used in only a few regions. Growers often assume that production methods that work in one region will work in another part of the country. This has not been adequately demonstrated. As there are regional- and state-level production practices for many established crops (i.e., fruits, vegetables, grains), regional production differences for NTFPs should be expected. Some production practices that need to be studied include propagation, planting dates, soil fertility, disease and insect control, weed and herbivore control, security, time and method of harvest, post-harvest handling, food safety, marketing, and economics.

More information on the monetary value of this industry within regions and across the country is needed. The knowledge about wild-harvested NTFPs in the South is predominantly based on one study (Greenfield and Davis 2003). This early study provides a foundation to understand the NTFP industry, but current and regular data are needed. Also, regional assessments are needed that examine the interactions of NTFP economies. As the forest-farming industry matures, raw material supplies should stabilize and their quality improve, which will influence demand and prices.

There is a lack of information to fully determine growth, yields, and costs needed to estimate optimal production. Forest farming is proclaimed to lead to better conservation of the NTFP, but the economics make wild-harvesting more attractive. Cultivated material should produce higher yields of uniform raw material that are positively identified (Davis and Persons 2014). More research is needed to optimize forest-farming systems to increase yields and reduce costs of priority products with significant market potential. Manufacturers and consumers using NTFPs need to be educated about the improvement in product quality and benefits to the forest and community economics of purchasing forest farmed products.

The impacts that policies and regulations have on NTFPs are not fully understood. Regulations affect various products at the international, Federal, and state levels. Should a plant become listed with CITES or as a federally endangered species, laws take effect that limit or restrict harvest and commerce of associated products. Nursery permits and inspections and export permits often are required depending on the product and state in which they are grown. Chapter 7 provides a comprehensive analysis of policies and regulations that impact NTFPs and provides valuable insights into the impacts that policies may have on the products.

The social and economic importance of NTFPs has been underestimated (see chapters 5 and 6) in the insular areas of the Caribbean and the Pacific. Data are usually not available on income produced from forestry-related activities and quantitative data for NTFPs are basically absent (Chakroff 2010; FAO 2000, 2005a, 2005b, 2005c). Major challenges and opportunities in the Caribbean region include the need for public education about the products, the need for a revival of a traditional knowledge about the plants and their uses (Alvarado-Guzmán et al. 2009, van Andel 2006), competition from imported souvenirs, and the need for improving marketing techniques. Building local capacity for the continuous operation of sound forestry programs and developing public awareness about sustainable forest management practices is essential (American Samoa Community College 2010, FAO 2001).

A confounding issue that affects NTFP inventory and monitoring is the tremendous diversity of plants and fungi that make setting priorities essential. Specific inventory methods may be required for each species or plant organ, but methods need to be tested and modified accordingly. With so many different products, developing and implementing standardized inventory protocols is challenging, but not impossible. Commonalities exist, however, between inventory methods that create potential for the transfer and sharing of techniques. The diversity of plants and fungi, and products, should not be a constraint undertaking inventory and monitoring programs, but impetus to prioritize products based on ecology, economics, and social and cultural importance.

FIA data do not provide sufficient information for thorough analysis of the sustainability of NTFPs under increased climatic variability. The main data are obtained from trees greater than 5-inch diameter, and smaller trees are recorded only in smaller nested plots and may be underrepresented in an inventory. As most NTFPs come from nontree plants and fungi, they are seldom, if at all, represented. Collection of vegetation profile information is optional, meaning it depends on funding and regional priorities and is not collected on all plots each cycle. Furthermore, vegetation profile data focus on the most abundant species, and important NTFPs that occur rarely may not be represented in the database. Fully and adequately representing NTFP species in forest inventory will require modified approaches that account for disparate population distributions.

The tree measurements that form the basis for many inventory parameters (e.g., volume and biomass) may not be related to measures of production of NTFPs (e.g., boughs, fruit, seed) but can be viable examples in the formulation of inventory systems. Thus, while the FIA data provide information on abundance and geographic distribution of trees, this information may not be readily translatable into data relevant to NTFP resource monitoring or management. Developing inventory or tracking systems for NTFPs will require a consideration of the phenology and ecology of diverse plants and fungi.

Another challenge with inventory of NTFPs is the difficulty of observing changes to individual plant species and populations over time. With trees harvested for timber products, it is a simple matter to determine whether a harvest has occurred: a tree that was measured on a prior inventory is no longer there, and usually a stump remains as an indicator of the removal. This is not true with many understory plants that may not be long lived, that may not be readily or easily identified, that may have unpredictable dormancy, and from which only portions are harvested. This is also the case for mushrooms, whose primary structure is underground. While mushroom fruiting body surveys are possible, they do not accurately represent the populations of the organisms. Finally, the sparse sampling intensity of FIA plots, while adequate for regional volume estimates for forests overall, leads to estimates that can be highly variable. This means that inferences about changes over time are only reliable at very large scales, which may not be adequate for NTFP species.

2.10 Implications of Increased Climatic Variability for Production and Management

Long-term effects on native NTFP resources will be challenging to predict and deserve significant examination. Projected shifts in forests imply that NTFP species will be impacted. Climate change models indicate warming and drier conditions that will affect trees such as pinyon pine, maple, and black ash that are the sources of valuable NTFPs. Understory NTFP species may be particularly sensitive to changes in forest structure. Coastal forests and insular forest ecosystems are particularly vulnerable to changes in climate and related stressors. Forest fragmentation with changing climate can have serious consequences on natural populations of NTFP resources and associated pollinators.

Increasing climatic variability has the potential to seriously affect populations and species of plants and fungi that provide NTFPs. Little is known about how climatic variability will affect understory plant communities. While shifts in precipitation regimes are likely more important than temperature on the forest floor, the lack of understanding of understory dynamics creates a great deal of uncertainty. Forest fragmentation combined with shifting climate envelopes can have serious consequences for demographics of wild populations of important NTFP species, specifically dispersal-limited myrmecochorous herbs. Phenological changes due to climatic variability could result in pollinator or dispersal asynchrony in species with highly specialized interactions (Hegland et al. 2009). Furthermore, changes in the intensity or frequency of climate-caused disturbances also can affect NTFP species distribution and levels of production (Dale et al. 2001). Further, environmental variability can affect the quantity and quality of some NTFPs, presenting additional challenges for management.

Interactions between climate and invasive species further complicate managing for NTFPs. Black ash (*Fraxinus nigra* Marshall), important culturally and economically to basket makers across the Northern United States, provides an exceptional example. The emerald ash borer (EAB) has killed millions of ash trees and is expanding its range. Because EAB has no known predators or natural resistance, all North American ash species are at risk of extinction (Herms and McCullough 2014). While duration of cold temperatures could slow the northern movement of EAB, occurrence and duration of low temperatures is declining even in the northern parts of the range (Crosthwaite et al. 2011). Black ash of the quality needed for basketry will become increasingly difficult to find, endangering a valued cultural tradition as well as the income generated by the sale of these baskets.

Other NTFPs may be impacted from climate, as well. Little is known about how ostrich ferns, which grow across a wide range of plant-hardiness zones and prefer hydric soil conditions, will respond to changing climates. Climatic variability is a concern for maple syrup producers, as production is primarily weather dependent and relies on predictable temperature swings below and above freezing to get sap to flow. Some researchers, however, have predicted that the habitat suitability for sugar maple will decrease in the Northeastern United States as ambient temperatures increase (Mohan et al. 2009). Climate change models indicate a warming and drier Western United States (Intermountain Society of American Foresters 2013) that could seriously impact pinyon production. Impacts to NTFP species is not limited to continental United States.

Climatic variability is likely to exacerbate many existing pressures and threats to the forests of the insular areas of the Caribbean and Pacific. Potential impacts of warming temperatures and altered hydrologic regimes include the loss of mangrove forests and arable land on the coast due to sea level rise, damage to terrestrial forests due to higher frequency of extreme events and fires, reduced agricultural yields due to decreased rainfall or droughts, and increased invasion by nonnative species as a result of higher temperatures (Neville 2014, UNEP 2008). If extreme meteorological events increase in frequency and intensity, changes of familiar species assemblages and availability of NTFPs are expected to occur due to variations in the time available for reproduction and senescence or selective pressure on organisms (Lugo 2000). In addition, future climatic variability could result in large changes in dust from African regions to the Caribbean, the effects of which on the vegetation have yet to be studied (Pett-Ridge 2009, Prospero and Lamb 2003).

Data released by NASA and NOAA verified that 2014 was the warmest year on record since 1880, and nine of the ten warmest years on record have occurred since 2000 (NASA 2015). Recent temperature trends and climate predictions have resulted in new terminology associated with climate issues, which will directly affect NTFPs. These include, “zone creep,” “season creep,” “simultaneous opposing temperature extremes,” “growing adaptation deficit,” “adaptive evolution,” “spring creep,” and “spring mismatches.”

Zone creep refers to changes in the USDA Plant Hardiness Zones Map, which is used to determine appropriate planting areas for crops. The revised 2012 Plant Hardiness Zones Map shows an average minimum temperature increase of 5 °F across the country as compared to the 1990 map. Changing the planting and growth boundaries and moving most zones northward will impact NTFP production, directly.

For example, Ohio was formerly within Zone 5 but now is almost entirely within the warmer Zone 6. As a result, NTFP growers and harvesters in these areas may have to reconsider their planting and harvesting choices in the future (Malcolm et al. 2012). The long-term results of zone creep will affect habitats associated with specific NTFPs, with some habitats and species being more vulnerable to climatic variability (USDA 2012). As a result, storing germplasm in the form of seed before more changes occur and predicting where and which species need to be prioritized for conservation are essential long-term strategies.

Season creep and *spring creep* refer to differentiation of first and last frost dates, which may alter pollinators (Schwartz et al. 2006, Sherry et al. 2007). Phenology is a sensitive biosphere indicator of climate. Long-term surface data and remote sensing measurements indicate that plant phenology has advanced by 2 to 3 days in the spring and been delayed by 0.3 to 1.6 days in the fall per decade over the past 30 to 80 years, which culminated in a significant extension of the growing season in 2015. As temperatures rise, spring seasons are arriving earlier while winters are shorter and more extreme. With this season change, frost vulnerability becomes more of a threat, where high spring temperatures create earlier flowering schedules, leaving blooms at risk of freezing (Inouye 2008, Souther and McGraw 2014). This is important to mountain-dwelling NTFP species, which are increasingly experiencing frequent frost damage due to early blooming.

Increased pests are yet another result of this phenomenon, wherein warmer, shorter winters provide favorable conditions for pest populations. Mild winters allow pest populations to increase instead of die out over the winter (Jamieson et al. 2012). For example, Gypsy moths, tent caterpillars (*Malacosoma* spp. Hübner), beech bark disease (*Neonectria* spp. Wollenw), and hemlock woolly adelgid (*Adeleges tsugae* Annand) are expected to expand their ranges due to the changing seasons, affecting crop and forest health (Dukes et al. 2009). Projections by the USDA speculate that the potential impact of this spread and redistribution of agricultural pests may reduce agricultural returns by $1.5 billion to $3.0 billion by 2030 (Malcolm et al. 2012).

Adaptational lag is another concern that will impact NTFP species as they adapt to changes in climate. If species cannot keep up with rapid climate alterations, populations and entire species may decline or go extinct (appendix 2—Assessment of Risk Due to Climate Change). In one European study, a common garden experiment tested lagging adaptation to a warming climate using banked seeds of the annual weed mouseear cress (*Arabidopsis thaliana* (L.) Heynh.) across the species' native climate range (Wilczek et al. 2014). Genotypes originating in southern climates, historically warmer than the planting site, had higher relative fitness than native genotypes at every site. This suggests that local adaptive optima have shifted rapidly with recent climate warming across the species' native range and that the potential for adaptational lag deserves consideration in conservation and wild harvest management decisions for many species.

The National Phenology Network reported that earlier spring dates create *spring mismatches* as some plants are budding earlier and the animals that depend on them have not adapted to this change (Fitzpatrick 2010). As example, bees may target specific habitats with plant populations they historically pollinate only to find those plants have already bloomed. These mismatches can be fatal. Many medicinal forest plants, such as bloodroot, are myrmecochorous: they have a specialized seed dispersal mutualism with ants. Warren et al. (2010) found that climate change differentially affects the phenology of hepatica or liverworts (*Hepatica nobilis* Schreb.) and their ant dispersers. Furthermore, Willis et al. (2008) found phylogenetic relationships between plant species with limited capacity to shift flowering time to respond to climatic changes. These species include a number of important NTFPs including orchids (Orchidaceae), mints (Lamiaceae), and roses (Rosaceae), suggesting that this lack of phenological plasticity may be a conserved trait and detrimental to long-term population maintenance under changing climate.

Long-term effects on native NTFP resources in the United States due to predicted climate trends will be difficult to forecast but deserve study to prepare for conservation of populations. Projected shifts, which were estimated using years for which data were available, in forest types for the United States (figure 2.7) suggest significant changes in structure that will affect NTFP resources (Karl et al. 2009). Depending on regional hardiness zones and habitat, long-term effects will vary by species and need to be prioritized based on predicted risk factors.

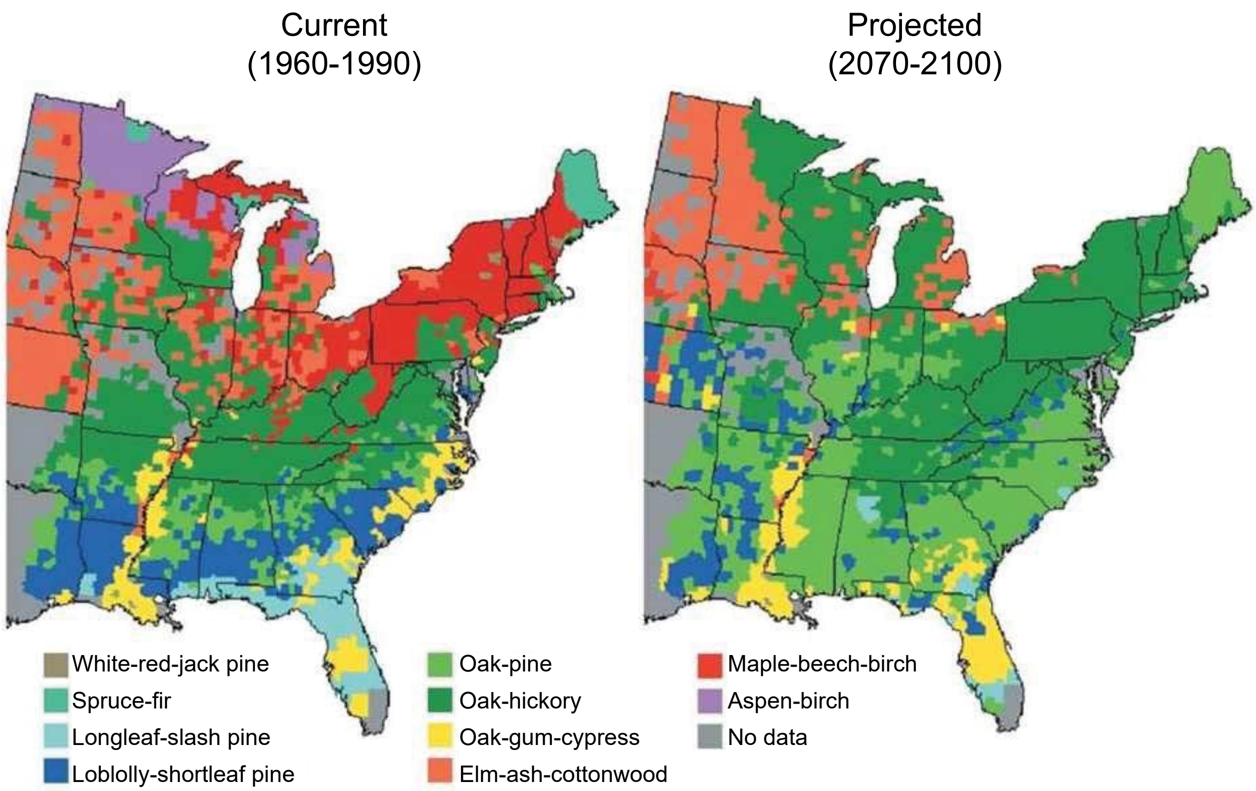

Figure 2.7—Current and projected shifts in forest types in the eastern United States with major changes. For example, in the Northeast, under a mid-range warming scenario, the currently dominant maple-beech-birch forest type is projected to be completely displaced by other forest types in a warmer future (Karl et al. 2009).

2.11 Key Findings

- Across all forest landscapes, throughout the United States and its insular territories, there is great variety of native plants and fungi, the organs of which are harvested for their nontimber values by a diverse group of people and for many different uses.
- There is rudimentary knowledge about the plants, products, people, and places, and evidence suggests significant ecological, social, cultural, and economic values.
- More is known about American ginseng than, perhaps, any other medicinal forest product, in part due to its listing in CITES, a mandatory reporting that has provided significant data useful for monitoring and management.
- Integrating NTFPs into forest management will require balancing multiple and often conflicting land use objectives; thinning and uneven-aged silvicultural treatments can lead to healthy stands valued for their NTFPs.
- Changes in forest dynamics, including soil moisture and temperature due to climatic variability and silvicultural practices, may impact growth and maintenance of natural populations of associated NTFP species, particularly understory spring ephemeral herbs.
- Silvicultural practices can address the complexities created when NTFPs are integrated with timber management that require understanding the interactions of NTFP species and the trees, which is essential for co-management of timber and nontimber products to continue providing benefits under climate change.
- Forest farming has potential for economic development of rural communities while improving conservation of native nontimber forest species, but production decisions often are based on anecdotal evidence that would be improved with science-based knowledge.
- To sustainably manage the utilization of NTFPs requires inventory data of the plants as well as the raw products, ways to track and monitor product volumes and values, as well as estimating and tracking demand for the final product.

- The complexity of forest management increases when NTFPs are considered, and that complexity should be viewed as an opportunity to improve forest management and other sectors of the forest products industry and constituents.

2.12 Key Information Needs

- There is an urgent need for a nontimber product output tracking system that will provide regular information on harvest volumes, whence products are harvested, prices, and other pertinent data that will generate better knowledge of the NTFP markets.
- Priority information needs exist that can only be realized through integration of NTFP species, prioritized by their ecological, economic, and cultural values, into all phases of Forest Inventory and Analysis.
- With growing interest in NTFPs, information is needed to determine sustainable harvest levels and practices for specific species, particularly when harvest kills or increases the likelihood of plant mortality, and how populations respond to harvest, across habitats, environmental conditions, and climates.
- Silviculture practices can encourage NTFP species growth and production, and information is needed on their ecology, life history, and growth and yield to coalesce the knowledge to encourage integrated forest management.
- Much of the information available on forest farming NTFPs is based on experiences with limited science-based knowledge on growth, yield, costs, and benefits needed to estimate optimal and sustainable products.

2.13 Conclusions

NTFPs originate from biological resources that are harvested from forests and may include fungi, moss, lichen, herbs, vines, shrubs, or trees. The Forest Service and BLM have promulgated official definitions of NTFPs and have policies and regulations to address the harvest and management of these products. By some estimates, a quarter of the U.S. population harvest NTFPs for their personal use as well as for financial gain through commercial markets.

The management of forests to include NTFPs is more complex and can produce a forest that is healthier and more resilient to climatic variability. Most NTFPs are harvested from natural populations with no science-based management of the resources to ensure long-term product sustainability. There are iconic NTFPs that provide insights that may be generalized to other NTFPs. Sustainable management of NTFP resources will require using local, traditional, and scientific knowledge. Silvicultural practices and treatments can be beneficial and detrimental to NTFPs. Integrating NTFPs into forest management requires understanding the ecology of NTFP species and the impacts of silvicultural treatments. Evaluating the sustainability of NTFP production requires integration of forest inventory data and market-based product tracking. Forest farming can provide landowners a means to generate revenues from their forests while retaining the forest cover.

The scale and extent of NTFP harvest are challenging to determine as there are few formal or institutionalized methods to track harvest or to inventory supply. Some data sources exist, but tracking of NTFPs is largely inconsistent, intermittent, and incomplete. Additional data are needed for adaptive management of NTFP production systems. Creating effective methodologies for estimating the scale and distribution of NTFP production is essential for sustainable utilization of these important resources. While some countries are implementing chain-of-custody tracking systems for NTFPs, such systems do not exist in the United States.

A collaborative approach to tracking products that emphasizes reciprocity can improve participation and participant investment in NTFP tracking and monitoring programs (Laird et al. 2010, McLain and Jones 2001). Future tracking strategies could benefit from a multi-method approach that integrates quantitative and qualitative data collection. Integrating data from various sources can be facilitated by greater communication between and across disciplinary boundaries and by creating standards and platforms for data sharing.

Nontimber forest species have critical functions in overall forest health. Their decline, extirpation, or extinction due to climate or lack of management will adversely impact biodiversity and the vigor and condition of forests across the country. NTFP production under increased climatic variability may not be fully predictable, but indicators suggest significant changes are likely. Plant

Hardiness zones may creep north with temperature fluctuations, thus reducing suitable habitats. NTFP species could decline or go extinct if they do not adapt quickly enough to changes in forest habitat. The biophysical changes will have significant deleterious impacts on the people who benefit from these products. The promotion of sustainable NTFP production should be seen as an adaptation and mitigation activity and economic opportunities for sustaining livelihoods (Wilkinson and Elevitch 2000). The development of appropriate interdisciplinary teams and approaches is vital to address the complex interactions between natural and socioeconomic systems regarding production of NTFPs under different climate change scenarios.

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CHAPTER 3

Ecological Dimensions of Nontimber Forest Product Harvest

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Hundreds of plant and fungi species (chapter 2) are harvested each year for nontimber forest products (NTFPs) because they play important roles in the cultural (chapter 4), social (chapter 5), and economic (chapter 6) lives of individuals and communities across the United States. Most of these species are harvested from natural populations, where they play important ecological roles, including providing food, cover, and habitat for diverse wildlife, including pollinators, and contribute to nutrient cycling, hydrological cycles, and erosion control. The continued use of NTFPs is contingent on each species ability to persist over the long term in their landscapes and with the qualities that people value. Species persistence depends in part on their ecological characteristics, the human and plant communities in which they grow, as well as the threats they face. This chapter reviews the effects of NTFP harvest on plant individuals, populations, communities, and ecosystems and then presents case studies of seven heavily harvested NTFPs in the United States. We conclude with a summary of key findings and recommendations.

3.1 Effects of Nontimber Forest Product Harvest on Plant Individuals and Populations

NTFP harvest systems can have impacts at multiple ecological scales—from individuals to populations, communities, ecosystems, and landscapes. Sustainable harvest requires populations to persist long term and that the harvest does not negatively affect community and ecosystem functions at multiple ecological scales (Small et al. 2011, Ticktin and Shackleton 2011).

The most direct impact of NTFP harvest is on the vital rates of individuals harvested for their parts: their survival, growth, and reproduction. For example, fern leaves (fronds) are harvested throughout the United States for food, foliage, and crafts. Frond harvest removes photosynthetic material, reduces available nutrients for new growth, and can decrease significantly the size of new leaves and leaf growth over time (Aderkas and Green 1986, Bergeron and Lapointe 2001, Ticktin et al. 2006).

Substantial changes in some vital rates can lead to important demographic and genetic changes at the population level (see review by Ticktin 2004). The resilience or vulnerability of populations to harvest varies according to life history traits, ecological, management, and social context of harvest (table 3.1) (Castle et al. 2014, Ticktin 2015). For plants, two important factors that influence a species' resilience or vulnerability to harvest are the part of the plant harvested and the life history traits of the plant. The latter includes patterns of growth, reproduction, pollination, and dispersal of seeds or spores, distribution, and habitat specificity (table 3.1). For example, long-lived perennials like trees and shrubs have reproductive parts (flowers, fruit, and seeds) that tend to have very high potential for sustainable harvest. Meta-analyses of demographic studies reveal long-term population growth rates of long-lived species are little affected by decreases in fecundity (Franco and Silvertown 2004). Demographic studies of trees and shrubs have shown that very high levels of fruit harvest tends to be sustainable at the population level (see review by Ticktin 2004, Emanuel et al. 2005, Sampaio and Maës dos Santos 2015, Ticktin et al. 2012). As such, the widespread wild-harvest of edible fruits, nuts, and berries—for example, more than 1.6 million pounds (>725,000 kg) on Forest Service and Bureau of Land Management lands per year (Alexander et al. 2011)—is not expected to lead to population decline. However, the effects of fruit harvest on other species, such as frugivores, remains poorly studied

In contrast, demographic rates of long-lived perennials tend to be highly sensitive to decreases in adult survival (Franco and Silvertown 2004). Therefore, harvest of adult individuals or increases in mortality of adults, such as some kinds of bark (figure 3.1), root, rhizome, and bulb harvesting, may have large negative impacts on long-term population persistence (Chamberlain et al. 2013, Schmidt and Ticktin 2012, Small et al. 2011). High levels of adult mortality are a concern for numerous species in the United States that are commercially traded. For example, many medicinal plants that are commercially traded are valued for their underground organs or for the whole plant (Alexander et al. 2011), and are therefore harvested whole. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species lists 66 U.S. plant species for which overharvest represents at least one of the threats; more than 75 percent of these are orchids and cacti—long-lived perennials collected as whole plants for the horticulture trade.

Demographic models of some species heavily harvested for their underground organs, such as the medicinal plants American ginseng (*Panax quinquefolius* L.) and goldenseal (*Hydrastis canadensis* L.), and edible

Table 3.1—Factors affecting the potential for sustainable NTFP harvest. Arrows indicate that the characteristics listed in the columns for high and low potential for sustainable harvest represent two ends of a continuum. Adapted from Castle et al. 2014, Cunningham 2001, and Ticktin and Shackleton 2011.

		Potential for sustainable use		
Category	**Attributes**	**High**	**Medium**	**Low**
Ecological	Plant part harvested	Fruit, seeds, short-lived leaves, dead wood	Exudates, phloem sap, long-lived leaves	Whole plants, roots, bulbs, bark, apical meristems
	Distribution and habitat specificity	Widespread, broad; high life history plasticity	⟶	Restricted, highly specific; low life history plasticity
	Population size and growth rates	Large populations, fast growth	⟶	Small populations, slow growth
	Reproduction	High rates of sexual and/or vegetation reproduction; continuous recruitment	⟶	Monocarpic or irregular and periodic sexual reproduction only; low recruitment
	Pollination, dispersal	Abiotic and/or generalist relationships	⟶	Specialist relationships
	Resilience to natural disturbance	High (e.g., high resprouting, fire tolerance, long-lived seedbank and/or good recruitment after disturbance)	⟶	Low
	Ecological integrity of landscape	Maintenance of historical disturbance regime	⟶	Change in disturbance regime (e.g., increase in fire frequency or fire suppression)
		Presence of mutualisms (pollinators, dispersers, mychorrhizae or other organisms that foster persistence of NTFP)	⟶	Low abundance or lack of other organisms on which NTFP depend
		No exotic invasive species	⟶	Abundance of invasive species
	Land use context	No major competing land-uses with NTFP harvest	⟶	Many competing land uses (e.g., logging, livestock grazing, fire, agriculture, etc.)
Sociopolitical	NTFP uses	Single or non-competing uses; harvest of selected size-classes only	⟶	Multiple conflictive uses and harvest of different or all size-classes
	Local ecological knowledge (LEK)	Harvest is a historical activity, and highly detailed and sophisticated LEK systems exist and can be applied.	⟶	Harvest is a new activity and no LEK developed yet
	NTFP management	Highly tended wild or maintained populations; farmed or domesticated	⟶	Uncontrolled collection from wild; cultivation not viable; open-access resource
	Governance systems	Secure tenure, institutional arrangements fit with social-ecological system, effective monitoring and enforcement	⟶	Insecure tenure, institutional arrangements are misfits for system, no monitoring or enforcement
Economic	Seasonality of harvest	Short season with high abundance	⟶	Available all year round
	Substitutability	Many species can provide the same or similar product	⟶	Only one or few species offer the same product

Figure 3.1—Mature slippery elm (*Ulmus rubra*) tree. The bark is harvested for its medicinal purposes. Forest Inventory and Analysis data indicates increased mortality of this species throughout its range, suggesting that harvesting is having negative impacts. (Photo courtesy of Rob Routledge, Sault College, Bugwood.org.)

species such as ramps (*Allium trioccum* Aiton), have demonstrated they can sustain only low levels of harvest (Christensen and Gorchov 2010, Nantel et al. 1996, Rock et al. 2004, Van der Voort and McGraw 2006) consistent with research on NTFPs with similar life histories elsewhere (e.g., Ghimire et al. 2008). For some species, the number and size of populations has decreased over time, and overharvest is considered a contributing factor (Mulligan and Gorchov 2004).

Focused harvest of large adult plants can lead also to a decline in plant size over time. For example, McGraw (2001) used U.S. herbarium specimens to show that American ginseng plants of the same age had declined in size significantly since 1900 across most of its range where harvest pressure was greatest. A decrease in size over time has also been shown for species elsewhere (Law and Salick 2005). Few studies exist on the genetic implications of harvest, but decreasing population sizes have been shown to cause inbreeding depression (Mooney and McGraw 2007) and decreased genetic diversity (Cruse-Sanders and Hamrick 2004) in American ginseng.

The findings discussed in this section do not imply that harvest of underground organs or of whole plants is always unsustainable. Traits such as the ability to reproduce vegetatively can greatly increase the resilience to populations to harvest (table 3.1). For example, the roots of the long-lived perennial echinacea (*Echinacea angustifolia* DC.) are harvested for the herbal product market. Data from both Kansas and Montana show that about 50 percent of the roots that remain in the ground following harvest resprout, and the plants grow back from 6 to 10 inches below the surface (Kindscher et al. 2008). Similarly, goldenseal's abundant rhizomes permit some to remain in the soil after harvest and allow some regrowth (Sanders and McGraw 2005a). Density-dependent responses to harvest—where reduced abundance due to harvest results in increased demographic rates—can increase the potential for sustainable harvest (Schmidt et al. 2011, Ticktin et al. 2002). In addition, management such as replanting roots or root parts can greatly increase the potential for sustainability.

3.1.1 Management and Local Ecological Knowledge for Sustainable Harvest

The methods used to harvest NTFPs influence plant persistence despite sustained harvest (table 3.1). Sustainable management practices for NTFPs that are harvested from natural populations can include weeding competitors, clearing the overstory to increase light, and planting seeds, root, or rhizome pieces or seedlings to replace, expand, or extend wild NTFP populations. For example, when harvesting bluedicks (*Dichelostemma capitatum* (Benth.) Alph. Wood) in California, American Indians harvest the corms and replant the cormlets, spare plants, and harvest after seeding to ensure replenishment of seed (Anderson 2005, Anderson and Rowney 1999). Similarly, when American Indians in the Great Plains harvested the roots of prairie turnips or tipsin (*Pediomelum esculentum* (Pursh) Rydb.), they planted seeds from ripe seed heads back in the holes created when they dug the roots. Loss of this activity has led to the prairie turnip paradox: this plant is now uncommon throughout most of its range because people no longer harvest and eat the root (and plant the seeds)

BOX 3.1
CASE STUDY:
American Ginseng Response to Climate Change

Despite wide latitudinal distribution, American ginseng (*Panax quinquefolius* L.) is sensitive to relatively small increases in mean temperature (Souther and McGraw 2011, 2014). Stochastic demographic models show that warming as little as 1.75 °F is sufficient to increase extirpation risk of an average ginseng population (Souther and McGraw 2014). This sensitivity to warming is attributed to the tendency of ginseng populations to adapt to local climatic conditions (Souther and McGraw 2011, 2014; Souther et al. 2012). Long-term demographic studies, simulations, and experimental manipulations indicate that climate change will negatively impact this species, especially in the presence of co-occurring stressors, such as harvest (McGraw et al. 2013; Souther and McGraw 2010, 2011, 2014; Souther et al. 2012). Rapid rate of climate change, coupled with habitat fragmentation, serves to reduce gene flow among populations and decreases the likelihood of adaptation to climate change (Davis et al. 2005, Etterson and Shaw 2001, Shaw and Etterson 2012). While rapid evolution is possible, adaptation to climate change for species like ginseng, which is characterized by slow-growth, long generation times, and low rates of reproduction, likely will be slow relative to fecund species that disperse seeds over long distances (Souther and McGraw 2014). Adaptation potential likely will be further reduced by decreased genetic variation resulting from harvest, as genetically based phenotypic variation is a requisite for evolution to occur.

Recently, several species of thrushes, including the wood thrush (*Hylocichla mustelina*), hermit thrush (*Catharus gutatus*), and Swainson's thrush (*Catharus ustulatus*), have been identified as potential dispersers of ginseng seed (Hruska et al. 2014). Juvenile thrushes may disperse seeds up to 300 m from parental plants. However, such long-distance dispersal events are considered rare, as most thrush dispersal events result in seed movement of less than 100 m from the maternal plant (Smith et al. 2004). Nonetheless, the occurrence of long-distance dispersal, however infrequent, indicates a possible mechanism for ginseng to track climatic change. Long-distance dispersal may introduce warm-adapted, southerly or lowland genotypes into northern and upland populations, thus potentially increasing the likelihood of adaptation to novel climatic conditions (Hampe and Petit 2005). Experiments testing the adaption of American ginseng and other NTFPs to rapidly changing climate are needed.

(Castle 2006). However, it should be noted that prairie turnips are still traditionally harvested on the Crow and Standing Rock (Lakota) reservations (Ruelle and Kassam 2013). Studies show the ecological impacts can vary significantly according to the seasonal timing of harvest, timing of harvest in the plant's life cycle, and the frequency, intensity, and methods and size of harvest (e.g., Albrecht and McCarthy 2006, Sanders and McGraw 2005a, Van der Voort and McGraw 2006). For example, Nantel et al. (1996) showed that for both ramps and American ginseng, "choosy" harvesters who collect mostly larger plants, have a much greater negative impact on population viability than do "busy" harvesters, who collect the same number of plants, but from a broader range of sizes (see box 3.1).

The decisions that harvesters make about how to harvest, manage, or steward NTFP populations are influenced by many factors, including cultural, social, political, economic, and ecological context. However, one key factor is harvesters' understandings of the ecological system. Generations of observation, experimentation, and adaptation by local harvesters often lead to development of detailed traditional or local ecological knowledge (chapter 4; Hummel and Lake 2015), including highly sophisticated local management practices for maintaining culturally and economically important resources and landscapes (Anderson 2005, Berkes 2011, Price and Kindscher 2007, Turner et al. 2000). NTFP populations managed by knowledgeable harvesters may show high growth rates under high harvest pressure, while populations of the same species managed by others may decline under much lower levels of harvest (Price and Kindscher 2007, Schmidt and Ticktin 2012, Ticktin and Johns 2002). As has been demonstrated for American ginseng, with the appropriate management, there is potential even for species at high risk of overharvest to be managed sustainably (e.g., Van der Voort and McGraw 2006). This highlights the value of cooperative management agreements for NTFP, where different stakeholders can be involved in making management decisions.

3.1.2 Spatiotemporal Variation in Nontimber Forest Product Population Dynamics

An important challenge in assessing harvest effects and designing plans for sustainable management of NTFPs is that effects vary over the landscape (Sinclair et al. 2005, Souther and McGraw 2011, Ticktin 2004) as well as over time, as climatic and other conditions vary (Schmidt et al. 2011). For example, available environmental resources (light, nutrients, water) influence long-term population growth rates. Populations of the Hawaiian vine, maile (*Alyxia stellata* (J.R. Forst. & G. Forst.) Roem. & Schult.)—widely harvested for its fragrant stems—grow significantly faster in closed-canopy than in more open-canopy forests (Wong and Ticktin 2014). Root yields of wild-harvested osha (*Ligusticum porteri* J.M. Coult. & Rose) are higher in open meadows than in forested areas (Kindscher et al. 2013). Similarly, international research has shown that population growth rates and levels of sustainable harvest can vary significantly between habitats (Ghimire et al. 2008), and environmental gradients (e.g., drier versus wetter environments) (Gaoue and Ticktin 2008, Gaoue et al. 2011). In some places, NTFPs are more often harvested along roads than from the forest interior. Differences across space and time in the surrounding ecological community and in management add to the large spatiotemporal variation observed for many NTFPs.

3.1.3 Community Interactions and Ecosystem Dynamics

Long-term sustainability of harvests depends upon numerous factors that operate across multiple scales and levels of ecological organization, requiring understanding of processes that go beyond individual populations and species (table 3.1). These include the maintenance of key interspecific interactions, resistance to herbivore pressure, resilience to natural and anthropogenic disturbances, appropriate landscape management, as well as competing land uses or management objectives.

A decline or loss of key interspecific interactions across tropic levels, such as pollinators, mycorrhizal fungi, and animal seed dispersers, may threaten the viability of NTFP populations and make them less resilient to harvest (table 3.1). For example, the pinyon jay (*Gymnorhinus cyanocephalus*) is a critically important seed disperser of pinyon pines (e.g., *Pinus edulis* Engelm., *Pinus monophylla* Torr. & Frém.) in western United States and has experienced a mean population decline of 4.3 percent annually from 1966 to 2012 (Chambers et al. 1999, Sauer et al. 2014). Continued decline of this bird species may threaten the long-term ability of pinyon pine to respond to increased climatic variability through loss of its long-range dispersal mechanism. Similarly, in the tropics, hunting of seed dispersers can have adverse effects on NTFP species, as has been observed for African crabwood (*Carapa* spp.), where subsistence hunting frequently targets the rodents that disperse its seeds (Forget and Jansen 2007).

Changes in population dynamics of species in the surrounding community, such as increases in populations of herbivores and/or the introduction of invasive species, can also threaten NTFP species and increase the potential for unsustainable harvesting (table 3.1). Overabundant deer and elk populations increase herbivory rates in many parts of the United States, threatening sustainable NTFP harvests of certain species in addition to impacting numerous other ecosystem properties (Cote et al. 2004). One study of white-tailed deer (*Odocoileus virginianus*) impacts on 26 species of NTFP trees and shrubs in a Nebraska forest-agricultural mosaic found that woody NTFP species with dense branching (e.g., redosier dogwood, *Cornus sericea* L.; weeping forsythia, *Forsythia suspensa* (Thumb) Vahl; white willow, *Salix alba* L.; purpleosier willow, *Salix purpurea* L.) were damaged the least by deer antler rubbing, while species with one or few unprotected stems (e.g., American black elderberry, *Sambucus canadensis*; smooth sumac, *Rhus glabra*) were damaged the most (Hygnstrom et al. 2009). Levels of browsing damage also varied by NTFP species with the most damage found in *Cornus* spp. and Chinese chestnut, *Castanea mollisima*. Similarly, the ability of American ginseng to withstand harvest is reduced with increasing populations of white-tailed deer (Farrington et al. 2009, McGraw and Furedi 2005).

The ability of ginseng to withstand harvest is also threatened by the invasive species, garlic mustard (*Alliaria petiolata*) (Wixted and McGraw 2009). In Hawai‘i, many NTFP species gathered for cultural practices such as hula (chapter 4) are declining in population due to competition from invasive species. In cases like these, harvest may be a contributing factor to population decline (Ticktin et al. 2006), although not necessarily the main cause. Studies elsewhere have shown that factors like grazing and invasive species may make much greater contributions to the decline of NTFP populations than harvest (Endress et al. 2004, Mandle and Ticktin 2012, Ticktin et al. 2012).

Responses of NTFP species to natural and anthropogenic disturbances are trait-dependent (Mouillot et al. 2013) and specific to the particular life history adaptations of a given species. In general, species will most likely be adapted to a characteristic disturbance regime. Therefore, populations will persist when ecosystem dynamics are maintained within a natural (or historic) range of variability, although management toward natural variability is complicated by processes such as climatic variability or invasive species (Landres et al. 1999). Traits that enable populations to survive or increase following fire include resprouting, seed dormancy, fire-stimulated seed production, and fast growth to rapidly colonize large areas of mineral soil. Within the fungal genus *Morchella* (morel mushrooms), certain species fruit in forests that are more frequently burned while other species favor unburned forests. However, productivity (count and fresh weight) at the genus level is generally greater in burned forests than in insect-damaged forests, and is least in undisturbed forests (Pilz et al. 2004). Fire frequency and severity can also play a key role in NTFP response. Blueberry (lowbush, *Vaccinium angustifolium* Aiton and velvetleaf huckleberry, *V. myrtilloides* Michx.) production in eastern Canada is favored by low-intensity fires with limited burn depth (i.e., consumption of soil organic layers) (Duchesne and Wetzel 2004). Fire was used traditionally by native peoples to increase the production and quality of roots and berries, improve produce materials for basketry and other arts and technologies (Kimmerer and Lake 2001, Wray and Anderson 2003). Some NTFPs adapted to particular fire regimes, including fires set by American Indians, are now less common, including Bradshaw's lomatium (*Lomatium bradshawii*), huckleberries (*Vaccinium* spp.), camas (*Camassia* spp.), tobacco (*Nicotiana* spp.), and deergrass (*Muhlenbergia rigens* (Benth.) Hitchc.) (Anderson 1996, Boyd 1999). Fire frequency plays a key role in sustainability of NTFPs harvested by native people who lived in Yosemite Valley (Anderson 2005) and who live elsewhere (Schmidt and Ticktin 2012, Sinha and Brault 2005). NTFPs that benefit from increased light availability but are intolerant of surface fire may be favored by wind disturbance or biotic disturbances such as forest insects (e.g., bark beetles) and pathogens.

Many North American NTFPs are understory species and strongly influenced by effects of disturbance and forest management on characteristics of the forest overstory (chapter 2). Shade-tolerant and shade-adapted NTFP species are favored by levels of overstory canopy cover that differ from those preferred by shade-intolerant species. Heavy thinning of Douglas-fir (*Pseudotsuga menziesii*) forests in the Oregon Cascade Range reduced production of shade-adapted chanterelle (*Cantharellus* spp.) mushrooms (Pilz et al. 2006). Beargrass (*Xerophyllum tenax* (Pursh) Nutt.) produces more commercially valued leaves in moderate shade and canopy density compared to heavy shade (Higgins et al. 2004). Leaves with qualities prized by tribal weavers are associated with sites with tree basal area less than 200 square feet per acre and densities less than 130 trees per acre (Hummel and Lake 2015). Studies elsewhere have shown that timber harvesting can have strong negative effects on the availability of NTFP species (Shanley et al. 2002; see also chapter 2, section 2.2). On the other hand, population growth rates and the potential for sustainable harvest may be greater in secondary forests than in old-growth forests for some NTFP species, such as terrestrial and epiphytic bromeliads (del Castillo et al. 2013, Ticktin and Nantel 2004).

Sustainable NTFP harvest also can be threatened where dominant land uses are competing and not complementary (table 3.1). Habitat transformation or destruction may be the main cause of decline for some NTFP species. For example, in the Great Plains habitat destruction (the plowing of more prairie lands for additional crop production in the last two decades) has had more negative impacts on coneflower (*Echinacea angustifolia*) stands than harvesting has (Kindscher 2006). Similarly, management of pinyon-juniper woodlands in the Great Basin region of the Western United States has arguably reduced the availability of the pine nut resource. In Florida, prime quality habitat for saw palmetto (*Serenoa repens* (W. Bartram) J.K. Small), which is heavily harvested for its medicinal fruit, appears to have decreased by one-half since 1945 (Mitchell 2014).

3.2 Implications of Nontimber Forest Product Harvest for Ecological Systems

The effects of NTFP harvest on maintaining biodiversity, ecological interactions, and ecosystem functions have not received sufficient study, as the great majority of studies of ecological effects have focused on sustainability of harvest at the population level (Ticktin 2004). Forest farming (chapter 2), a land use approach for more profitable NTFPs such as ginseng, goldenseal, (Burkhart and Jacobson 2009) and black cohosh

(*Actaea racemosa*) (Small et al. 2014), may have some adverse effects on forest ecosystems but may be less detrimental on ecosystem services than converting forests to agricultural land (e.g., Trauernicht and Ticktin 2005). Wild harvesting of NTFPs can have variable impacts on nutrient cycling and soil erosion, depending on plant parts harvested (reviewed in Ticktin 2004).

NTFP harvest may also influence community successional dynamics. In the Oregon Coast Range, modern strip harvesting methods for commercial moss production influence the ecological succession of epiphytic bryophyte communities and reduce species and age-class diversity, in contrast to historical effects of more patchy, less efficient moss production that likely increased species diversity (Peck and Frelich 2008). Incidental taking of bryophyte species of low commercial value is also common during commercial moss harvesting (Studlar and Peck 2007), and likely has adverse effects on community structure and biodiversity.

Although sustainability of NTFP harvest at the population level may be greater when harvested plant parts are reproductive (flowers, fruits, seeds) rather than vegetative (leaves, roots, apical shoots; table 3.1), harvest of forest fruits may have important impacts on ecological community dynamics and biodiversity. There is little published information on such effects, although a few studies in the neotropics have found negative effects of palm fruit harvesting on avian frugivore diversity and abundance (e.g., Galetti and Aleixo 1998) (Moegenburg and Levey 2002). Forest plantings of palms can increase populations of fruit-eating birds, but also change the composition of avian community toward fruit eaters (Moegenburg and Levey 2002). Tree nuts can be especially important resources for bird and mammal species (e.g., whitebark pine nuts and grizzly bears) (Mattson et al. 1991). Competition between human harvesters of pine nuts and other animals that rely upon these food sources has been little studied. There appears to be competition between insect and vertebrate herbivores for pinyon pine seeds, such that birds and mammals were able to increase their seed harvest when insect cone herbivores were experimentally excluded (Christensen and Whitham 1993). Such observations suggest that pine nut supply may be limiting for herbivore species and that increased human harvest of pine nuts may compete with requirements of other species for this important food resource.

Fruit harvest by people does not always imply conflict with other frugivores. For example, in Florida hundreds of tons of saw palmetto drupes, commonly called berries, are harvested annually (AHPA 2012). Most saw palmetto habitat, however, does not coincide spatially with those areas most important for black bear foraging within their primary ranges. Harvesting therefore does not appear to represent a critical threat to the food resources for black bears outside of their primary ranges (Mitchell 2014). Saw palmetto derives its name from the "saw-like teeth of its petiole margins" and grows into thick, dense clusters and shrubs (Bennett and Hicklin 1998). These characteristics lead harvesters to concentrate their efforts on the berries easily reached from the outside of the thicket, leaving much of the fruit within it available to wildlife (Bennett and Hicklin 1998, Mitchell 2014). Unlike saw palmetto that has defenses such as thorns, American ginseng is an understory plant readily grazed upon by deer (Farrington et al. 2009, McGraw and Furedi 2005). Competition between harvesters and wildlife would be expected to be greater for these types of NTFPs.

3.3 Sustainable Harvest of Key Nontimber Forest Product Species

Descriptions of seven key NTFPs harvested across the United States provide insight on the range of environmental and harvest contexts, responses to harvest, and research and management needs for NTFPs. For each of the seven key NTFPs, we discuss the responses to harvest in the context of the plant's ecology, natural history, and distribution. These species represent a sample of some of the heavily harvested NTFPs in the United States and were selected because they span a range of plant parts harvested and of ecosystems, and because, in contrast to most NTFPs, there has been a fair amount of research conducted on the ecological impacts of harvest.

3.3.1 American Ginseng

American ginseng is an herbaceous understory species found in the eastern deciduous forest of North America (Anderson and Fralish 1993). Harvest of ginseng for the medicinal plant trade began over 200 years ago in Canada (Robbins 2000). During the period of peak harvest in the 1800s, the United States exported hundreds of thousands of pounds of dried ginseng root to Asia annually (Kauffman 2009, McGraw et al. 2013). Intensive harvest, like that which occurred during the 19th century, likely reduced overall ginseng abundance, mean population size, and genetic diversity (Case et al. 2007; Cruse-Sanders 2005; Cruse-Sanders and Hamrick 2004; Kauffman 2009; McGraw et al. 2003, 2013). Reduction in ginseng population size decreases per capita reproductive rates (Hackney 1999, Hackney and McGraw 2001) and increases the risk of inbreeding depression (Mooney and McGraw 2007). Loss of genetic variation may inhibit ginseng's ability to adapt if environmental conditions change. Through such impacts, past harvest events continue to influence population performance today.

In 1975, ginseng was listed in appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Robbins 2000). Since that time, the U.S. Fish and Wildlife Service must issue a "no detriment" finding for export to continue. While ginseng harvest programs vary among U.S. States, generally, regulations establish a harvest season and a minimum age/size limit for harvest. Harvester behavior, and regulations that govern harvest behavior, dramatically influence plant population growth (Van der Voort and McGraw 2006). In model simulations, population growth rates of harvested populations were similar to those of nonharvested populations *if* harvesters complied with regulations, *as well as* actively stewarded populations by planting seeds and limiting harvest intensity (Van der Voort and McGraw 2006). Conversely, harvest that occurred prior to annual seed set and that removed undersized plants resulted in precipitous population decline (Van der Voort and McGraw 2006). Given this, illegal and/or irresponsible harvest poses a significant threat to ginseng persistence and continued trade of the species (McGraw et al. 2010).

In addition to irresponsible harvest (McGraw et al. 2013, Van der Voort and McGraw 2006), deer browse, (Farrington et al. 2009, McGraw and Furedi 2005), increasing abundance of invasive species (Wixted and McGraw 2009) and climatic variability (Souther and McGraw 2010, 2011, 2014; Souther et al. 2012) negatively impact ginseng population growth. In combination, these stressors may influence viability in complex and unanticipated ways. For instance, harvest in combination with climate change increases extinction risk well above the additive effects of either factor alone (Souther and McGraw 2014). Because shifting environmental conditions exacerbate negative impacts of harvest, increased protection, particularly in the form of stricter enforcement of current harvest regulations, may be required to prevent extinction as climate shifts away from historic norms (Souther and McGraw 2014). Future research should focus on developing climate change-integrated harvest regulations and conservation strategies.

3.3.2 Common Beargrass

Common beargrass grows in western North America in maritime and continental areas and over a variety of habitat and soil types (Hummel et al. 2012). It can be a significant component of subalpine meadows and dry, mixed-coniferous forest types (Higgins et al. 2004). Vegetative reproduction occurs in spring and summer (Peter and Shebitz 2006). Flowering—which varies with soil temperature, aspect, canopy cover, and elevation—has been reported as early as April (Vance et al. 2004), and as late as September (Maule 1959), and is most prevalent in the open or in canopy gaps (Maule 1959, Vance et al. 2004). When environmental conditions do not favor flowering or pollination a population can reproduce vegetatively (Vance et al. 2004).

Beargrass is difficult to cultivate, so most harvest occurs from natural populations (Hummel et al. 2012). The maritime distribution of the plant—from the mountains of northwestern Washington and southward into west-central California—is the main location for commercial and traditional harvesting. While the industry mainly exports the plant for use as decoration (Blatner and Alexander 1998, Hansis 1998) and has since the 1990s, for many American Indian tribes beargrass is a key fiber in traditional weaving and has been for centuries (Hummel and Lake 2015).

The preferred leaf properties of beargrass differ between commercial and traditional harvesters and thus, so do the preferred site conditions where harvest occurs. Commercial-quality beargrass leaves are deep green, long, wide, and absent any discoloration (Schlosser et al. 1992, Schlosser and Blatner 1997). These leaf properties seldom exist under open forest canopy (Higgins et al. 2004). In contrast, tribal harvesters prefer a mid-green color, regardless of leaf length or width and weaving style (Hummel and Lake 2015). Good sites for traditional leaf harvest have lower densities of large diameter trees and lower levels of down wood than do poor sites (Hummel and Lake 2015).

Figure 3.2—More than ¼ million pounds of black cohosh (*Actaea racemosa*) roots are harvested from natural populations each year to supply the herbal medicine market. Long-term collaborative research with university partners indicate that populations are not recuperating from the harvest. *In situ* inventory of the roots is one the major challenges being addressed to support management efforts. (Photo credit: James Chamberlain, U.S. Department of Agriculture, Forest Service.)

A key challenge to sustaining populations of beargrass on accessible sites and with desirable leaf properties is an apparent tension between forest conditions that are good for commercial versus traditional harvest (a dense versus open canopy, respectively). A related challenge is designing, implementing, and enforcing a system for monitoring beargrass harvest levels according to type. Commercial harvest on government lands is monitored through a permit system, with tracking on permitted harvest volumes and not actual harvests. A system that allowed for monitored volumes by harvester group could be beneficial. The effects of different harvest methods and intensities are not well studied or documented. Future research on the following is needed: effects of harvest practices (different intensities, and resident versus migrant harvest methods); plant responses to different drivers (climate, shade, fire, light levels/competition from overstory trees); phenology (growth, development, response to warmer drier temperatures projected for western North America are not well understood); persistence and viability of beargrass seed; competition-density relations (e.g., effects on whitebark pine seedling regeneration and reproduction, drivers and thresholds for flowering versus vegetative reproduction across longitudinal and latitudinal gradients).

3.3.3 Black Cohosh

Black cohosh, a native Appalachian forest herb, has been extensively harvested for its commercial value as an herbal medicine used to address symptoms of menopause (figure 3.2). Black cohosh has been listed as one of the top 10 selling herbal supplements each year since 2002. The American Herbal Products Association (2007, 2012) estimates that between 1997 and 2010, more than 3.76 million pounds of black cohosh roots and rhizomes were harvested from the deciduous forests of the Eastern United States. The mean annual harvest from natural populations over the 14 years was approximately 268,000 pounds. As nearly all the black cohosh sold commercially is wild-harvested, the potential for harvesting impacts is considerable without proper management practices in place. Mitigating potential harvest impacts requires determining harvest intensities that have minimal impact and allow for post-harvest recovery and long-term population persistence (Small et al. 2011). After 3 years of intensive harvesting (66 percent of stems within a plot harvested per year), Small et al. (2011) measured a significant reduction in foliage area and stem production, relative to control plots. After 1 year of recovery, plots from which plants were subjected to intensive harvesting showed no improvement. Instead, most growth measures continued to diverge relative to control plots. Thus, the harvest of two-thirds of a population appears unsustainable. Sustainable management of black cohosh, and other medicinal plants, requires effective and reliable inventory of marketable plant components. Chamberlain et al. (2013) used data from long-term sustainable harvest studies to develop a predictive model to estimate marketable rhizome biomass at the stand level. Slow-growing perennials that require extended periods to reach reproductive maturity are particularly vulnerable to over-harvesting. With increasing demand for medicinal forest plants, such as black cohosh, assessing harvesting practices and determining viable management approaches is critical to the long-term sustainability of natural populations of forest herbs (Elliot et al. 2014, Small et al. 2014, Vickers et al. 2015).

3.3.4 Echinacea

Echinacea is a native perennial to the Great Plains of the United States and southern Canada, and its roots are harvested from wild populations (typically the top 10 to 15 cm of root) using shovels or other implements (Kindscher et al. 2008). Roots are used extensively as a medicine for treating illness, wounds, snakebite, rabies, and other ailments by at least 16 American Indian tribes (Kindscher 2016a, 2016b). It is an important immune stimulant and flu and cold remedy in the herbal products trade with significant international exports to Europe. Other echinacea species have been harvested from the wild from central and eastern United States, but the vast majority of roots harvested are *Echinacea angustifolia* (Riggs and Kindscher 2016). Other species, especially those already rare or uncommon, or in locations where their populations are limited, are at risk because they can be sold as echinacea roots.

Over-harvest of wild echinacea species' root has been a significant concern to the herbal product industry and conservationists. However, research has shown that harvest can be sustainable. In one study of commercial harvest in Kansas and Montana, 50 percent of harvested root reserves had resprouted after 2 years despite droughty weather (Kindscher et al. 2008). The length of root harvested affected resprouting ability in that study, with those plants having less root length removed more likely to resprout. Because the plants can produce substantial amounts of seed annually, recovery from intensive harvest is possible if periods of nonharvest occur. Additional work has demonstrated that there is a greater than 120-year history of harvest in locations of mixed grass prairie in central Kansas that, based on research on harvest practices, ecological monitoring, and demographic modeling, also appears to be sustainable (Price 1999, Price and Kindscher 2016). Concerns about the persistence of echinacea populations remain, however, due to a variety of factors related to the conversion of prairie lands to croplands, herbicide application to control "weeds" in rangeland, extensive oil and gas development (including national grasslands in North Dakota), and other development. Wild echinacea harvest is sustainable but populations should be monitored due to persistent habitat threats and to a changing climate.

3.3.5 Goldenseal

Goldenseal is an herbaceous understory species native to the central Appalachian Mountains, west to Missouri and Arkansas, and north into southern Ontario, and is most abundant within the Ohio River watershed. While quantified accounts of historic (pre-1900) abundance are not available, narrative accounts suggest this species has experienced marked declines in both number and size of populations. This decline is not well understood and several contributing factors are likely. Evidence suggests harvest pressure, which has increased over the past 10 to 15 years (Inoue et al. 2013), as well as habitat loss and herbivory by increased populations of white-tailed deer have contributed to goldenseal decline (Mulligan and Gorchov 2004).

While harvest of natural populations is undoubtedly a contributing factor to population decline, the species' abundant rhizomes promote that some vegetative propagules are left in the soil following harvest, and permit a degree of regrowth (Sanders and McGraw

2005a). For example, after a wild-harvest in WV in which only four stems remained, 932 stems were present the following year (Van der Voort et al. 2003). Stem densities then declined initially, before remaining relatively stable 2 and 4 years post-harvest. Similarly, ramet densities increased 210 percent from 2 to 4 years post-harvest in Ohio (Albrecht and McCarthy 2006). Since preharvest densities were unknown in both locations, it is not known how long it takes populations to recover from harvest.

Decline of goldenseal also may be linked to its conservative growth rate; it is a slow-growing species with little reproduction from seed. Several studies have documented that population growth rates are at or just above replacement value (Christensen and Gorchov 2010, Sinclair and Catling 2005). Common garden experiments indicate that soil moisture is important for successful germination and growth, but deep litter layers may hamper growth (Albrecht and McCarthy 2009). Goldenseal persists for the entire first season of growth with only its two seed leaves (cotyledons); it does not produce true leaves until the second growing season. In this first year state, seedlings may not be able to emerge through thick litter or even dense herbaceous cover.

As population decline continues, gene flow between populations will likely decrease. More than 80 percent of the genetic variation is within populations (Inoue et al. 2013), suggesting limited gene flow between populations. However, plasticity within populations has been documented (Sanders and McGraw 2005b), which would allow some degree of response to varying site conditions. Most studies of goldenseal have been limited to 4 years or less. A thorough understanding of population recovery, microsite response, demography, and plasticity can only be reached from longer-term research. To elucidate goldenseal's ability to respond to environmental fluctuations and changing environmental and climatic conditions, these four topics should be prioritized with well-designed, longer-term (at least 10-year) studies. Population recovery approaches should be multi-tiered and focus on (1) limiting harvest, (2) maintaining genetic diversity within populations, and (3) promoting gene flow among populations. Accomplishing this first point may involve legislation in Canada and the United States, as well as multiple States. Accomplishing the second two points may require development of breeding and restoration programs.

3.3.6 Osha

Osha, bear root, or *chuchupate* is a slow-growing member of the parsley family (Apiaceae), found in the southern Rocky Mountains in the United States and the Sierra Madre of Mexico. Across its range it is primarily found from 1830 to 3570 m in moist meadows, parklands, riparian areas, and forests. It has a long history of use by American Indians and Hispanics (Latino/as) as its pungent and distinctively spicy roots are used to treat influenza, bronchitis, and sore throat, and a variety of other ailments, particularly those relating to the lungs and heart and general illness (Kindscher et al. 2013). Today osha roots are primarily wild-harvested for personal use, but some are sold to herbal product companies, a demand that has been increasing.

Osha is a large plant (up to 6 ½ feet tall) and apparently long-lived, with large root crowns and rhizomes, often weighing more than a pound per plant. Information available on the sustainability of osha harvest indicates that plants and populations can recover from some harvest pressure (Kindscher et al. 2017, Mooney et al. 2015). Population densities of geographically separated dense populations in the Rio Grande and San Juan National Forests average of 7.8 percent osha cover (Kindscher et al. 2013). In a manipulative field experiment in the Rio Grande National Forest (Colorado) established to analyze osha's recovery from harvest, a meadow site had 15 percent more mature plants and 58 percent more root mass than the adjacent forested site. This meadow population exhibited 10-percent cover (a dense stand) and had on average 1.8 oz dried root weight per 10.76 ft^2 (465 pounds/acre), while a forest population exhibiting a 9 percent cover had on average 0.48 oz dried root weight per 10.76 ft^2 (122 pounds/acre) (Kindscher et al. 2013, 2017). This plant is very productive, but long-term concerns, especially related to climatic variability, may have negative impacts on future populations, but more research is needed on this topic.

3.3.7 Pinyon Pine

Approximately 11 species of North American pinyon pine produce edible nuts. The most important are Colorado pinyon (*P. edulis*), dominant throughout 56 million acres of pinyon-juniper woodlands of New Mexico, Arizona, eastern Utah, and Colorado, and singleleaf pinyon pine (*P. monophylla*), which is abundant throughout the Great

Basin areas of Nevada and western Utah. Pine nuts were a staple food of native peoples in the Western United States for millennia (Simms 2008). Pine nuts remain culturally important to traditional gatherers, although they are harvested locally and in relatively small quantities (Mitchell and Roberts 1999). There is much potential for further development of the pine nut industry in the United States. The domestic market is estimated at $100 million, where more than 80 percent of pine nuts consumed are imported (Sharashkin and Gold 2004). Pine nuts are valued as a gourmet food item used primarily in pesto, salads, and various Mediterranean dishes, and can be pressed to make oil and ground to make meal. Pinyon pine nuts compare favorably with other tree nuts in their nutritional content of protein, carbohydrate, and unsaturated fats, with *P. edulis* the richer in oils and *P. monophylla* in carbohydrates (Lanner 1981). Harvest of *P. monophylla* nuts is usually by collection of closed cones in early autumn, following which cones are heated or allowed to dry so that seeds fall out after the cone scales open. Harvest of the smaller-coned *P. edulis* is usually by collection of individual seeds on the ground (Little 1993). Good pine nut crops are produced every 4 to 7 years (Barger and Ffolliott 1972), although the frequency of good mast years can be greatly reduced during drought periods, and during high late-summer temperatures, by as much as 40 percent (Redmond et al. 2012). Redmond et al. (2012) observed a 40-percent reduction in cone production from 1974 to 2008 in *P. edulis* populations of New Mexico, associated with high late-summer temperatures at the time of cone initiation.

Ecological sustainability issues associated with pinyon pine nut harvesting include competition with wildlife species that rely upon the nuts, including pinyon jay (*Gymnorhinus cyanocephalus*), Clark's nutcracker (*Nucifraga columbiana*), and several species of seed-caching rodents (Vander Wall 1997), as well as possible adverse effects of nut harvesting on long-term population viability of the tree species. These aspects have been but little studied. An ecologically based, silvicultural management of pinyon woodlands for pine nut production has been advocated over many decades (Lanner 1993, Little 1941) but little progress has been made toward this goal, which will require field trials, adaptive management, and an integration of scientific and traditional ecological knowledge. Pine nut silviculture would likely include uneven-age management of nut pines on favorable sites (Gottfried and Severson 1993). Judicious pruning and thinning could be implemented to reduce fire risk, stimulate perennial herbaceous understory development, and encourage nut production. Thinning has been observed to stimulate cone production in other nut pine species, such as stone pine (*P. pinea*) stands in southern Europe (Moreno-Fernandez et al. 2013). Fundamental challenges include limits in silvicultural knowledge (stand dynamics, tree spacing, pest control); high variability of good crop years; climate change effects; labor and transportation costs; and competing landscape management objectives that currently emphasize removal of large acreages of pinyon-juniper woodland for fire risk reduction and to create or maintain sagebrush-dominated ecosystems (e.g., Davies et al. 2011).

Further research is needed concerning the optimal spacing for nut production, pinyon pine stand dynamics in response to uneven-aged silvicultural management (Gottfried 2004), and potential impacts of pine nut harvesting on woodland biodiversity including closely associated species such as pinyon jay. The pinyon pine nut resource faces an uncertain future due to current management efforts aimed at maximizing sagebrush habitat, which often incorporate large-scale tree removals, as well as potential climate change effects. Increasing temperatures and altered precipitation regimes have already affected pinyon pine populations through reduced growth (Williams et al. 2013), increases in mortality (e.g., Clifford et al. 2008), altered patterns of seedling recruitment (Redmond and Barger 2013), and declining cone production (Redmond et al. 2012). More research is needed to determine effects of climate change on cone production across environmental stress gradients and for different species, populations, and genotypes of pinyon pine.

3.3.8 Saw Palmetto

The saw palmetto palm is considered to be the most common native palm in the United States, found from Georgia to Mississippi and throughout Florida (Bennett and Hicklin 1998), where it is considered most abundant (figure 3.3). Once thought a weed and pest by farmers and ranchers (Bennett and Hicklin 1998), recent research has focused on the plant's range, distribution, preferred habitats, interactions with other plants and wildlife, adaptation to fire, longevity (some palms are believed to be over 1,000 years old) and more (cf., Abrahamson

1995, Abrahamson and Abrahamson 2009, Carrington et al. 2000, Carrington and Mullahey 2006, Maehr et al. 2001, Takahashi et al. 2011, Tanner and Mullahey 2012).

Saw palmetto has a long history of use by American Indians in Florida as food, fiber, medicine, and more (Bennett and Hicklin 1998). The commercial harvest of saw palmetto drupes, or berries, for herbal remedies in Florida goes back at least to the early 1900s (Bennett and Hicklin 1998). Today demand for the berries derives both from the European pharmaceutical industry, which processes the berries into a standardized oil used to treat benign prostratic hyperplasia (BPH) symptoms, and from the growing demand from the U.S. herbal supplement market, where in 2012 it was the third best-selling herb in the United States (Lindstrom et al. 2013). Berries are harvested primarily from Florida, where they are dried and processed for industry (Bennett and Hicklin 1998, Mitchell 2014). Reported harvests between 1997 and 2010 ranged from 763 tons to 2,893 tons of dried berries (AHPA 2012), reflecting both variable availability and demand. Berry harvesters are often seasonally unemployed agricultural workers who harvest informally for cash to bridge that employment gap. Companies formally lease land in order to maintain access to berries, but an informal market for the berries exists in Florida (Bennett and Hicklin 1998, Mitchell 2014).

There has been speculation that harvesting berries within black bear ranges has led to recent conflicts between humans and bears, though there is no evidence of a shortage of berries within their ranges, or that a lack of food led to human-bear conflicts. Recent research illustrates (1) much saw palmetto habitat exists outside of current black bear ranges, and (2) saw palmetto habitat within bear ranges should be more than adequate to meet bear foraging needs so bears would not have to leave their ranges to find this favored food (Mitchell 2014). Bennett and Hicklin (1998) note that harvester collection activities usually center on accessible public lands and in areas close to buyers. It is theoretically possible that this might result in localized scarcity during years of low fruit production (Bennett and Hicklin 1998). Much more research needs to be done to understand the relationship between the saw palmetto harvest and frugivores, such as black bears, toward improved management of both.

The act of harvesting berries should not harm the palm as only clusters of the berries are harvested (cf. Bennett

Figure 3.3—Saw palmetto (*Serenoa repens*) berries are harvested, predominantly from pine forests of Florida. The habitat for this important medicinal forest product is at great risk due to potential rise in sea level. (Photo credit: Karan A. Rawlins, University of Georgia, Bugwood.org.)

and Hicklin 1998, Mitchell 2014). To determine whether the harvest is sustainable we would need to know more about the habitats where it is found and the quality of these. We also need to know more about where people harvest and national and international demand. We need to better understand harvest rates and patterns and other potential drivers on fruit production, plant regeneration, and long-term population growth rates and viability. The extent of the informal market is unknown as is the amount of annual production that flows into the herbal supplement industry. Florida's ongoing population growth has made it the third most populous state in the Nation. This in turn drives development into natural areas, reducing saw palmetto populations. This, along with expected climate change effects, such as sea level rise, will result in a decrease of saw palmetto habitat, which could increase pressure on remaining populations. More research is needed in these areas.

3.4 Effects of Climate Change on Nontimber Forest Products

NTFPs include a diverse array of species that span broad taxonomic and environmental boundaries. This makes assessing the vulnerability of NTFPs to climate change a challenge. However, the life history traits that distinguish the majority of NTFPs from other well-studied species (e.g., timber species) can provide insight of their potential demographic, evolutionary, and spatial responses to climate change.

3.4.1 Potential and Observed Species Responses to Climate Change

Mean global temperature has increased approximately 1.2 °F over the last century, with over half of warming (0.7 °F) occurring in the last 3 decades (IPCC 2013). To persist as climate changes, species must respond plastically, spatially, or evolutionarily to novel climate conditions (Davis et al. 2005, Jump and Penuelas 2005, Parmesan 2006). Long-term studies and biotic resurvey projects show that certain species have responded to contemporary climate change in a manner consistent with expectations (Badeck et al. 2004; Hoffmann and Sgrò 2011; Parmesan 2006; Parmesan et al. 2000, 2013; Parmesan and Yohe 2003; Walther 2010). For instance, many species have shifted distribution northward or upward and advanced the timing of critical life history events, such as spring emergence in plants or migration in avian species (Badeck et al. 2004; Hoffmann and Sgrò 2011; Parmesan 2006; Parmesan et al. 2000, 2013; Parmesan and Yohe 2003; Pinsky et al. 2013; Walther 2010). Despite this clear ecological fingerprint of climate change, there have been ecological surprises as well. A significant proportion of species, 20 percent or more depending on the datasets analyzed, either remain unchanged or respond opposite to expectations (Tingley et al. 2012, Wolkovich et al. 2012). In general, species at greatest risk of extinction are characterized by narrow distribution, small population size, and/or limited dispersal, or that occupy habitats at distributional limits, like arctic and alpine systems (Brook et al. 2008, Cahill et al. 2013, Franco et al. 2006, Lewis 2006, Sax et al. 2013, Slatyer et al. 2013, Thomas et al. 2004, Wilson et al. 2005).

3.4.2 Vulnerability of Nontimber Forest Products to Climate Change

Range breadth is frequently used as a primary indicator of vulnerability to climate change driven extinction, because a narrow distribution may indicate sensitivity to changing climate as well as habitat specificity, which could preclude successful colonization of northerly or upland sites (Bellard et al. 2012, Brook et al. 2008, Thomas et al. 2004). At first glance, NTFPs—generally not characterized by narrow range—may appear robust to changing climate. However, specialization to local climate conditions may narrow the thermal niche of a species, thus increasing vulnerability. Such specialization, termed local adaptation or ecotypic differentiation, is common among plant species (Linhart and Grant 1996). In essence, locally adapted species evolve traits that optimize performance at mean, site-specific climatic conditions. While this specialization enhances local competitive success, directional change away from historic norms reduces fitness (Atkins and Travis 2010, Davis et al. 2005, Etterson and Shaw 2001, Kawecki and Ebert 2004, Linhart and Grant 1996). In this way, climate change may threaten widespread species that are seemingly robust to changing conditions, in an analogous way to those that are narrow-range endemics (Atkins and Travis 2010).

Species comprised of many, locally adapted populations are not only more vulnerable to climate change driven decline, they also may be less likely to successfully track home-site conditions as climate changes (Davis et al. 2005). Local adaptation is promoted when gene flow among populations is low (Kawecki and Ebert 2004). Hence, species for which the formation of ecotypes is the norm are often characterized by restricted dispersal, and thus exhibit low potential for rapid distributional shifts in response to changing climate. Many NTFP species display relatively limited dispersal distances, which increase the likelihood of local adaptation (Bennington and McGraw 1995, Gregor 1946, McGraw 1985), and hence climate change vulnerability (Davis et al. 2005, Etterson 2004). Climate change may interact synergistically with other stressors like harvest pressure to increase extinction risk (Brook et al. 2008, Mandle and Ticktin 2012, Souther and McGraw 2014).

3.4.3 Climate-change Integrated Management of Nontimber Forest Product Species

Climate-change integrated management of ecosystems encompasses a wide range of strategies. Such strategies include the removal or reduction of stressors (e.g., invasive species) to increase ecosystem resilience to changing climate, conservation of habitat corridors to allow species to track climatic niches upward and poleward, conservation of climate refugia, and human-assisted relocation of species that are unable to shift ranges (Hannah et al. 2002, Keppel et al. 2012, Richardson et al. 2009). Effective habitat management and conservation of habitat corridors and refugia seemingly have few drawbacks and are believed to benefit a wide range of species within ecosystems (Gilbert-Norton et al. 2010). However, sedentary or stationary species, with low migration potential (e.g., characterized by short dispersal distances, low rates of seed production) may be unable to shift distribution in response to changing climate even if habitat corridors are preserved. Such traits characterize a number of NTFP species.

When species imperiled by climate change are unable to track shifting climatic conditions, persistence may be contingent on human assistance (Etterson and Shaw 2001, Jump and Penuelas 2005). Due to their economic and cultural value, and likely vulnerability to climate change-driven extinction, NTFPs are potential candidates for *ex situ* conservation programs, such as managed relocation. Managed relocation, also known as assisted dispersal, migration, or colonization, refers to the transport of species, populations, or propagules to higher latitudes or elevations as climate changes (Richardson et al. 2009, Schwartz and Martin 2013). Interpreted broadly, managed relocation also may include the intentional introduction of genes preadapted to future climate conditions into a population's gene pool in order to accelerate adaptation to changing climate. Conceptually, managed relocation decreases extinction risk by assisting the colonization of an area with a climatic regime similar to which the species (or population) is adapted.

Because species may be adapted to other site-specific variables in addition to climate, managed relocation has the potential to negatively impact fitness when associations with key environmental factors are broken. Additionally, the introduction of nonlocal genotypes into a locally adapted population may cause outbreeding depression or lowered fitness of subsequent generations due to infiltration of nonlocal, and hence maladapted, genotypes (Frankham 1995, Kramer and Havens 2009, Pertoldi et al. 2007). However, gene flow from populations adapted to warmer climates may provide genetic variation and traits necessary to adapt to novel climatic conditions (Hampe and Petit 2005). Given the uncertain efficacy of managed relocation, considerable research is needed to determine the relative benefits and risks of this conservation strategy for NTFPs, as well as to develop methodological considerations to perform successful relocations (Benito-Garzón et al. 2013, McDonald-Madden et al. 2011). If managed relocation is considered a viable strategy, citizen-based managed relocation programs that enlist harvesters to intentionally disperse seeds to cooler habitats should be evaluated as a potential approach. Additional lines of inquiry should address the possible role of cultivation in NTFP conservation. Cultivation programs for many NTFPs exist and could serve as sources for managed relocation, as well as reservoirs of adaptive genetic variation critical for evolutionary response to changing climate (Kramer and Havens 2009; Vitt et al. 2009, 2010).

3.5 Key Findings

- Significant changes in a plant's vital rates may result in demographic and genetic changes at the population level. Resiliency of NTFP populations varies according to life history traits, as well as the ecological, management, and social context of harvest.

- Long-lived perennial plants tend to be highly sensitive to decreases in adult survival from their harvest or the harvest of parts (e.g., bark, roots, rhizome, bulb), and may have significant negative impacts on long-term population persistence.
- Long-term harvest sustainability operates across multiple scales and levels of ecological organization, requiring understanding of processes that go beyond individual populations and species.
- Crafting plans for sustainable management requires understanding the effects of harvest over time and across landscapes, as well as the impacts of climatic variability and change.
- Species response to disturbance is determined by reproduction mechanisms and responses to changes in light or water availability, substrate condition (e.g., mineral versus organic soils), and nutrient availability, as well as other edaphic factors.
- Most ecological studies have focused on harvest sustainability at the population level and effects on biodiversity, community interactions, and ecosystem functions have received insufficient study.
- NTFPs include a diverse array of species that span broad taxonomic and environmental boundaries which makes assessing the vulnerability of them to climate change a challenge, especially demographic, evolutionary, and spatial responses to climate change.
- Climate-change integrated forest management requires a wide range of strategies that mitigate stressors, increase forest resilience, and conserve habitat refugia and corridors to allow for responses to range shifts and human-assisted relocation of species that are unable to shift ranges.

3.6 Key Information Needs

- A comprehensive understanding of the ecological impacts of harvesting and stewardship.
- Improved maps and other geospatial tools of NTFP species ranges.
- Accurate estimations of growth, yield, and mortality that allow sustainable harvest levels and practices in natural and forest farmed settings, including many types of plant organs (e.g., roots, leaves, fruit).
- Monitoring more populations over longer periods and testing of different management practices.
- Improve abilities to evaluate the impacts on native NTFP species and populations in the context of potential drivers of population change (e.g., habitat conversion, invasive species, pollinators, fire, herbivory, drought) relative to climate change.
- Improve modeling of projected impacts on NTFP species and populations from climate change and variability that would support risk assessments for NTFP species leading to mitigation and adaptation strategies.
- An understanding of potential impacts at all ecological levels, from species to landscapes, that consider ecological interactions to sustain populations, with clear understanding on how NTFP species contribute to forest health and resiliency to climate and other factors.
- Information from traditional, local, and science-based knowledge sources that are integrated fully into comprehensive management strategies.

3.7 Conclusions

Hundreds of NTFPs are harvested in the United States and its affiliated territories, but ecological studies exist for relatively few of these. Despite current overharvest of some species, reviews and meta-analyses suggest potential for sustainable harvest of many (Schmidt et al. 2011, Stanley et al. 2012, Ticktin 2004). The challenge lies in identifying and meeting the conditions necessary to long-term sustainability. Because data are lacking on a majority of NTFP species, research on basic ecologies, harvest dynamics, harvester stewardship practices, and production and market dynamics are needed.

Basic ecological information needs include reproductive biology, habitat requirements, and response to disturbances. Data on interactions between pollinators and seed dispersers will be needed to sustain NTFP populations and understand their contributions to the resilience of ecological communities. Improved mapping of NTFP species ranges, monitoring of populations over longer periods, and testing of management practices are needed to measure variation over time, space, and management strategies. Examining population recovery rates from seeds and resprouts in different habitats is a priority for species harvested for their underground organs.

Understanding harvest dynamics and harvester stewardship practices is critical and will require studies of how, why, and where harvesters gather, including traditional and local ecological knowledge (Baron et al. 2015). Analyses of the relative effects of harvest versus other potential drivers of population decline (e.g., habitat destruction, invasive species, fire, herbivory, drought), as well as potential synergistic effects, is a priority. Best practices for such research and its use as a basis for management plans includes long-term participatory collaboration with harvesters and managers (Cudill and Rodela 2012).

Production and market studies also are essential to understanding the long-term sustainability of commercially traded NTFPs. Research on the volume and timing of trade will benefit basic ecological and harvest dynamics research alike, as will production analyses examining the absolute and distributional costs and benefits of wild harvests versus cultivation. Phytochemistry research may support improved sustainability by identifying options for substitution of plant materials with lesser impacts on species and community viability and determining whether harvest practices affect the presence of active medicinal compounds.

The potential vulnerability or resilience of NTFP species can be identified based on ecological, social, and market characteristics of species, habitats, and harvest systems. For species potentially at risk, there are multiple approaches to assessing and identifying sustainable harvest, depending on the needs, time, and resources available (see Cunningham 2001, Schmidt et al. 2011, Ticktin 2015, for guidelines on what methods to use, and when). Demographic models provide powerful tools for evaluating the effects of harvest and other pressures on long-term population growth rates (Crone et al. 2013, Ellner and Rees 2006). Risk assessments for key species would include identification of life history traits linked to vulnerability; assessments of how harvest interacts with changing climate to affect viability of NTFP populations; impacts of harvest on local genotypes and associated implications for adapting to climate change; and, evaluation of methods for, and relative benefits and risks of, managed relocation, including cultivation.

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CHAPTER 4

Cultural Dimensions of Nontimber Forest Products

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4.1 Nontimber Forest Products and Culture

Nontimber forest products (NTFPs) provide cultural ecosystem services for peoples throughout the United States and its affiliated territories. Cultural ecosystem services of NTFPs are those tangible and intangible functions that contribute to the traditions, livelihoods, and well-being of social groups including, but not limited to, indigenous and minority communities (Daniel et al. 2012, Hernadez-Morcillo et al. 2013). The Millennium Ecosystem Assessment (2005) recognized six services of ecosystems necessary to support cultural landscapes and traditions: heritage values, cultural identity, spiritual functions, inspiration, aesthetic appreciation, and recreational tourism (Tengberg et al. 2012). Some NTFP species are so fundamental to the cultural identity of a people because of their diverse roles in diet, materials, medicine, and spiritual practices that they may be thought of as cultural keystone species, with loss of access presenting a risk to cultural survival (Emery et al. 2014, Garibaldi and Turner 2004).

For purposes of this chapter, we define culture as learned customs and traditions of thought and behavior expressed as everyday life practices, especially as these maintain social cohesion and help groups live in their biophysical environment (American Anthropological Association 2014, Barnard and Spencer 2002). Culture includes ways of thinking and acting, as well as material objects that shape and reinforce a people's shared way of life and identity. Preservation of culture and cultural identity is positively associated with human well-being (Dockery 2010) and may be particularly important in times of change and insecurity (Kassam et al. 2010, National Scientific Council on the Developing Child 2015) such as rapidly changing climatic conditions.

Cultural ecosystem services of NTFPs derive from landscapes, plant materials and mushrooms, *and* the social and economic practices that surround their use (Burger et al. 2008, de Groot et al. 2002, Fisher et al. 2008). Contributions of NTFPs and associated practices to culture and human well-being include, but are not limited to:

- Support for food, health and economic security.
- Inputs for culturally appropriate livelihood strategies.
- Materials for spiritual and ceremonial observances.
- Occasions for sharing cultural stories and teachings.
- Conservation of traditional ecological knowledge and connections to nature.
- Distribution traditions that create social cohesion and provide security for vulnerable community members.

Like all aspects of culture, NTFP practices and habitats are dynamic even as they maintain aspects of cultural continuity. Cultures may adopt the use of new species as humans and plant materials move (Emery 2002a). The technologies used in the harvest and processing of NTFPs also may change over time. For example, equipment used historically for collecting maple sap has evolved from folded and sewn birch bark vessels, to wooden and then metal buckets, to vacuum tubing. However, such developments are not unidirectional or universal, such that multiple technologies may be in use simultaneously without fundamentally altering the cultural functions of a NTFP. The choice to adapt or modify traditional methods or adopt new practices and methods to contemporary circumstances and conditions can empower NTFP harvesters (Turner 2001). Nevertheless, while the adaptive capacity of cultures are considerable, it is not limitless. The speed and intensity with which changes occur, their cumulative effects, and the resources available to communities will affect the resilience of cultural ecosystem services from NTFPs and the cultures that rely on them (Bennett et al. 2014, Berkes et al. 2000, Daniel 2012, Tengberg et al. 2012).

This chapter uses a cultural ecosystem services framework (Daniel et al. 2012, Hernández-Morcillo et al. 2013) to synthesize the literature on cultural uses of NTFPs by diverse United States communities, with reference to the implications of a changing climate. Section 4.2 provides a brief introduction to the cultural values and functions of NTFPs. Section 4.3 examines how biophysical and social factors that affect the condition and availability of NTFPs and their physical properties combine with NTFP-based practices to support cultural ecosystem services. Section 4.4 discusses potential impacts of increasing climatic variability on cultural ecosystem services provided by NTFPs. Finally, sections 4.5 and 4.6 identify gaps in knowledge about the cultural ecosystem services provided by NTFPs and potential strategies to fill these gaps. The chapter draws primarily upon research conducted in the United States and its territories, but incorporates international literature where this provides insights relevant to the United States context.

4.2 Cultural Values and Functions of Nontimber Forest Products

Cultures that rely on NTFPs for ecosystem services make use of dozens to hundreds of species of plants and mushrooms from diverse habitats, across landscapes of many ecosystems (see appendix 1—Regional Summaries for more detailed descriptions of NTFP species, their uses, and cultural values). The material (i.e., tangible) functions of these plants and mushrooms include food, medicine, ceremonial, and utilitarian purposes. There are countless nonmaterial (i.e. intangible) services or functions NTFPs provides as well (Satterfield et al. 2013, Tengberg et al. 2012). Their cultural values are derived from social practices that surround the harvest and use of plant materials and mushrooms, including traditional teachings, ceremony, preparation, and distribution, as well as harvest. Further, their values extend beyond harvesters, as family and community members generally take part in and benefit from NTFP management and harvesting practices. NTFPs have particular salience and legal standing for many indigenous cultures. However, settler and immigrant cultures also make use of plant materials and mushrooms that grow wild, are semicultivated, or are developed and produced in agroforestry systems (e.g., cultural landscapes) of varying degrees of management intensity (Satterfield et al. 2013, Tengberg et al. 2012).

4.2.1 Indigenous Cultures and Nontimber Forest Products

There are hundreds of indigenous cultures in the United States and its affiliated islands. As of publication date there are over 560 federally recognized American Indian and Alaska Native tribes. There are many state-recognized and federally unacknowledged tribes and indigenous communities with the United States and its affiliated territories. Outside the continental United States, the Native Hawaiian Health Care Act of 1988 codified the fact that "Native Hawaiians comprise a distinct and unique indigenous people…determined to preserve…their cultural identity in accordance with their own spiritual and traditional beliefs, customs, practices, languages, and social institutions." In addition to federally recognized tribes, more than 300 groups have sought or are seeking Federal recognition as a tribe of the United States and affiliated territories.

The centrality of access to NTFPs for the cultural survival of indigenous peoples is illustrated by a decision of the U.S. Supreme Court, which described access to such resources as "not much less necessary to the existence of the Indians as the air they breathe" (U.S. v. Winans 1905). Access to land and the plant materials and mushrooms on them plays a central role in the capacity of any people to maintain their NTFP-based cultural practices and identity. Tribally controlled land bases, such as Alaskan Native Corporation managed land, reservations, rancherias, and allotments, range in size from several million acres to scarcely more than 1 acre. In some cases, indigenous peoples in the United States have legally retained rights to hunt, fish, and gather in their ancestral territory, although these rights may not always be fully realized. However, not all indigenous communities have land or legally specified retained rights. Further, in the 2000 Census, 64 percent of people identifying as American Indian and Alaska Native lived off Indian lands and 45 percent were urban residents (National Urban Indian Family Coalition 2008). Harvesting and using NTFPs provide powerful ways for these individuals to reconnect with or maintain their indigenous heritage, lands, and resources (Turner 2001). Despite these reserved tribal rights another barrier for tribal access to and the utilization of NTFPs can occur from competition with nontribal communities, commercial interests, and other nontraditional uses.

4.2.2 Settler and Immigrant Cultural Uses of Nontimber Forest Products

NTFPs also play cultural roles in some communities of long-settled (referred to here as settlers) and recent immigrants to the United States and territories, including those who arrived voluntarily and those who were forcibly relocated (figure 4.1). Their NTFP uses include practices adapted from their ancestral place of origin (e.g., Voeks and Rashford 2013), as well as those learned from indigenous peoples (Still 1998, Turner and von Aderkas 2012). In either case, harvesting and use of NTFPs may sustain cultural identity and capacity to live in place for nonindigenous communities throughout the Nation, whether they have been settled inside the current boundaries of the United States for many

Figure 4.1—Harvest and use of nontimber forest products sustain cultural identities for diverse peoples. For example, making baskets from bulrush needles (*Juncus roemerianus* Scheele), strips of palmetto leaves (*Sabal palmetto* (Walt.) Lodd.), longleaf pine needles (*Pinus palustris* Mill.), and blades of sweetgrass (*Muhlenbergia filipes* M.A. Curtis) is important to the culture and economy of contemporary Gullah/Geechee artisans in South Carolina (top and bottom left). Lupines (*Lupinus* spp.) and other plant material harvested by the Swedish colony of northern Maine are used in its Midsommar Fest (top and bottom right). (Photo credits: Brian Grabbatin (left), Michelle J. Baumflek (right), U.S. Department of Agriculture, Forest Service.)

generations or a few years. Some examples of cultural uses of NTFPs by nonindigenous peoples include Gullah/Geechee basketmaking traditions (Hurley et al. 2008), lupines (*Lupinus* spp.) and other plant materials harvested by the Swedish colony of northern Maine for its annual Midsommar Fest (Baumflek et al. 2010), the iconic status of ramps (*Allium tricoccum* Aiton) as a regional food in the Appalachian Mountains (Hufford 2000, Shortridge 2005), and the values of harvesting and eating brackenfern fiddleheads (*Pteridium* spp.) for Japanese and Korean immigrants to southern California (Anderson et al. 2000).

4.3 Nontimber Forest Product Social-Ecological Systems and Ecosystem Services

The cultural ecosystem services that flow from NTFPs are produced through social-ecological systems with spatial, temporal, and social dimensions that operate at scales from the individual plant or person to entire landscapes and cultural groups (de Groot et al. 2002, Fisher et al. 2008, Satterfield et al. 2013, Tengberg et al. 2012). Biophysical availability of plant materials and mushrooms is essential. However, cultural potency arises from their use by human beings and the social structures and processes in which these are embedded (Cocks and Wiersum 2014).

Figure 4.2 offers a visualization of NTFP social-ecological systems and cultural ecosystem services. As a necessarily simplified representation of rich processes and meanings, figure 4.2 and the ensuing discussion inevitably omit much important detail. In particular, five aspects of NTFP cultural ecosystem services, as cultural values, are discussed (Burger et al. 2008). However, in actual cultural life these are often interdependent and mutually reinforcing; the distinctions between them presented here may be regarded as largely artificial and assumed for explanatory purposes only. The authors mean no disrespect in taking this approach, which is necessary to accurately assess cultural implications of NTFP use from a systems perspective that is national in scope.

4.3.1 Management and Nontimber Forest Product Availability

Land management has direct bearing on the presence and density of NTFPs in a location and also may affect their material properties (Hummel and Lake 2015). Ethnobotanical research in diverse ecosystems documents how local and indigenous management historically and presently works at scales from the landscape to individual plants to enrich populations of desired species (Cocks and Wiersum 2014, Peacock and Turner 2000) and reduce populations of competing species such as invasives (Pfeiffer and Voeks 2008, Ticktin et al. 2006). Some of this work also has recorded traditional ecological knowledge (TEK) regarding changes in NTFP populations in response to settlement, other land management priorities (e.g., timber and fire suppression), and prohibition of traditional practices (Voggesser et al. 2013). In urban to ex-urban environments, development and land use conversion can eliminate or severely reduce populations of NTFP species (Hurley et al. 2008). However, NTFPs also may be present in residential and novel landscapes and habitats, such as greenways or parking lots (Head and Muir 2006, Hurley et al. 2008, Rocheleau et al. 1996), although their material properties may be altered and harvesters may be required to negotiate equally novel terms for access or consider health and safety for consumption or medicinal uses from contaminants.

The response of NTFP species to land management practices remains an area for research on cultural ecosystem services in temperate and boreal regions (Anderson 2005, Daniel et al. 2012). Noteworthy examples of research to date include work conducted in Finland on the response of production levels of berries to differing silviculture practices (Miina et al. 2010) and the United States Pacific Northwest on the response of mushrooms (Pilz et al. 1999, 2004; Wurtz et al. 2005) and huckleberries (Kerns et al. 2004, Minore et al. 1979) to fire and silvicultural techniques.

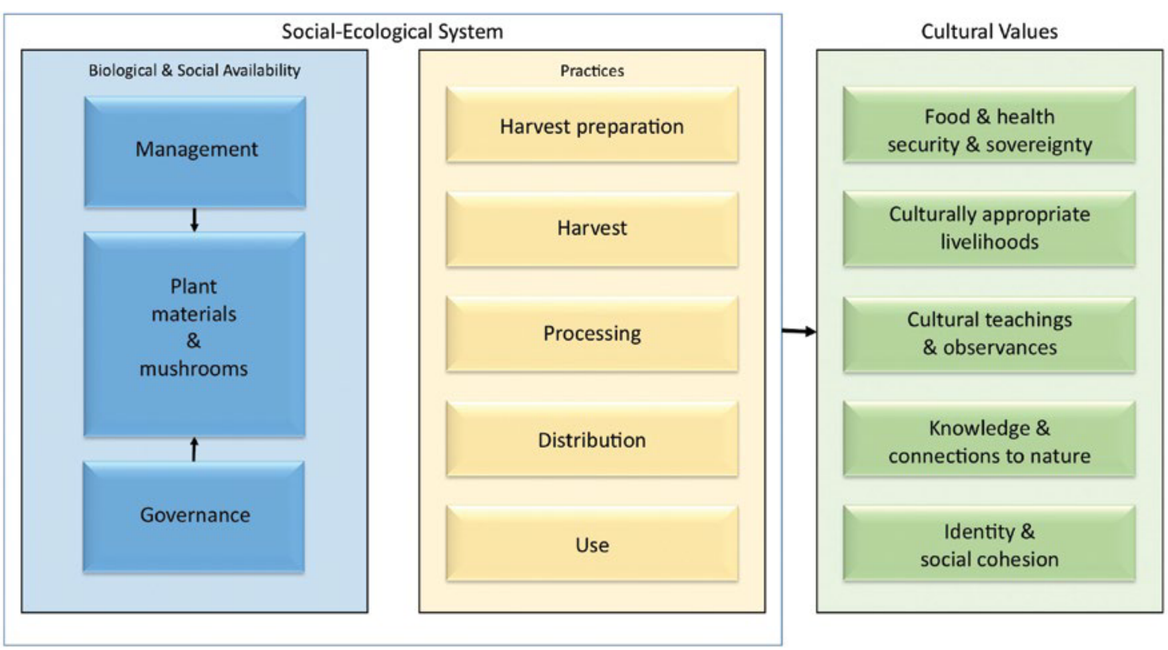

Figure 4.2—Nontimber forest product social-ecological systems and cultural ecosystem services. (Source: M.R. Emery, U.S. Department of Agriculture, Forest Service.)

4.3.2 Governance and Access to Nontimber Forest Products

While land management practices can affect the presence of NTFPs in a landscape, governance and legal standing influence whether people make use of them without fear of sanctions (Laird et al. 2010). In addition to formal legal governance (see chapter 7 for detailed discussion of the laws and regulations that apply to NTFPs), access to NTFPs also is governed by informal governance structures, including traditional community-based norms. Examples include customs regarding the timing and allocation of berry harvests in the Pacific Northwest (Peacock and Turner 2000) and the traditional Hawaiian system, which designates to a community or kinship group responsibility for management and right of access to resources throughout a watershed (*ahupua'a*), from the mountains (*mauka*) to the ocean (*makai*; Minerbi 1999).

Effects of governance on indigenous peoples have particular importance in a discussion of NTFP cultural ecosystem services (de Groot et al. 2002, Fisher et al. 2008, Hernández-Morcillo et al. 2013, Satterfield et al. 2013). Here, again, formal and informal structures condition access to NTFPs for cultural uses. Informal structures can be both enduring and particularly vulnerable to disruption. For example, in northern Maine, changes in agricultural technology and land ownership severed relationships between Maliseet and Mi'kmaq basketmakers and farmers, which had been the basis for ready access to black ash (*Fraxinus nigra* Marshall) on the latters' land (Ginger et al. 2012). In contrast, indigenous peoples are still the majority or plurality of the population on most U.S.-affiliated Pacific islands and retain largely indigenous patterns of land tenure and rights to resource management and use.

Formal governance structures must navigate complex land ownership and jurisdictional boundaries. In the Upper Midwest, harvest of NTFPs by American Indians takes place in a mix of legal and political jurisdictions. On reservations, harvests are under the control of the tribal governments. Few, if any, tribes in the region use harvest regulations such as seasonal restrictions or harvest limits in the management of NTFPs. Harvesting off reservation by tribal members presents a more complex picture. Following key court decisions (Lac Courte Oreilles Band of Lake Superior Chippewa v. Wisconsin, 700 F2d 341 (7th Cir. 1983); Minnesota v. Mille Lacs Band, 199 S. Ct. 1187 1999), treaty-reserved gathering rights have been restored on most public lands, including national forests managed by the Forest Service. Some tribes have negotiated harvesting regulations with the Forest Service and have documented those agreements in Memoranda of Understanding or similar agreements at a government-to-government basis. In some instances, permits are required for tribal gathering on public lands and monitoring techniques are employed to document harvests. In California, the 2006 Indian Free Use Policy reaffirms tribal members' access to manage and harvest NTFPs for traditional and cultural purposes without permits or fees on lands managed by the Bureau of Land Management and Forest Service. Similar policy is now nationally available for federally recognized tribes to harvest forest products for traditional and cultural [noncommercial] purposes "free of charge" on Forest Service-administered lands (Cultural and Heritage Cooperation Authority of 2008).

4.3.3 Nontimber Forest Product Practices

Biophysical and social availability are necessary but not sufficient to produce NTFP cultural ecosystem services. Brief descriptions of the practices essential to these values follow.

Harvest preparation: Short-term preparations may include visiting potential harvest locations and assembling and checking any tools or other implements needed for harvesting. Long-term preparations include acquiring the knowledge needed for successful harvesting. In some cases, preparations may include managing plants, populations, or landscapes to ensure the presence of a desired NTFP on a seasonal or ceremonial need basis.

Harvest: In addition to locating desired NTFP species, harvest involves decisions about which plant materials and/or mushrooms to take and which to leave. Harvest also may be used as a form of or opportunity for management to promote future harvests.

Processing: Most NTFPs require some form of processing before they can be used. Processing varies with plant material or mushroom and intended use. Examples include cooking or preserving foods and weaving one or more NTFP species into baskets.

Distribution: NTFPs used for their cultural values commonly are distributed beyond harvester households to social networks composed of friends, family, and others. Distribution takes diverse forms including gifts and trade.

Use: Among their cultural functions, NTFPs are consumed or used as food, medicine, aesthetic and utilitarian objects, and ritual and ceremonial resources.

4.3.4 Nontimber Forest Product Cultural Ecosystem Services

Food sovereignty and health security—NTFPs play central roles in the food security and sovereignty of indigenous and other peoples throughout the United States and its affiliated islands (Emery and Pierce 2005, Kuhnlein et al. 2009, Lynn et al. 2013). The 1996 World Food Summit defined food security as "access to sufficient, safe, nutritious food to maintain a healthy and active life" (World Food Summit 1996). Food sovereignty refers to the ability of an individual or group to produce and/or obtain the foods of their choice, especially as these are defined by sociocultural traditions (Kassam 2010). The related concepts of health security and sovereignty are referenced in Article 24, Section 1 of the United Nations Declaration on the Rights of Indigenous Peoples, to which the United States is a signatory. The Declaration states that, in addition to the right of access without discrimination to all other health and social services, indigenous peoples have "the right to their traditional medicines and to maintain their health practices, including the conservation of their vital *medicinal plants*, animals, and minerals" (United Nations 2008; emphasis added).

The actual and potential contributions of NTFPs to health and nutrition are considerable (see also section 6.5 in this report). Tribal health professionals have noticed that as traditional food consumption has declined, rates of nutritionally related diseases such as diabetes and heart disease have increased (Lynn et al. 2013, Phillips et al. 2014). This trend in tribal community health and well-being is expected to be compounded by the impacts of increasing climatic variability (Ford 2012). Research on the nutritional content of NTFP food species is limited but growing (Kuhnlein 1986, Phillips et al. 2014). As of 2014, the USDA Agricultural Research Service's National Nutrient Database includes a dataset of the nutritional content of 165 American Indian or Alaska Native foods, including over 40 single or combination NTFP foods (USDA ARS 2014). Analyses of traditionally foraged plant foods harvested on American Indian reservations in North Dakota found high nutritional values (see also section 6.5 in this report). Recommendations based on these results support reintroducing or increasing consumption of edible NTFPs for their nutritional and cultural values (Phillips et al. 2014). Such efforts are under way in tribal communities regarding efforts within USDA school lunch and farm-to-school programs.

Access to and uses of NTFP foods are central to the cultural survival of peoples, as well as their material survival (figure 4.3). Food is a key ingredient in bringing families and larger social groups together to celebrate, define, and maintain their identity (Reddy 2015). An indication of the importance of edible NTFPs to identity is their role in foundational cultural teachings. For example, the Mohawk creation story, *Tsi Kiontonhwentsison*, describes how strawberry seeds (*Fragaria* spp.) were carried to this world from the Sky World. Today, strawberry drinks continue to be served during ceremonies and other community events (Hoover 2010). Anishinaabe (also known as Ojibwe or Chippewa) teachings relate how, expelled from their territory in the East, the Anishinaabe were instructed to travel west until they found "the place where food grows

Figure 4.3—Nontimber forest product foods are central to the material and cultural survival of indigenous peoples. Lion's mane mushroom (*Hericium erinaceus* (Bull.) Persoon), tanoak acorns (*Notholithocarpus densiflorus* (Hook. & Arn.) Manos, Cannon, & S.H. Oh), and evergreen huckleberries (*Vaccinium ovatum* Pursh) are foods important to the Karuk and other tribes of northern California. (Photo credit: Frank K. Lake, U.S. Department of Agriculture, Forest Service.)

on water" (Janowiak et al. 2014). This is a reference to the aquatic grain, wildrice or *manoomin* (*Zizania palustris* L.), a traditional staple in the Ojibwe diet.

Contemporary practices using NTFPs for medicinal purposes remain important to diverse communities (e.g., Garibaldi 1999). Ethnobotanical studies of indigenous peoples published in the 19th and 20th centuries list hundreds of plant species used for medicinal purposes in simple and compound formulations (e.g., Smith 1923 and Moerman 1998 for North America). Today, NTFPs continue to be used to treat illness and support physical and psycho-social health. It is common for families to have their own NTFP-based traditional medicinal practices. Many communities also have traditionally trained healers, who harvest and administer NTFPs. Medicinal and spiritual practices using NTFPs are among the most culturally sensitive (Geniusz 2009), and detailed information about these uses is generally avoided in this report, including the regional summaries, except where information is broadly known and published.

The line between food and medicine frequently is indistinct, a widely observed phenomenon encapsulated in the quotation attributed to Hippocrates (460–370 B.C.E.), "Let medicine be thy food and let food be thy medicine." Berries offer one example of the importance of NTFP foods for the physical and social health of many communities. These small fruits are traditional foods throughout most of the continental United States. Recent research has documented the value of phytochemicals present in many berries for regulation of a variety of metabolic conditions (Basu et al. 2010, as cited in Lynn et al. 2013). In Wabanaki culture (the Maliseet, Mi'kmaq, Passamaquoddy, and Penobscot tribes of Maine), berries are used extensively for women's health, and in coming-of-age ceremonies (Lynn et al. 2013).

A similarly blurred line exists between the medicinal and spiritual functions of many NTFPs used throughout the United States and its affiliated islands. Examples from two regions illustrate. Devil's club (*Oplopanax horridus* (Sm.) Miq.) is the most common and widely used medicinal plant of coastal Alaska Natives (Garibaldi 1999). It is also considered to have spiritual properties (Moerman 1998). In Pacific island cultures with rich ethnobotanical traditions, *Piper methysticum* ((G.) Forst.), known as *kava* in Polynesia and *sakau* in Pohnpei, is commonly used for ceremonial, medicinal, and recreational purposes.

Culturally appropriate livelihoods—The U.N. Declaration on the Rights of Indigenous Peoples recognizes economic practices as having cultural bases fundamental to the survival of peoples (United Nations 2008). The ways households and communities meet their needs for material survival can be grounded in and have profound implications for cultural practices. Many indigenous peoples struggle to maintain livelihoods that support material well-being while honoring cultural teachings about right relationships among human beings and between humans and the nonhuman world. NTFPs play important roles in such efforts through their use as subsistence goods, in traditional trade and barter, and trade in formal and informal economies (Emery 1998, 2001; Emery and Pierce 2005).

Basketry traditions offer a case in point. A wide variety of wild plant materials are used in the making of baskets by peoples from Maine and New York (Benedict and Frelich 2008) to California, Oregon, and Washington (Hummel and Lake 2015). Basketry traditions have endured ecological and political transitions (Hill 1997) and are central to indigenous cultural revitalization efforts taking place throughout the country (figure 4.4). Baskets in many sizes and shapes are used for utilitarian purposes including food storage and cargo. They also are works of art that rely on and give physical form to traditional ecological knowledge (TEK) and culture (Anderson 2005). The sale of baskets made from NTFPs allows individuals and families to derive some or all of their needs for cash income through traditional cultural practices. For example, in the Pacific islands, over one hundred cultivars of *Pandanus* spp. (common names include pandan and screw palm) provide fruit and palm-like leaves that are processed and woven into mats, traditional clothing, and baskets. Some of these items have profound cultural significance, such as fine mats offered as gifts in ceremonies of marriage or meetings of leadership. Others, including baskets, have been adapted to modern markets and are major sources of income for indigenous women, especially in the Marshall Islands and other atolls.

Subsistence practices are central to many cultures, particularly indigenous peoples. Hunting, fishing, trapping, and gathering NTFPs are regarded as forms of acquiring wealth. Loss of capacity to engage in subsistence practices is a form of impoverishment and represents a fundamental threat to material, cultural, and economic survival (Emery and Pierce 2005, Hunn

Figure 4.4—Nontimber forest products are foundations for culturally appropriate livelihoods. Sale of baskets using traditional techniques and contemporary artistry is an important source of income for many Native artisans. Left: Gabriel Frey (Passamaquoddy Tribe) pounding a black ash log (*Fraxinus nigra* Marshall) to delaminate annual growth rings for basket making. Right: Black ash purse with a leather lining, created by Gabriel Frey. (Photo credits: Suzanne Greenlaw.)

1999, Schroeder 2002). The subsistence practices of some peoples in the United States enjoy legal status (see chapter 7), although the actual terms under which these are exercised are frequently contested.

Alaska has 229 federally recognized tribal governments that represent indigenous peoples of that state. Alaska Native groups maintain strong physical and cultural ties to traditional areas used for subsistence harvests of fish, wildlife, plants, and mushrooms. For Alaska Natives, subsistence is a cultural marker and a way of maintaining what it means to be a native. NTFP harvesting, including the gathering of traditional foods, provides connection to place, belief, and heritage that are essential to expressing and maintaining native culture and indigenous identity (Schroeder 2002). The Alaska State Department of Fish and Game maintains data on subsistence practices in the United States. While these records have focused on fish and game, NTFPs such as berries and wild greens also are widely used for subsistence purposes (Norris 2002).

Cultural teachings and observances—Each step in the suite of NTFP practices, from preparation for harvest to final use of a plant material or mushroom, offers an occasion for cultural teaching (figure 4.5) and NTFPs are essential to many cultural observances. The description of cultural teachings and observances, like other information presented here, is not intended to romanticize or universalize what actually happens on the ground. In any community, there are individuals who follow or adhere to social guidelines about correct behavior and those who do not. This is no less true where NTFPs are concerned than it is in any other arena. Likewise, there are variations in customs between and within cultures. Nevertheless, the following describes common teachings across cultures about how to do things “in a good way,” which dedicated cultural practitioners teach, observe personally, and hold as the measure of best practices and personal integrity (as stewardship obligations and respectful use of NTFPs). Taken as a whole, it demonstrates the importance of NTFPs to the survival and maintenance of culture.

Often, NTFP practices are social occasions, in which people of different ages and levels of ability take part. Each activity is an opportunity to teach interrelated material and spiritual and cultural values to youth and others (Ruelle and Kassam 2013).

Figure 4.5—Nontimber forest product practices offer an occasion for cultural teaching. Elders of the Karuk Tribe, Lillian Rentz (upper left) and LaVerne Glaze (lower right), harvest edible corms (*Brodiaea coronaria* (Salisb.) Jeps.). (Photo credit: Frank K. Lake, U.S. Department of Agriculture, Forest Service.)

Preparations for harvest may include instruction in making tools or containers from other NTFPs. Understanding phenological characteristics, i.e., the relationship between observable phenomena in the landscape such as weather or events in the lifestage of a species with appropriate timing for the harvest of a plant material or mushroom, can be especially important to success [see chapter 2] (Armatas et al. 2016, Lantz and Turner 2003). Instruction about these relationships occurs in practice on the ground, but also may be embedded in cultural teachings that have ensured the survival of people through extended periods of time.

Teachings that accompany harvest include information about how to find a NTFP and choose materials with the desired properties. They also may involve orientation to and reinforcement of larger world views, including human beings' roles, relationships, and responsibilities to the natural world (Emery et al. 2014). Often, instruction in best practices includes prayers and other forms of respect and reciprocity (Reo and Whyte 2012, Turner 2001)

Processing NTFPs can provide occasions for diverse members of a community to come together, including those who are unable to participate in harvesting. When the plant material or mushrooms are intended for sacred use, rituals may be an essential part of their preparation. Practices surrounding *imu*, or underground ovens, exemplify cultural values embedded in preparations that involve NTFPs. *Imu* is a traditional food preparation that has been used across Oceania for over 4,000 years to cook taro (*Colocasia esculenta* (L.) Schott), breadfruit (*Artocarpus altilis* (Parkinson) Fosberg), and other staples for nutritional and ceremonial purposes. Events surrounding *imu* bring people together to gather resources, prepare the *imu*, enjoy food, clean up, and distribute leftover food. It also brings people together metaphorically, through sharing culturally meaningful experiences and maintaining social relationships (Kamelamela 2012).

In addition to cultural teachings and practices that emphasize relationships between human beings and the natural world, NTFPs are integral to customs that reinforce cultural norms about right relationships among people. Harvesting, processing, distributing, selling, and using NTFPs for cultural and social activities allow different individuals in a family, tribe, community, or business to serve roles that strengthen sociocultural cohesion. This is particularly evident in the distribution and use of NTFPs. Redistribution or sharing of NTFPs serves as a form of social capital and an expression of respect, as when younger individuals make "payment" with NTFPs to elders or mentors who instructed them. Frequently, plant materials and mushrooms are distributed so that their benefits extend beyond harvesters and their households. Sharing NTFPs may be as formalized and ceremonial as the potlatches of Pacific Northwestern tribes (Turner et al. 2008) or as commonplace as taking a slice of wild berry pie to a neighbor. In either case, such forms of distribution reinforce relationships between people and reflect cultural teachings about respect and reciprocity. Day-to-day use of an object made from an NTFP can create continuous, living connections between a person and the environment from which it came (Deur and Turner 2005), but also between the user and the people who harvested, prepared, and distributed that item.

NTFPs also are essential materials in special cultural observances. With their role in observances of major life passages such as marriages and coming of age ceremonies, cultural uses of NTFPs are part of supporting individuals and weaving together communities. As the focal point of seasonal celebrations, they help to orient people in time and reinforce resource-based livelihood strategies.

Knowledge and connections to nature—Local and traditional ecological knowledge are essential to the exercise of NTFP cultural values. As described earlier in this chapter, knowledge developed through stewardship, gathering, and using NTFPs is comprehensive (Turner 2001). It includes, among other things, information about factors needed to access, harvest, process, and use plant materials and mushrooms. Local and traditional ecological knowledge employed to access and use NTFPs includes species identification, phenological relationships, microsite and landscape characteristics, stewardship strategies, and processing to unlock nutritional and medicinal values and produce items such as baskets.

NTFP knowledge and practices are not homogenous within individual tribes and communities. Rather, gathering and use of NTFPs varies across and within them. As some practices are widespread (e.g., berry picking), specialization of knowledge and practices for particular NTFPs also is common (Emery 1998). Individual families may focus on a particular species or suite of species and it may be inappropriate to share some or all of this knowledge. Further, like other forms of TEK (Reo and Whyte 2012), NTFP knowledge is dispersed. No individual or family possesses the full body of a tribe or community's collective knowledge about the plants and mushrooms in their environment.

In addition to its value for cultural maintenance, such knowledge and the practices associated with it create connections to nature with demonstrated benefits to physical and psycho-social well-being of individual community members (Tenberg et al. 2012). Research demonstrates that time spent in natural environments reduces cortisol levels and other physiological measures associated with stress-related diseases (Park et al. 2011), and some research indicates a reduction in behaviors associated with attention deficit/hyperactivity disorder (Kuo and Taylor 2004).

Erosion of such knowledge poses corresponding risks to cultural survival and individual well-being. In addition to traditional methods of passing information within families, many communities have institutions and programs designed to teach youth about their cultures, including NTFP use and TEK of species, habitat requirements, environmental processes, and disturbance or management effects, all associated with sustainability of the resources (Turner 2001).

Such detailed ecological knowledge has clear value for understanding effects of climatic variability at local and regional scales. Much effort has been dedicated to understanding TEK (Berkes 2012, Parrotta and Trosper 2012) and establishing ethical protocols for respecting indigenous knowledge and culture (Geniusz 2009, Smith 1999). Key principles include recognizing the rights of communities, especially indigenous communities, to choose what information is and is not shared and how it is used (Williams and Hardison 2013) (box 4.1). Applying these principles to work on cultural values of NTFPs in an era of changing climate will provide a foundation for respectful, productive collaboration between harvesters, their communities, scientists, and policymakers.

Identity and social cohesion—NTFPs are part of cultural expression and identities of indigenous peoples and contribute to social cohesion of individuals and communities, whether residing in ancestral homelands, cities, or distant locations. The role of NTFPs in identity formulation is especially evident in indigenous origin stories. In addition to examples provided earlier in this chapter, traditional accounts state that Native Hawaiians are descendants of Sky Father (*Wākea*), Earth Mother (Papa), the Progenitor of the stars (*Ho'ohōkūkalani*), and the taro plant (*Colocasia esculenta* (L.) Schott) is the elder sibling of man. Wabanaki teachings say that the peoples of present day Maine sprang from black ash (*Fraxinus nigra* Marshall).

Material practices using NTFPs also are potent markers of identity. As noted earlier in this chapter, subsistence practices, including uses of NTFPs, are regarded as an important part of what it means to be an Alaska Native. Arts and crafts produced from forest plants are integral to culture and are vehicles for expressing identity. For example, California and Pacific Northwest basketmakers traditionally have used combinations of materials, techniques, designs, and patterns distinctive to their tribe (Hummel and Lake 2015).

NTFPs also play a role in, among other elements, a sense of belonging and responsibility to a larger group and forms of social assistance for individuals understood to be vulnerable or in need (Norton and Haan 2013). NTFP practices and celebrations that use foraged plant materials and mushrooms are occasions for extended families and broader social networks to come together around a

BOX 4.1
ETHICS AND NONTIMBER FOREST PRODUCT KNOWLEDGE

Often people ask, "How do American Indians use this plant?" It is a simple enough question and the questioner usually expects a commensurately simple response. To answer this question in a culturally appropriate manner, however, takes time, depth of understanding, respect, and trust not obtained quickly. As knowledge holders, culture keepers may be charged with maintaining a body of knowledge with proscriptions such as what information can be shared, with whom, at what time of year, and under what circumstances. The responsibility of those entrusted with the traditional knowledge of how the plant is used extends to rules about how that knowledge may be shared, if at all. It may be that specialized or sacred information can be shared only with the individual or family who will become the next steward(s) of that knowledge. Others may be deemed not culturally qualified or unable to honor the responsibility to safeguard that knowledge in culturally appropriate context.

In her book, "Our Knowledge is Not Primitive: Decolonizing Anishinaabe Botanical Knowledge", Wendy Makoons Geniusz discusses the history of ethnobotanical work with tribes in the U.S. Upper Midwest:

> Researchers have recorded a fair amount of information about how the *Anishinaabeg* work with plants and trees; however, much of this information has been colonized. To use this knowledge for cultural revitalization, it must be reworked and reinterpreted into a format that is appropriate and usable to contemporary *Anishinaabe-izhitwaawin* (Anishinaabe culture). (2009: 4)

Thus, to answer the simple question posed in this box in a respectful manner, any response must be complete including who provided the information, the community they are from, and when it was provided. The information should include how and when the plants or mushrooms are collected, how they are prepared, and instructions for their use. It is only through this complete set of information, including any traditional teachings, special instructions for use, prayers, or songs that may go with the plant or mushroom that a culturally appropriate portrayal can be presented. Given the critical nature of NTFPs to the cultural survival of indigenous communities, it becomes equally critical to ensure that their traditional knowledge be protected against misappropriation and maintained in the most culturally relevant and useful forms possible.

In this chapter, which documents uses of NTFPs by indigenous peoples, some specific uses of forest products are presented. Out of respect, the authors have avoided mention of plant uses involving medicinal, ceremonial, or spiritual purposes that are not widely known. We have attempted to limit our description of NTFPs to those which are more public and utilitarian in nature. For example, noting that maple sap is collected for the purpose of making maple syrup does not disclose a use for a plant not already widely known.

While recognizing the cultural intricacies of sharing traditional knowledge, it is hoped that knowledge exchange between Western scholars and traditional practitioners will help to ensure the continued viability of culturally important NTFPs in the face of increasing climatic variability and the associated disruptions to knowledge systems and traditional practices. The authors thought it important, however, to offer this perspective so the indigenous people who read this chapter will know we tried to offer this knowledge in a respectful and inclusive manner.

sense of community. Norms surrounding the distribution of NTFPs can provide for the most vulnerable in a community, particularly elders. The role of NTFPs in social cohesion is evident in many cultures and economies, where harvesting and using plant materials and mushrooms are integral to celebrations, healing, and redistribution of food and adornment resources.

4.4 Impacts of Climatic Variability on Cultural Uses of Nontimber Forest Products

Direct and indirect effects of increasing climatic variability on NTFPs may result in significant disruptions to culture and its contributions to human well-being (Chief et al. 2014, Parrota and Agnoletti 2012). Altered spatial and temporal distributions of NTFP may have some of the most immediate consequences. Changes in location of suitable habitat may mean that a culturally important species is no longer available within the treaty territory or trust lands of a tribe or becomes effectively inaccessible because of long travel distances (Ginger et al. 2012). Observances central to cultural identity and the transmission of knowledge may be compromised by episodic or chronic shortages in volumes of cultural keystone species whose life cycles are dependent on particular climatic conditions. Likewise, altered timing of seasonal variation in temperatures and precipitation may result in phenological asynchronies (decoupling of events that previously occurred simultaneously or in predictable sequence), which reduce the effectiveness of TEK or result in lack of availability of species at key times in culturally defined livelihood cycles (Armatas et al. 2015, Lantz and Turner 2003, Turner and Clifton 2009). Where species continue to be available in place and time, the physical properties needed for spiritual, religious, utilitarian and craft materials may be altered directly by factors such as changes in hydrology and temperature, or indirectly by the emergence of insects and diseases.

Many sacred sites are considered as such, because of the high significance of spiritually or religiously important NTFPs found and utilized in those localities. Climate-related disturbances and mechanisms that result in changes of species at sacred sites, could have a profound impact on the continuance of cultural practices that require the locality and the NTFP resource both be present.

The effects of climatic variability on social structures and processes also will have ripple effects for culturally important NTFPs. For example, rising sea levels may result in greater pressure on upland NTFP resources as land bases are reduced in island and coastal environments. With sea level rise, coastal and island communities face physical displacement, domestic freshwater source contamination, and impairment to habitats that sustain them culturally (Feary et al. 2012, FSM 2010, Maldonado et al. 2013, Parrotta and Agnoletti 2012). Where these displaced community members move into areas with existing cultural uses of NTFPs (and there are few places where this will not be the case), there is potential for conflict due to competing demands for resources. In the case of displaced peoples for whom NTFPs have cultural keystone values, movement into areas where these species are unavailable by virtue of bio-physical absence or social barriers to obtain them could represent a threat to material and cultural survival. At the same time, it should be noted that on some Pacific islands, traditions of accommodating kin displaced by drought or storm are being adapted today as governments with higher elevation lands proactively provide land for displaced atoll dwellers (FSM 2010, Parrotta and Agnoletti 2012).

Within these general parameters, specific effects of climatic variability on NTFP cultural functions will vary by region and cultural group. Each cultural group is vulnerable to effects depending on their geographic location, the cultural values of the species, and interacting stressors at multiple scales (Bennett et al. 2014, Burger et al. 2008). Some examples of impacts that may be anticipated in particular regions are provided in the regional appendixes.

4.5 Key Findings

- NTFPs are important to the cultures of diverse peoples in the United States.
- Direct and indirect effects of increasing climatic variability on NTFPs may result in significant disruptions to culture and its contributions to human well-being.
- The resilience of cultures and their NTFP-based practices may be a function of the intensity, speed, and duration of events that pose ecological and/or social challenges to them.

4.6 Key Information Needs

- Many culturally important overstory species and their likely responses to increasing climatic variability have not been modeled and understory species largely are absent from such analyses.
- Research on the cultural functions of NTFPs is lacking for many peoples and parts of the Nation.
- Analyses are needed to understand the interactions of increasing climatic variability impacts, management, governance, and cultural uses of NTFPs.

4.7 Conclusions

NTFP cultural values derive from practices of harvest, processing, distribution, and use, as well as plant materials and mushrooms themselves. As changes associated with altered climate affect landscapes and social systems in which cultural uses of NTFPs occur, they will affect and possibly threaten cultures throughout the United States and its affiliated islands. Among the contributions to human well-being at risk are the roles of NTFP knowledge-practice-belief systems (Berkes 2012) in food sovereignty and health security (Kassam et al. 2010, Lynn et al. 2013), identity formation, social cohesion, and livelihoods (Cocks and Wiersum 2014, Emery 2002b, Lynn et al. 2013, Voggesser et al. 2013).

Such alterations could have adverse consequences for indigenous, settler, and immigrant populations across rural to urban environments. Particular attention may be required to fulfill the treaty and reserved rights and comply with laws relevant to cultural values of NTFPs to American Indians, Native Hawaiians, Alaska Natives, and other rural residents of a state.

At the same time, culture is dynamic and there are opportunities to mitigate and adapt to climatic variability effects on NTFP cultural values. Indeed, NTFPs frequently provide essential survival resources in times of disruption when and where commercially products are limited or not available (e.g., Redzic 2010) and may do so during climate-related disturbances. The resilience of cultures and their NTFP-based practices may be a function of the intensity, speed, and duration of events that pose ecological and/or social challenges to them. Indigenous peoples have noted that their cultures are the product of millennia of adaptation to social and ecological change. As a consequence, indigenous peoples have knowledge systems and wisdom to offer as all of humanity seeks to adapt to changing climate (Voggesser et al. 2013).

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CHAPTER 5

Social Dimensions of Nontimber Forest Products

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5.1 Introduction

Although public and private forests in the United States have long been dominated by timber management (McLain 2002), these forests are also the source of hundreds of nontimber forest products (NTFPs) (Hurley et al. 2008, Schlosser and Blatner 1995). The variety of NTFPs is matched by the diversity of people who harvest them. The existence of these varied and often competing interests means that issues of power, access and control, labor relations, and social justice are equal to ecological and economic issues in their importance.

The potential consequences of climatic variability lend a special urgency because the distribution of costs, risks, and opportunities will change as forest species distribution changes and spatial and temporal patterns of natural hazards change. A key issue is that the impacts of harvest for most NTFPs are not well understood, and social, economic, and ecological sustainability requires continuous research, monitoring, and discussion. For example, where frequently harvested species are affected, particularly where populations decrease or respond in ways that adversely affect desired characteristics, formerly sustainable practices may no longer serve. New knowledge and adjustments in governance may be needed. This chapter seeks to provide a framework of the social dimensions of NTFPs on public and private lands across the United States.

Our starting point in discussing these issues is to acknowledge large-scale data on the social dimensions of NTFPs are sparse. It is thus difficult to characterize NTFP harvesting on a national scale and to draw general conclusions about the conditions, impacts, costs, and benefits of harvesting. Nevertheless, we discuss the findings of a number of regional and local studies that permit us to draw some tentative conclusions about harvester demographics, stewardship, and environmental and social justice issues.

We begin this chapter by providing a brief overview of NTFP user communities, drawing on results from regional surveys to provide information on NTFP harvester demographics. The survey data also provide insights into the social and economic values of NTFPs for the people who harvest them.

Next, we consider social relationships of governance—specifically, cooperation and communication between landowners/land managers and harvesters. This discussion suggests communication and cooperation are key to integrating scientific knowledge with the knowledge of harvester communities for more effective governance. A closely related discussion explores the literature on harvester stewardship practices and how these might inform NTFP governance strategies. There appears to be some correlation between land tenure and conditions of access directly affecting harvesting practices, and this effect needs to be taken into consideration in developing strategies to ensure resiliency and good stewardship on forested lands.

Following the discussion of governance and stewardship, we explore social networks and labor structures of NTFP harvesting. It is likely that the greatest volume of harvested plant materials and mushrooms goes into commodity production systems, although many people involved in harvesting NTFPs do so entirely outside formal markets. Within commodity production systems there may be labor supply chains involving many intermediaries. Harvesters within these labor supply chains are often vulnerable. The literature on this topic leads us to conclude that land tenure, race, immigration status, income, and education play roles in harvester vulnerability and affect the abilities of harvesters to access sites as well as to participate in forest management decisions that directly affect their lives and livelihoods.

Our discussion ends with a review of findings from recent research on NTFP harvesting in more populous areas and the environmental justice considerations this brings to the foreground. It would be easy to assume that NTFPs are exclusively products of rural and wilderness locations; however, recent research documents their harvest in urban, suburban, and exurban locations by diverse peoples for diverse purposes. This research also suggests that the extent to which people of color disproportionately face barriers to access and inclusion poses important social and environmental justice challenges for landowners in rural, urban, and urbanizing settings.

5.2 An Overview of Nontimber Forest Product Harvesters in the United States

Viewed in terms of the numbers of people who harvest, United States residents enjoy the benefits of NTFPs largely unmediated by markets. The nonmarket nature of NTFP uses may be fundamental to their value (Dick 1996, Emery 2002). If prospective harvesters possess the knowledge and access to land where the desired NTFPs are present, the practice is open to anyone with the physical capacity to engage in it (see section 6.5). Perhaps as a result, the demographic profile of harvesters looks like America. Among the larger social goods are environmental justice and the public health benefits associated with exercise, time spent in nature, and nutritional quality of products consumed.

The number of people who participate in NTFP harvesting, their demographic characteristics, and the ways they use gathered materials provide one measure of the social significance of this use of United States forests. Results of random sample, general population telephone surveys conducted in the U.S. Northeast provide such numbers (table 5.1). Two cycles of a survey assessing participation in a variety of outdoor recreation activities asked people in 20 states[1] if they had picked mushrooms and/or berries in the previous 12 months (Cordell et al. 2012). Weighted results show that for the period 1999–2001, 27.9 million people 16 years of age and older had gathered NTFPs. In 2005–2009, that number was 35 million people, an increase of 25.7 percent. This rate of increase exceeds all other surveyed activities except the category of "visiting farm or agricultural settings" (Cordell et al. 2012). In addition, of eight common public pursuits in forested areas, only viewing or photographing birds is reported more frequently than gathering NTFPs (Cordell et al. 2012; table 5.2).

In 2004, respondents to a general population survey conducted in four New England states[2] were asked, "Have you collected any tree or plant materials around woodlands: e.g., mushrooms, berries, cones, or moss?" (table 5.1). Eighteen percent reported they had done so in the previous 12 months, while 26 percent had done so in the previous 5 years. Analysis of the demographics of positive respondents to the survey showed that gathering crosses socioeconomic boundaries, including age, gender, income, and place of residence. This survey also asked how respondents used the materials they gathered (table 5.3). Functional uses mentioned were food (62 percent), decoration (59 percent), cultural (16 percent), and medicine (8 percent). Reported livelihood uses were personal consumption (88 percent), gift-giving (5 percent), value-added sale (2 percent), and sale of raw material (1 percent), with 4 percent reporting other, unspecified uses (Robbins et al. 2008).

Survey results on livelihood uses of NTFPs are striking. The number of respondents who directly use the NTFPs they gather is an order of magnitude higher than those who sell them in any form. Further, ethnographic research suggests that gatherers frequently share and gift NTFPs to family and friends, such that the number of people who use NTFPs in the absence of market exchange of any sort is greater than the number of those who gather NTFPs to sell them (Emery 2001b, Emery and

Table 5.1—Rates of participation in nontimber forest product gathering by residents of the Northeastern United States. Sources: Cordell et al. 2012, Robbins et al. 2008.

Location	Year	Sample size	Previous 5 years percent	Past 12 months percent
Northeastern States[a]	2005–2009	30,000	n/a	36
New England[b]	2004	1,650	26	18

[a] Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin.

[b] Maine, Massachusetts, New Hampshire, and Vermont.

[1] Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin.

[2] Maine, Massachusetts, New Hampshire, and Vermont.

Table 5.2—Rates of participation in forest-based activities by residents of 20 northeastern states, 2005–2009. Source: Cordell et al. 2012.

Activity	Positive response rate	Change in participation rate 1999–2009
	percent	
Viewing or photographing birds	38.2	17.8
Gathering mushrooms/berries	36.0	25.7
Day hiking	32.7	15.1
Visiting wilderness areas	31.3	10.7
Warmwater fishing	24.5	17.3
Developed camping	20.6	-10.4
Canoeing	12.3	8.2
Primitive camping	11.6	-2.5

Table 5.3—Functional and livelihood uses reported by positive respondents to a 2004 New England survey. Totals may exceed 100 percent, as most respondents use harvested plant materials and/or fungi for more than one function and also may engage in multiple livelihood uses. Source: Robbins et al. 2008.

Functional uses						Livelihood uses				
percent						*percent*				
Edible	Medicinal	Decorative	Cultural	Landscaping	Other	Personal use	Gifting	Sale raw	Sale value added	Other
62	8	59	16	n/a	13	88	5	1	2	4

Ginger 2014, Emery et al. 2003). For those who sell some or all of what they harvest, more do so after adding value, suggesting that NTFPs are a basis for microenterprises. Here, ethnographic research suggests that much of this activity likely takes place within the informal economy and, therefore, leaves no records in formal economic statistics. Practices within the informal economy include bartering; trade; personal use; and recreational, spiritual, and cultural uses (McLain et al. 2008).

Two recent cycles of the National Woodland Owner Survey (NWOS; 2002–2006, 2011–2013) included questions about NTFP harvests on family forest lands (Butler 2008, Butler et al. 2016), providing another important source of data on their social values and uses. The NWOS has been conducted periodically since 1953 and is the official database of nonindustrial private forest owners in the United States. It uses a stratified random sample design to survey over 10 million family forest landowners per cycle. The NWOS is implemented on an annual basis with a subset of the total sample (20 percent) contacted each year.

Results for the 2002–2006 and 2011–2013 surveys show a marked increase in family forest landowners reporting that NTFPs have been harvested on their lands at some point in the past, from 16 percent (2002 and 2006) to 29 percent (2009 and 2013), but a drop of nearly 50 percent in those indicating that harvest has occurred in the previous 5 years. This trend may reflect aging of the landowner population. Proportions of those reporting harvest for sale and personal use were more stable over the two survey cycles and parallel livelihood uses reported by respondents to the general population surveys discussed in the previous paragraph. In the 2011–2013 cycle, reported rates of harvest for personal consumption were an order of magnitude greater than those reported for sale (table 5.4).

The data represented by the 2002–2006 and 2011–2013 NWOS cycles are particularly significant because they span a period of deep economic recession. Data on NTFP harvesting from future NWOS surveys will be invaluable in understanding relationships between NTFP harvesting, owner demographics (particularly age), and macroeconomic conditions.

Table 5.4—Family forest owners with >1 acre reporting harvest of nontimber forest products on their land. Sources: Butler 2006, Butler et al. 2016.

	Estimated # of owners		Percent of owners	
	2002–2006[a]	2009–2013[b]	2002–2006	2009–2013
NTFPs ever harvested	1,701,000	10,777,027	16	29
Harvested in past 5 years	1,239,000	1,215,370	73	38
Harvested for sale	163,000	244,238	10	8
Harvested for personal use	1,319,000	2,750,548	78	87

[a] Estimated total number of owners = 10,398,000.
[b] Estimated total number of owners = 10,777,027.

5.3 Nontimber Forest Product Stewardship

The concept of stewardship encompasses informal practices that NTFP harvesters develop and apply in their daily lives, as well as formal programs initiated by trade associations, amateur science societies, conservation nongovernmental organizations, or Government agencies. Scientific knowledge of NTFP stewardship practices in the United States is fragmentary, as is knowledge about their socioecological impacts or the factors associated with the use and transmission of such practices. For example, researchers in the following studies have examined harvester stewardship: New England (Baumflek et al. 2010, Emery et al. 2003, Emery and Ginger 2014), New York (Emery and Ginger 2014), the Southeast (Emery et al. 2003, 2006), the Pacific Northwest (Ballard and Huntsinger 2006, Jones 2002, Love et al. 1998, McLain et al. 2014, Peck and Christy 2006, Pilz et al. 2003, Poe et al. 2013, Richards and Creasy 1996), southern California (Anderson and Blahna 2000), Pennsylvania (Burkhart et al. 2012), Kentucky (Hembram and Hoover 2008), Kansas (Price and Kindscher 2007), the Washington, D.C. region (Barron and Emery 2009), and the Great Lakes region (Emery 2001a).

Studies of NTFP stewardship practices have primarily used qualitative methods, typically combining key informant interviews with participant and direct observation of harvesting practices; a few researchers have used mail or in-person surveys (e.g., Anderson and Blahna 2000, Burkhart et al. 2012, Richards and Creasy 1996) or field experiments (Ballard 2004, Peck and Christy 2006, Price and Kindscher 2007). Data on NTFP stewardship practices have been systematically collected and reported on a number of products, including western brackenfern (*Pteridium aquilinum* (L.) Kuhn) (Anderson and Blahna 2000); American ginseng (*Panax quinquefolius* L.) (Burkhart et al. 2012); echinacea (*Echinacea* spp.) (Price and Kindscher 2007); salal (*Gaultheria shallon* Pursh) (Ballard and Huntsinger 2006); galax (*Galax urceolata* (Poir.) Brummit) (Emery et al. 2003); and wild mushrooms (Barron and Emery 2009, Jones 2002, Love et al. 1998, Richards and Creasy 1996). Additionally, Baumflek et al. (2010) report data on sustainable harvesting practices for 30 species in northern Maine.

5.3.1 Knowledge

Much NTFP research on stewardship seeks to document what harvesters perceive to be sustainable harvesting, as well as how they produce and share their knowledge. Emery (2001b) argues that three types of knowledge—ecological, economic, and use knowledge—are important for stewardship. Harvesters' ecological knowledge is often characterized as traditional or local. Berkes et al. (2000, p. 1252) define traditional ecological knowledge (TEK) as "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans), with one another and with their environment." Ballard and Huntsinger (2006, p. 531) defined local ecological knowledge (LEK) as "local expertise of peoples that may not have a long-term relationship with the local environment, but nevertheless have local wisdom, experience and practices adapted to local ecosystems."

Many people view TEK/LEK as incompatible with scientific knowledge. However, some harvesters engage in informal experiments or carefully document observations of plants and ecological conditions to inform their harvesting practices (Barron and Emery 2009, Charnley et al. 2007, Jones and Lynch 2002, Love et al. 1998). Moreover, some harvesters design and implement studies aimed at establishing harvesting "best practices." An example from the Pacific Northwest is a 13-year experiment conducted by members of the Oregon Mycological Society in the 1990s and early 2000s to determine how harvesting affected chanterelle (*Cantharellus* spp.) productivity and whether the manner of harvesting (pulling versus cutting) made a difference (Pilz et al. 2006).

Harvesters acquire and pass on knowledge about harvesting practices in a variety of ways, with many using multiple learning and knowledge transmittal strategies (Baumflek et al. 2010). Many harvesters learn about NTFPs through on-the-ground training by family members, friends, or neighbors (Barron and Emery 2012, Emery et al. 2006, Emery and Ginger 2014). Field guides, Internet websites, forays, foraging walks, and courses are also common means by which harvesters acquire NTFP knowledge, as is participation in clubs, associations, and informal "meet-up" groups (Baumflek et al. 2010, Hurley et al. 2015, McLain et al. 2014). NTFP buyers are important conduits for the transmittal of knowledge about sustainable harvesting practices (Burkhart et al. 2012, Emery et al. 2003); among healers who use wild plants in their practice, particularly American Indians, apprenticeships are not uncommon.

A key theme in the NTFP stewardship literature is that NTFP knowledge is often differentially distributed and acquired in different ways across social categories, such as age, gender, ethnicity, and class; it also varies by experience level (Ballard and Huntsinger 2006, Emery et al. 2003, Richards and Creasy 1996). This highlights the importance of designing stewardship research in ways that will capture the variation among harvesters in the type, depth, and breadth of their knowledge.

5.3.2 Practices

Knowledge shapes how people harvest, and conversely, harvesting is the means by which people acquire knowledge about the biological, physiological, and ecological factors that affect plant growth and reproduction under different harvesting regimes. As indicated in table 5.5, researchers have documented the use of a broad array of harvesting practices aimed at ensuring the long-term sustainability of plant populations and minimizing disturbance to the surrounding ecosystem. The practices used vary by species, product, and harvester. Harvesters also often use practices aimed at minimizing disturbance

Table 5.5—Practices designed to sustain plant populations and minimize habitat disturbance.

Practices	Studies that document the practice
Timing harvests to avoid collecting when plants are vulnerable	Emery et al. 2003, Hembram and Hoover 2008
Rotating harvest sites	Emery and Ginger 2014, Hembram and Hoover 2008, McLain et al. 2014, Price and Kindscher 2007
Retention of some mature plants	Anderson and Blahna 2000, Emery et al. 2003, Hembram and Hoover 2008
Monitoring resource abundance and restricting harvests if population declines	Baumflek et al. 2010, Emery et al. 2003, Emery and Ginger 2014, Hembram and Hoover 2008, McLain et al. 2014
Avoiding damage to vulnerable plant parts	Anderson and Blahna 2000, Emery et al. 2003
Propagating plants or fungi by planting berries, seeds, cuttings, or spreading spores	Barron and Emery 2009, Burkhart et al. 2012, Emery et al. 2003, McLain et al. 2014
Avoiding species known to be endangered or threatened	Emery et al. 2003, Emery and Ginger 2014, Poe et al. 2013
Restricting amounts harvested (often as a percentage of product available)	Emery et al. 2003, Emery and Ginger 2014, McLain et al. 2014, Poe et al. 2013
Keeping site locations secret from or off-limits to other harvesters	Emery et al. 2003, Price and Kindscher 2007
Selective harvest	Baumflek et al. 2010, Emery et al. 2006, Emery and Ginger 2014, McLain et al. 2014, Price and Kindscher 2007

of other ecosystem components, such as avoiding trampling on endangered plant species, filling in holes when digging roots, and leaving a portion of fruits, berries, or seeds for wildlife (Baumflek et al. 2010, Emery and Ginger 2014, Emery et al. 2003).

5.3.3 Ethics

Researchers studying NTFP harvesters have documented a set of ethical principles that guide what people harvest, how much they harvest, and when they harvest it (Anderson and Blahna 2000, Baumfleck et al. 2010, Emery 2001b, Emery and Ginger 2014, Emery et al. 2003, Price and Kindscher 2007). Emery and Ginger (2014, p. 16) summarize these into five guiding norms:

1. Gather in areas where the targeted species is plentiful.
2. Do not take all the leaves, seeds, fruits, or other parts, and rotate where you harvest
3. Minimize disturbance to the harvesting site.
4. Avoid trampling or harvesting species known to be endangered.
5. Take only what you need.

Additionally, many American Indian harvesters include giving thanks or asking the plant's permission to be harvested among their ethical guidelines (Baumflek et al. 2010), a practice that many nonnative herbalists also follow (Emery and Ginger 2014, Poe et al. 2014).

The American Herbal Products Association has published a set of "good collection practices" for wild plant harvesters (AHPA 2006) that echoes the guidelines described by Emery and Ginger (2014). Harvester rules governing stewardship practices in the United States are often self-enforced (Hembram and Hoover 2008), or as one key informant in Burkhart et al.'s (2012) study of ginseng harvesters put it, "ginseng is an honor system." Hembram and Hoover (2008) point to the lack of community-level enforcement mechanisms as a barrier to sustainable NTFP management. However, to some extent, buyers function as community-level enforcers for products such as American ginseng by complying with legal provisions that require them to refuse to buy small or immature roots (Burkhart et al. 2012). Wild matsutake (*Tricholoma* spp.) mushroom dealers in southwestern Oregon perform a similar function by refusing to buy very small mushrooms (Richards and Creasy 1996).

5.3.4 Stewardship

Limited data are available on the factors associated with stewardship behavior or higher levels of local ecological knowledge among NTFP harvesters. Studies document substantial levels of difference in knowledge and harvesting practices between more experienced and less experienced Latino immigrant salal harvesters (Ballard and Huntsinger 2006); and between American Indians with a generations-old cultural tradition of harvesting matsutake for subsistence and recently arrived Southeast Asian commercial matsutake harvesters in southwestern Oregon and northern California (Richards and Creasy 1996). In all three studies, more experienced harvesters had greater depth and breadth of ecological knowledge and used what they perceived to be more sustainable harvesting practices. However, it is unclear whether the differences in the use of harvesting practices between the Southeast Asian and American Indian harvesters were linked to differences in experience, harvesting motivations, or both since the Southeast Asian harvesters had only recently begun to participate in the matsutake harvest.

Land tenure also influenced harvesting practices of Latino salal harvesters, with experienced pickers practicing less sustainable harvesting on lands on which their tenure was insecure and sustainable harvesting on lands to which they had secure longer-term access (Ballard and Huntsinger 2006). Price and Kindscher (2007) also found that echinacea harvesters used less sustainable harvesting practices on *de facto* open access harvesting sites than on private lands on which anti-trespassing laws were enforced.

5.3.5 Integrating Local and Scientific Knowledge

Managing forests for NTFPs is challenging for many state and Federal land agencies owing to the diversity of species, limited knowledge of these species, and lack of scientific knowledge about most NTFPs. In many cases, harvester knowledge is the only source of knowledge based on long-term observations about the ecological impacts of NTFP harvesting (Emery 2003). In the absence of surveys in peer-reviewed studies, NTFP harvesters are an important yet often under-utilized potential source of knowledge.

One approach to addressing the knowledge gaps within management agencies and the uncertainties associated with NTFP harvesting is to integrate harvesters' LEK with scientific research projects (Emery and Barron 2010). Burkhart et al. (2012) document state and Federal agencies' lack of capacity to enforce ginseng regulations and call for the establishment of "bottom-up" ginseng planting and restoration partnerships between conservation agencies, harvesters, ginseng growers, and traders as a way to address the regulatory enforcement gap. Pilz et al.'s (2006) guide for participatory monitoring provides detailed guidelines for planning, implementing, and following through on collaborative research involving harvesters and scientists.

Few assessments of such partnerships exist. However, Ballard et al.'s (2008) comparative assessment of community-based forestry groups involved in scientific partnerships included one initiative involving NTFP harvesters that was successful in developing a photo point monitoring system for wild mushrooms. They found that building in mechanisms for regular interaction between scientists and harvesters was a key to developing the trust and respect for the collaboration to work. They highlight the need for more research on strategies that enable greater integration of LEK and scientific knowledge.

For the most part, NTFP harvesters who depend on the resource or the supplemental income their harvesting provides each year recognize that their livelihoods depend on sustainability of the resource. Some NTFP harvesters are keen observers of cause and effect, and the impacts harvesting has on the resource. For example, matsutake harvesters who harvest on the forests of central Oregon argue that soil compaction from mechanical thinning as well as thinning too heavily will inhibit matsutake production. In response to input by mushroom harvesters, officials revised their initial plans for a recent timber sale to protect more matsutake habitat and also required logging over snow to limit soil compaction (Headley and Wilmsen 2010). Such place-based ecological knowledge, gained through years of experience with the resource and working partnerships with the Forest Service on national forests, can complement scientific knowledge, thereby improving forest inventories for specific uses of NTFPs as well as monitoring of those uses (Emery et al. 2014).

Engaging with resource users as stewards of the land they harvest may be a valuable undertaking for land managers. Neither local nor scientific knowledge is expected to replace the other knowledge system, but to bolster the effectiveness of science-based management. Everett (2001) found that NTFP groups often have the most "reliable information about the specified NTFP abundance, distribution, and impacts of harvesting. Research indicates that without such knowledge, users and managers have no basis for decisions about sustainable harvest levels" (Everett 2001, p. 340). For example, Barron and Emery's (2012) research on morel (*Morchella* spp.) harvesters in the Eastern United States has shown the importance of participatory approaches when designing and implementing forest management on Federal land. Local knowledge provided valuable insight into morel habitat, ecology, and phenological characteristics.

Harvesters and primary processors are key actors in NTFP commodity production-to-consumption systems. As the people most directly engaged with commercially traded plant materials and mushrooms and the ecosystems in which they occur, many harvesters possess extensive knowledge and have strong interests in the outcomes of management and governance processes. Consequently, their input can strengthen management for NTFPs and other forest values (Ballard and Huntsinger 2006, Charnley et al. 2007). Because commercial harvesters and primary processors commonly are members of socially marginal groups by virtue of income, ethnicity, and other characteristics, special efforts may be needed to integrate their perspectives into land management strategies.

Landowner/producer organizations may offer an opportunity for achieving greater integration and cooperation between land managers and harvesters. The Alabama Medicinal Plant Growers Association (AMPGA) is one example. Established around 2008, the AMPGA serves as an umbrella for small landowners from minority and underserved communities and producers to network and share information about production, processing, and marketing of medicinal plants, such as American ginseng, goldenseal, and black cohosh. While much of their product is cultivated, some members also use wild-harvested materials. The AMPGA provides these individuals with a vehicle for networking and peer-to-peer learning to improve financial return to group members. Such organizations also may serve as a source of information for policy and management.

Additionally, harvesters are more likely to adopt and follow permit or other management systems if they perceive that they have contributed to its development

(Everett 2001). This is important because such policy and management are likely to impact resource users most and it is critical there be support from harvester communities for sustainable use and management of forest resources. In many cases, NTFPs provide a much needed source of income or they have significant social and cultural capital, linking people to their natural environments, providing sources of medicinal plants, and maintaining what are sometimes multi-generational ties to the art of harvesting (Emery and Pierce 2005, Fisher 2002, Watson 2010). Increasing gatherer and primary producer input represents an opportunity for enhancing environmental justice, reducing litigation potential, and enhancing the information base available for NTFP policy and management.

5.4 Stakeholder Organizations, Labor Issues, and Social Networks

There is a long history in America of people harvesting NTFPs to supplement their incomes or to support themselves during hard times or when they have few other options (Fisher 2002). The Multiple-Use Sustained Yield Act of 1960 (see chapter 7) requires public land managers to promote "stability of communities" and "to provide for a continuous and ample supply of timber" and "secure the benefits of forests in maintenance of water supply, regulation of stream flow, prevention of soil erosion, amelioration of climate change and preservation of wildlife." Ensuring these multiple use categories are all met thus requires a balancing act—one that requires that harvesting options remain viable while at the same time forest resiliency remains intact for long-term sustainability.

Including diverse opinions from harvesters in forest management decisions is important for long-term sustainability and resiliency of forested lands (Fisher 2002). Often low-income and minority groups may not have the interest or organizational, educational, or economic capacity to participate in forest management decisions that directly affect their lives and livelihoods and for the benefit of the forests they harvest. Moreover, many harvesters got a start in the commercial harvest of NTFPs in the United States due to events and forces set in motion by political forces. Therefore, immigrants often arrived in the United States lacking the skills demanded by a developed country's market economy. With few other options, they turned to what they knew best: earning a living from the land (Saechao and Wilmsen 2012).

Four major areas of concern to NTFP harvesters include lack of consistent access to harvesting sites, fluctuating prices, security and safety while collecting, and resource sustainability that will supply future harvests. Access to NTFPs is mediated by a variety of ecological, economic, structural, cultural, historical, and political concerns. Permitting and leasing are two very common ways of allowing access to harvesting areas. Public and private landowners do both.

Mediation of access is a function of the lower socioeconomic positioning of some groups of NTFP harvesters. In California, Oregon, and Washington, e.g., harvesters of matsutake mushrooms, huckleberries (*Vaccinium* spp.), and floral greens are ethnically diverse and many are recent immigrants with limited English proficiency and low incomes. There are essentially two ways that they are organized as workers: as independent contractors, or employees of a business. When they are independent contractors, they buy permits, lease land, or contract with landowner(s) (as sharecroppers or some other arrangement) to gain access to harvesting areas. They may hire employees to harvest the NTFP, or harvest it on their own or together with family members and/or friends, and sell their harvest to a buyer. Employees work for someone who acquires the needed permits, leases, or contracts, and are paid by the hour or piece.

The way in which control of land and resources is structured affects harvester access to NTFPs. In the floral greens industry in the Pacific Northwest, e.g., brush shed operators (the people who buy greens directly from the harvesters) have increasingly controlled leases. This is due in part to the fact that low-income harvesters typically do not have the capital needed to pay the up-front costs, such as bonding insurance and rent paid in advance, needed to lease land. Under these circumstances many floral greens harvesters, especially recent immigrants from Latin America, are dependent on brush shed owners or agents who sublet from them for transportation and the sale of their product. The sublessees, referred to by the Spanish term *raiteros* (van owners), transport the harvesters to and from the leased land and take them to the brush shed that holds the lease to sell their product at the end of the day.

The *raiteros* charge the harvesters a fee for transportation services and may also charge them a percentage of the value of their daily harvest. Although the brush shed owners treat them as independent contractors, harvesters are not free to sell to any shed. They cannot afford to travel to alternative buyers often in more distant locations, nor do they have access to market and price information from which they can make selling decisions. This means that they must accept the price the leasing brush shed offers them. Many harvesters fear retaliation if they speak publicly or complain to the authorities about being taken advantage of or poor working conditions. A lack of law enforcement means that working conditions may remain dangerous (McLain and Lynch 2010).

Public land agencies' traditional approach to gathering information for proposed management actions may also affect access to harvesting sites. This process often excludes stakeholder groups that lack formal organizational structures, and members of these groups rarely have the financial ability or time to participate in forest decisionmaking (McLain 2002). Nongovernmental organizations have been useful in bridging these gaps to assist disadvantaged groups in overcoming these barriers. Responsiveness of agency officials can help as well. To address these issues and be responsive to forest communities as well as improve access to national forest land, the USDA Forest Service 2012 Planning Rule (National Forest System Land Management Planning of 2012) and its directives are designed to enhance public outreach so that land management decisions factor in public inputs. In many parts of the country, the Forest Service also reaches out to ethnic minorities in appropriate languages to ensure critical communications and needs are addressed. The 2012 Planning Rule, which explicitly calls for collaborative planning, may provide for expanding the breadth of stakeholder involvement in forest management decisions.

Conditions in the floral greens industry differ markedly from those in the harvest of wild mushrooms. Buyers of wild mushrooms never gained control of land and leases as their counterparts in the floral greens industry did. Moreover, most wild mushroom harvesters are United States citizens or legal residents and therefore are less fearful of retaliation. These differences in the structures of the floral greens and wild mushroom markets prevent large mushroom-buying companies from gaining as much control over the market, as well as access to harvesting sites, as large floral greens companies have (McLain and Lynch 2010).

Cash flow and overhead costs are economic factors that mediate access to NTFPs. Large numbers of harvesters often begin the harvest season with little cash to spare, and thus are very sensitive to changes in permit prices, campground fees, and other expenses. Commodity prices are clearly a major concern to NTFP harvesters because the price they receive for their products determines their income. To the extent that harvesters of floral greens who are dependent on *raiteros* are not free to find the highest price for their product, their annual incomes are lowered. The seasonality of NTFP harvests means that many harvesters of wild mushrooms and other NTFPs depend on intense harvesting activity during only a few months of the year to earn a large portion of their annual household income. Some mushroom harvesters follow the different seasons around western United States and thus spend most months of the year harvesting some type of mushroom (e.g., morels, matsutake, chanterelles). Many also pick huckleberries during the late summer and early fall. Many of these harvests may be under-reported, as collection data rely on the honesty of harvesters, who may be wary of oversight and regulation.

Security and safety are also major concerns of harvesters. These concerns include confrontations with other harvesters, robbery, and theft. There are tensions between commercial, personal use, and cultural harvesters, and these can sometimes lead to confrontations between harvesters. There have been cases of harvesters being robbed of their day's harvest at gunpoint. Theft of floral greens occurs when harvesting on a lease without permission or harvesting on public lands without permits (Welch 2006). In the case of salal on private land, thieves often harvest at night. In the early light of dawn, they bring trucks in to haul away the greens before the lessee arrives for work. While it is not clear how often this occurs, it is a significant enough concern for harvesters to bring it up without being prompted.

Addressing the major concerns of harvester communities is a key step in mediating the disconnect between harvesting communities and land managers. Access to harvesting sites, information about price variability, security and safety, and resource sustainability are major concerns of NTFP harvesters. However, many harvesting communities may be marginalized, due to employment and income, language challenges, or cultural barriers (Emery and Barron 2010, Fortmann and Ballard 2011, McLain 2002, Watson 2010) and therefore lack formal outlets for participating in forest management decisions.

These decisions, however, directly affect the lives and livelihoods of harvesting communities as well as the sustainability of the forest. Therefore, building and improving communication between landowners and harvester communities are critical, as are developing and implementing NTFP policy and management to ensure resiliency and good stewardship on forested lands.

5.5 Urban Harvesting and Social Justice

A diversity of urban spaces support NTFP harvesting opportunities, including city parks, institutional campuses, vacant lots, cemeteries, and other locations (Hurley et al. 2015, Jahnige 2002; McLain et al. 2014). Beyond selected urban areas (i.e., Seattle, WA; Philadelphia, PA; New York, NY) featured in a limited number of studies (Hurley et al. 2015, McLain et al. 2014), research on suburban and rapidly urbanizing areas is also generally lacking (see Grabbatin et al. 2011; Hurley et al. 2008, 2013; and Gianotti and Hurley 2016, for exceptions).

Researchers are paying increased attention to the role that diverse species in the forests of urban, suburban, and urbanizing United States play in meeting the material and cultural needs of residents. Studies, though limited, are documenting the diversity of plant species, range of plant parts, types of uses, motivations for harvest, and the importance of these harvests to diverse peoples living in the cities being studied. Studies have been completed in Seattle, WA (McLain et al. 2012; Poe et al. 2013, 2014), and Philadelphia, PA (Gabriel 2006, Hurley et al. 2015), as well as Baltimore, MD, Washington, DC, and Boston, MA (Jahnige 2002). These studies reveal that harvesters collect common weeds, including many invasive species, from native, nonnative, and invasive shrubs and vines and from many native, ornamental, and nonnative trees. Public and private lands, including actively managed (i.e., public parks and institutional campuses) and largely neglected spaces (i.e., vacant lots), provide an abundance of harvesting opportunities for harvesters. These harvests provide residents with foods, medicines, and materials that support their everyday needs or are part of their regular recreational endeavors (McLain et al. 2014).

Our understanding of NTFPs within United States cities is still in its infancy. For example, while analyses of species have been completed for some United States cities, with some analysis of the ecosystem service benefits, no studies have assessed the range of provisioning or cultural services associated with the full complement of species occurring within cities. However, analyses of New York City's urban tree inventories and vegetation databases reveal 553 tree, shrub, and understory plant species representing more than 1,100 uses. Most of the species with one or more uses are native, while a significant minority of species—particularly herbaceous species—are nonnative. Whether native, nonnative, or invasive, many species are abundant, although species abundance and distributions within urban greenspaces are uneven throughout the city (figure 5.1).

Most research on urban NTFPs has focused on documenting the range of species that are being harvested, the diversity of peoples engaged in harvesting, motivations for harvesting, places where harvesting occurs, and uses of species targeted (Community Resources 2000; Hurley et al. 2015; Jahnige 2002; McLain et al. 2012, 2014; Poe et al. 2013, 2014). In Seattle, qualitative interviews with NTFP harvesters revealed that 433 plant species and 53 species of fungi are gathered (Poe et al. 2013). A number of species, such as Himalayan blackberry (*Rubus armeniacus* Focke), were commonly mentioned as targeted, whereas species such as salmonberry (*Rubus spectabilis* Pursh) and stinging nettle (*Urtica dioica* L.) were identified as culturally distinct species harvested by Coast Salish native communities. In addition, other species were preferred by particular cultural groups: chestnuts, watercress, pennywort, and plantain for Korean, Hmong, Vietnamese, and Cambodian gatherers; hawthorn fruit for Eastern European collectors; amaranth for Mexican households; and plums and various types of mushrooms for Russian gatherers (Poe et al. 2013). Similarly, research in New York City is finding that several species are particularly important to Chinese immigrants, including ginkgo nuts (*Ginkgo biloba* L.), black mulberries (*Morus nigra* L.), mugwort (*Artemisia vulgaris* L.), and common dandelion (*Taraxacum officinale* F.H. Wigg). Interviews with this immigrant group revealed an additional 49 foraged species, of which 12 are mushrooms, one is a seaweed, another 25 are herbs, five are shrubs, and six are trees. In Philadelphia, PA, engagement with NTFPs by new groups that organize through social media is on the rise (Hurley et al. 2015). In-depth interviews with 38 members of this group and other NTFP harvesters revealed that 160 plants and four species of fungi are gathered. Providing a food source is

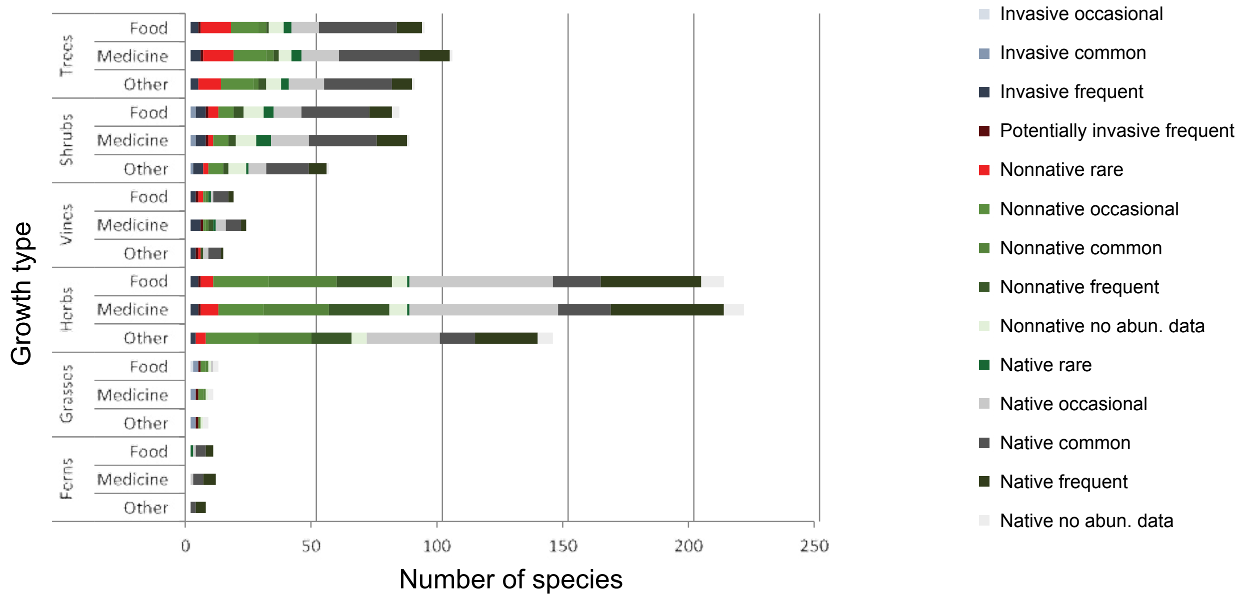

Figure 5.1—Potentially forageable species found in New York City by growth type, types of use, status, and abundance. Status and abundance in the region as per the New York Metropolitan Flora Project. (Source: Brooklyn Botanic Garden 2016.)

a dominant reason for harvesting, but some collect raw materials for basketry and other NTFPs and a minority sell items harvested from city parks and other areas.

These qualitative studies point to particular urban spaces, such as city parks, institutional campuses, vacant lots, and cemeteries, as key sites that support the forest, shrub, and understory vegetation that create opportunities for NTFP harvest in cities. Parks and recreational trails are particularly important to NTFP harvesters in the Philadelphia area, e.g., with social meet-up groups regularly organizing hikes in parts of the city's parks to learn about useful species and their NTFP values (Hurley et al. 2015). Importantly, limited observations suggest the reactions of municipal governments to these practices may differ markedly. Whereas Seattle policymakers have worked to embrace some aspects of foraging (Floberg et al. 2013), including through new policy language in the city's stewardship plan, managers in the Philadelphia area see NTFP harvesting activities as a threat to park resources (Hurley et al. 2015).

The harvesting of NTFPs is not limited to urban areas, but also takes place in suburban areas (Hurley et al. 2015, Robbins et al. 2008). Drawing on qualitative interviews with "Wild Foodies," research in the Philadelphia metropolitan area suggests that parks, greenways, and trails, as well as institutional campuses, are key to NTFP opportunities. However, as with the urban context, the legality of foraging within parks in the Philadelphia metropolitan area spans a spectrum, ranging from the harvest of berries and nuts in limited quantities for personal use, principally on lands managed by the Commonwealth of Pennsylvania (e.g., state game lands, state parks) to outright prohibition in county, municipal parks, and on private land trust reserves (Hurley et al. 2015).

Many formerly rural portions of the country are rapidly urbanizing at densities ranging from urban to exurban (Brown et al. 2005). Research is generally lacking on the status of NTFPs in rural areas experiencing diverse types of urbanization. A major exception is the work on sweetgrass (*Muehlenbergia sericea, M. capillaris*, or *M. filipes*)[3] basketry among African Americans living in the South Carolina lowcountry (see Grabbatin et al. 2011; Hart et al. 2004; Hurley et al. 2008, 2012). This work highlights similarities in the situation of rural NTFP users with regard to stable NTFP supplies in other areas of the country (Emery 2002), including the extent to which changing patterns of land tenure, ownership, and management play roles in shaping access to key NTFPs. For sweetgrass basketmakers in the greater Charleston area, urbanization has meant changes in patterns of supply for and access to the three key materials that are traditionally harvested from area forests and *de facto*

[3] Note: The common name "sweetgrass" is used to refer to *Muhlenbergia filipes*, not to be confused with *Hierochloe odorata* (Alpine sweetgrass).

resource commons: blades of sweetgrass, palmetto fronds (*Sabal palmetto*), and longleaf pine needles (*Pinus palutris*). Decades of suburban development have contributed to a decline in the ecological conditions that produced relatively abundant supplies of sweetgrass.

Some key questions have emerged about the social justice aspects of continued access to NTFPs that support cultural and material relationships to forested ecosystems in urban environments. Indeed, urban forested ecosystems are key to the cultural and material practices of diverse peoples who have been marginalized within natural resource and land use decisionmaking processes. The cases of African American basketmakers in the greater Charleston area of the South Carolina lowcountry (Hurley et al. 2008) as well as American Indians in the Seattle area (McLain et al. 2012) illustrate social justice dimensions raised by questions of access to NTFPs in United States cities. Similar issues are at play in other areas of the country, where the traditional relationships of native peoples to plants for material needs and cultural uses are seen as potentially out of place in urbanizing areas (Matthewson 2007). Longstanding uses may be threatened by regulatory dynamics on public lands and changes to social-ecological dynamics on private lands, including those uses that support household economies and food security. Changes in ownership patterns, land use, and land management, however, represent opportunities for and challenges to the continuation of these practices (Grabbatin et al. 2011, Hurley et al. 2013, Poe et al. 2014). For example, the inclusion, principally, of sweetgrass and, to a lesser extent, other species associated with sweetgrass basketry within ornamental landscape plantings in the common areas of residential and commercial development in the Greater Mt. Pleasant, SC, area has contributed resource supplies to these livelihood users. Likewise, new efforts within Seattle to incorporate NTFP foraging perspectives into local policy documents as well as to develop new food forests and public urban orchards suggest proactive efforts to deal with the needs and desires of NTFP users.

Quantitative research on NTFP harvesting in urban areas confirms qualitative work, while suggesting that issues related to access and land-use change may extend to more than just distinct cultural groups. In the survey carried out by Robbins et al. (2008), most respondents were Caucasian, college-educated, in the highest income brackets, and lived in the city. Robbins and coauthors concluded that NTFP harvesting is a practice that transcends socioeconomic background and involves diverse individuals entering environments around them to gather products for their own purposes, directly using and consuming plants. Further, the authors note that "in the absence of significant Federal lands in the New England region, moreover, this body of gatherers is harvesting from private lands, roadsides, city parks, and other areas" (Robbins et al. 2008, p. 272).

Continued research on urban and suburban NTFPs needs to focus on shifting perceptions of urban forests and green spaces. Most analyses are qualitative and limited to a small number of cities, primarily in the Eastern United States. Most focus on species being harvested and their uses, the people engaged in harvesting and their motivations, and identifying where harvesting occurs (Community Resources 2000; Hurley et al. 2015; Jahnige 2002; McLain et al. 2012, 2014; Poe et al. 2013, 2014). Urban and suburban harvesting present an important and emerging area for research on NTFPs in the United States.

5.6 Key Findings

- In some regions of the United States, as much as 16–36 percent of people have harvested NTFPs for primarily personal use.
- People of all ages, incomes, and ethnicities harvest NTFPs outside of formal markets, whether harvesting on public or private land.
- Harvesting, preparing, and using NTFPs connect people directly and materially to forests and are sources of social and cultural capital.
- NTFPs are harvested in landscapes from urban to wildland environments.
- Including diverse harvesters in forest management decisions may enhance the long-term sustainability of NTFPs.

5.7 Key Information Needs

- National baseline data on NTFP harvesters are needed as a basis for monitoring NTFP use in an era of changing climate.
- Enhanced understanding is needed to address barriers to participation in NTFP management planning for diverse harvesters, particularly those least likely to participate in formal consultation processes.
- Additional information is needed to understand the social, ecological, and governance implications of foraging in (sub)urban landscapes.

5.8 Conclusions

The research reviewed in this chapter suggests a number of conclusions about the social dimensions of NTFP harvesting in the United States. First, NTFPs provide social and cultural capital and economic capital. Studies on harvester demographics demonstrate that many people gather NTFPs outside of formal markets (Butler 2008, Cordell et al. 2012). Harvesting, preparing, and using NTFPs connect people directly and materially to forests (Emery et al. 2006, Robbins et al. 2008). Second, data show that harvester demographics cross social categories of age, gender, ethnicity, and income.

Continued research on harvester populations across the United States is high priority. Also there is an urgent need to examine variation in NTFP knowledge and stewardship practices among harvesters. Governance structures will function best when they are grounded in realities of NTFP gathering systems. This will include recognizing and accommodating people who gather and use NTFPs outside of formal economic markets, while being informed by labor and economic structures of formal NTFP markets. Resource users are in direct contact with forest resources and local knowledge may bolster the effectiveness of management on public and private lands.

Opportunities exist to increase the effectiveness of NTFP monitoring and management by enhancing communication and cooperation between stakeholders and land managers. Special attention will be needed in such efforts to reach out to populations frequently absent from natural resource decisionmaking processes.

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CHAPTER 6

Economics of Nontimber Forest Products

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6.1 Introduction to Economics of Nontimber Forest Products

Nontimber forest products (NTFPs) encompass a broad variety of edible, wood-based, decorative, and medicinal goods derived from various plant and fungus parts (Chamberlain et al. 1998). NTFPs provide significant economic benefits to users in the United States; however, many of these values have not been systematically researched or quantified (Alexander et al. 2001). Interest in assessing the economic value, impact, and potential of NTFPs surged in the 1990s and early 2000s probably in part because of controversies over the impact of timber harvest on endangered species and other conservation priorities; NTFPs seemed like a way to generate income and maintain standing forests (Robbins et al. 2008). Research in the United States and transferable knowledge from other countries provide an important baseline of evidence. However, these diverse studies typically address individual species at a specific location at a single point in time. They may have divergent or even contradictory findings. Furthermore, there are very few data consistently collected over time regarding NTFP harvest, trade, and consumption. This chapter is an attempt to synthesize the knowledge of the economics of NTFPs, but when necessary we utilize individual studies or data points from specific regions, which while not generalizable to the Nation as a whole, can be seen as illustrative or suggestive.

NTFPs, as well as their harvesters, traders, and consumers, have very diverse characteristics:

- NTFP collection, trade, and consumption have important values for individual households (micro) and the overall economy (macro).
- NTFP collection, consumption, and trade may involve monetary transactions (market) or no monetary transactions (nonmarket).
- Monetary trades may be through formal or informal markets.
- NTFPs may be wild-harvested from natural forests, forest farmed (chapter 2), or produced by other methods. Wild-harvested products have limited production costs for the harvester, while forest farming follows a more traditional investment-return model.
- Individuals may be influenced to begin wild-harvesting or forest farming by an array of factors including their own personal circumstances (internal) and the outside economy, markets, culture, and geography (external).

Because of this diversity, any synthesis of the economics of NTFPs must include various interpretive frameworks and analytical approaches.

This chapter is organized around micro/macro and market/nonmarket attributes (figure 6.1). Section 6.2 examines the overall monetary value of NTFPs, in terms of prices and quantities traded, in regional markets (market, macro). Section 6.3 explores the valuation of broader benefits of NTFPs not traded in markets (nonmarket, macro). Section 6.4 discusses financial returns from production of NTFPs on individual farms/woodlots (market, micro). Section 6.5 considers how NTFPs contribute to the well-being of households other than direct income (nonmarket, micro). The following sections consider two topics that span these areas: the factors that are correlated with NTFP harvest and production (section 6.6), and identification of potential economic impacts from climatic variability that are related to NTFPs (section 6.7).

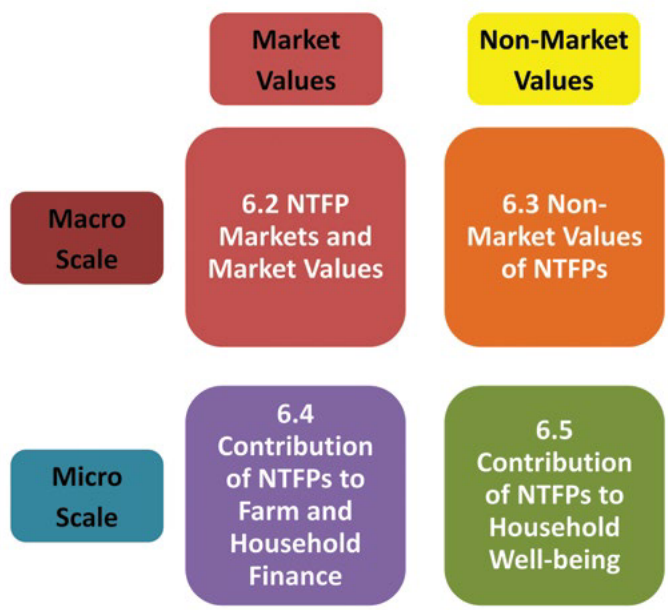


Figure 6.1—Principle sections of Chapter 6: Economics of Nontimber Forest Products. (Source: Greg Frey, U.S. Department of Agriculture, Forest Service, Southern Research Station.)

6.2 Markets and Market Values

Much of the early economic research on NTFPs in the United States focused on describing the products, characterizing their markets, assigning monetary values, and estimating the contribution of the industry to regional economies. Schlosser et al. (1991) and Schlosser and Blatner (1995) were among the first peer reviewed articles published pertaining to production of and markets for NTFPs in the Pacific Northwest. Blatner and Alexander (1998) reported additional information on NTFP price trends in the Pacific Northwest. Although additional work has been published for NTFPs and regions since the early 1990s, there is relatively little market information available for these products over time. The only notable exception to this is the recent work by Alexander et al. (2011b), which compiled the first national assessment of indicators related to NTFPs in the United States. This work is being updated (Chamberlain et al. 2018) as part of the United States responsibility to report on the state of forests for the Montreal Process (Alexander et al. 2011b). While these studies provided the first national-level summary data on the overall NTFP industry, they are at best an approximation, given largely undocumented nature of much of the industry.

There are several key questions that must be answered in assessing NTFP markets and market values. Among these are: "What do we know about the industry?" and "What are we likely never fully to understand?" To date, we have compiled a basic understanding of the overall industry, the markets and the distribution channels; however, we have very little understanding of yearly fluctuations in the markets or the major factors influencing them. Further, there is an unwillingness to share detailed information on the part of harvesters, buyers, and companies engaged in the industry. Early research on NTFPs viewed the products and industry through the lens of traditional commodity markets (Schlosser et al. 1991, Schlosser and Blatner 1995); however, later research has pointed out that this characterization may not be well suited for some NTFPs. There are harvest, sales, trade, and cost data on some specific products classified as NTFPs, such as American ginseng (*Panax quinquefolius* L.) root, sugar maple (*Acer saccharum* Marshall) syrup, and wild blueberries (*Vaccinium* L. spp.; figure 6.2). However, many NTFPs are difficult to value or track through various sales points from harvest to consumption, such as wild edible fungi (Alexander et al. 2011a).

Figure 6.2—Wild blueberries (*Vaccinium* spp.) are one of the few nontimber forest products tracked by the National Agricultural Statistics Service (NASS). Populations of this species are managed, not cultivated. Maine is the major producer of wild blueberries in the world, producing more than 90 million pounds in 2012. (Photo credit: David Yarborough, University of Maine.)

Furthermore, production methods and markets can shift over time, so economic research that values economic impacts at a single point in time may not be a reliable estimate for understanding future market values and markets. As an example, the harvest and sale of noble fir (*Abies procera* Rehder) boughs for holiday greenery has changed dramatically over the past decade. Historically, noble fir boughs from high elevation sites were considered of superior post-harvest quality compared to boughs from low elevation sites. This preference stems, in part, from the need for a period of cold temperatures prior to harvest to enhance needle retention. However, availability of higher-elevation material has declined due to the increasing size and age of noble fir stands established after the eruption of Mt. Saint Helens in 1980. This caused a shift to the boughs produced as a part of Christmas tree operations on lower elevation sites.

These issues are compounded by the fact that many NTFPs can be part of a complex informal economy, particularly at early stages of the various commodity chains, at harvest and first point of sales.

6.2.1 Formal Markets

National accounting of NTFPs likely will underestimate the amount of production and the contribution of NTFPs to broader economic indicators because much of the economic activity is informal. However, some NTFP businesses in the United States are accounted for through official reporting channels. For example, data on businesses are collected annually by the Statistics of U.S. Businesses (SUSB) program (U.S. Census Bureau 2016), compiling results from various sources including administrative records, such as tax records, and census surveys.

Businesses are classified according to industrial category through the North American Industrial Classification System (NAICS). In the 2012 SUSB (U.S. Census Bureau 2016), many formal NTFP businesses were categorized in the six-digit NAICS code 113210, “Forest Nurseries and Gathering of Forest Products” (box 6.1). However, there were some significant NTFP activities that were not included in this list, including gathering tea and maple syrup production, which is in NAICS 111998. Also, data on agricultural businesses including some tree nut and maple syrup production businesses were not gathered by SUSB, but rather by the USDA, National Agricultural Statistics Service. Finally, some businesses that were not

BOX 6.1
NONTIMBER FOREST PRODUCT HARVESTING ACTIVITIES COVERED BY NORTH AMERICAN INDUSTRIAL CLASSIFICATION SYSTEM (NAICS) CATEGORY 113210:
Forest Nurseries and Gathering of Forest Products. This category includes many, but not all, NTFP production activities. It also includes some activities, such as forest nurseries, which are excluded from most definitions of NTFPs.

- Aromatic wood gathering
- Balsam needles gathering
- Bark gathering
- Cherry gum, gathering
- Chestnut gum, gathering
- Forest nurseries for reforestation, growing trees
- Gathering of forest products (e.g., barks, gums, needles, seeds)
- Gathering, extracting, and selling tree seeds
- Ginseng gathering
- Gum (i.e., forest product) gathering
- Harvesting berries or nuts from native and noncultivated plants
- Hemlock gum gathering
- Huckleberry green gathering
- Moss gathering
- Nurseries for reforestation growing trees
- Pine gum extracting
- Spanish moss gathering
- Sphagnum moss gathering
- Spruce gum gathering
- Teaberries gathering
- Tree seed extracting
- Tree seed gathering
- Tree seed growing for reforestation

necessarily NTFP-related, such as tree nurseries, were included in NAICS 113210. Thus, while the data are not ideal, they allow a suggestive basic mapping of NTFP businesses and other businesses like nurseries (figure 6.3).

According to the 2012 SUSB data (U.S. Census Bureau 2016), 182 businesses carried out activities classified under NAICS 113210. Total receipts for this category were $226 million in 2012. The map of business receipts by state supports observations from elsewhere in this assessment that significant NTFP economic activity is centered in the Southeast, the Upper Midwest, and the West Coast (figure 6.4).

Since NTFPs are so varied, no one classification scheme in use adequately summarizes production of this "sector," so to gain a clear understanding of the patterns of NTFP production from the various statistical services it is necessary to combine data from different sources. There are clearly gaps in the data and much room for improvement to summarize business data on NTFPs for the United States. While the SUSB tracks businesses with employer identification numbers and payrolls, it is likely that many businesses involved in NTFP production are seasonal, or are nonemployer businesses. As mentioned, a number of NTFPs were recorded as specialty crops in the Census of Agriculture. Finally, because the NAICS code that most adequately describes NTFPs also includes forest nursery industries, which are not NTFPs, some regions of the country, such as the Southeastern United States, appeared as higher-producing regions than may actually be the case.

6.2.2 Informal Markets

"Informal economies refer to unregulated or undocumented markets or labor activities in an environment where similar activities are regulated" (Alexander et al. 2002b, p. 116). Workers in the informal economy tend to have characteristics referred to as "downgraded labor." Specifically they tend to receive lower incomes (frequently in the form of cash), with few if any benefits, and experience difficult working conditions. These individuals tend to work in the informal economy due to a lack of other options. Some factors that contribute to the choice to work in an informal economy include: documented and undocumented immigration status of employees, unemployment in other sectors, and limitations due to language or education (McLain et al. 2008). Conversely, these same jobs provide workers with otherwise limited opportunities the chance to improve their socioeconomic position over time and move into more traditional labor markets. These and other factors make this type of economic activity very difficult to document and characterize.

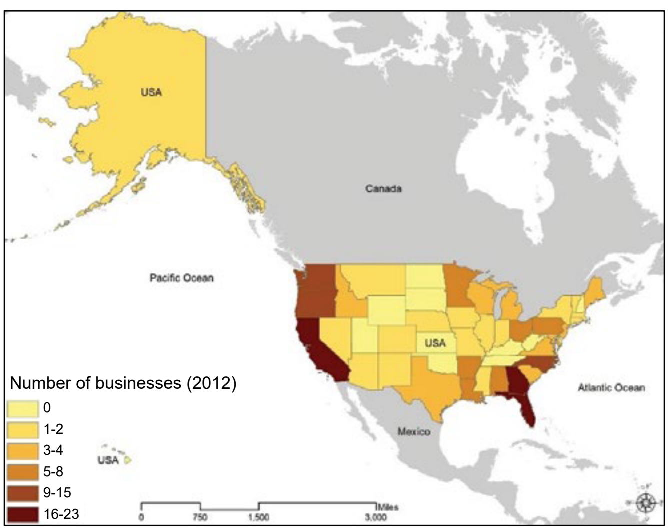
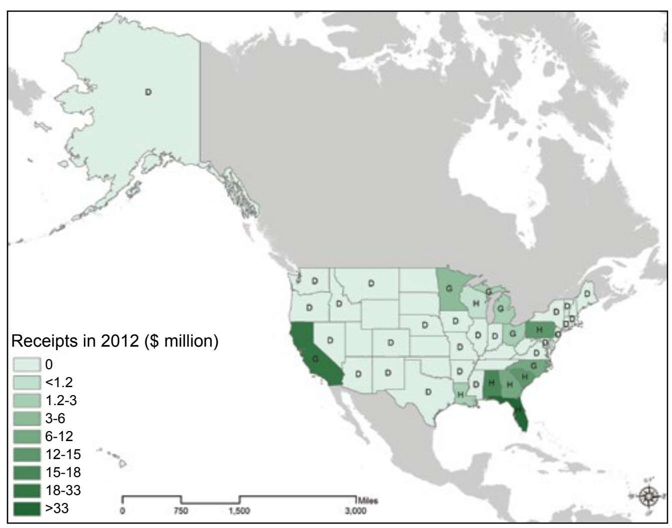


Figure 6.3—Concentration and distribution of firms classified under North American Industrial Classification System (NAICS) 113210: Forest Nurseries and Gathering of Forest Products in 2012. The total number of establishments in the United States was 182 in 2012. (Source: U.S. Census Bureau 2016.)



Notes:
D: Data withheld and value set to 0 to avoid disclosing data about individual businesses; data are included in higher level totals.
G: Low noise applied to cell value (0 to <2%).
H: Medium noise applied to cell value (2 to <5%).

Figure 6.4—Receipts ($U.S. millions) by state of firms classified under North American Industrial Classification System (NAICS) 113210: Forest Nurseries and Gathering of Forest Products. The total receipts for the entire United States was $226 million in 2012. See map notes for information about flag codes. (Source: U.S. Census Bureau 2016.)

Due to the constraints on tracking NTFP economics activity, Alexander et al. (2011b) developed an indirect measure of the industry's contribution to the economy based on the number of Forest Service and U.S. Department of the Interior, Bureau of Land Management (BLM) permits and contracts along with a number of basic economic assumptions based on input from key informants and broader economic rules of thumb about wholesale and retail price markups. These Forest Service and BLM permit and contract data are the only national-scale harvest and first point of sales data available on the majority of NTFPs in the United States.

Chamberlain et al. (2018) updated the analysis of Alexander et al. (2011b). They estimated the total wholesale value of wild-harvested landscaping materials, crafts and floral materials, regeneration and seed items, edible fruits, nuts and sap, grass and forage, and herbs and medicinal plants in the United States from 2004 through 2013 (table 6.1). The total wholesale value of these products ranged from a low of $160.6 million in 2009 to a high of $344.2 million in 2007.

6.2.3 Examples of Economic Impact by Region and Species

American ginseng may be the most well understood medicinal NTFP from the Eastern United States. Ginseng roots have been marketed from eastern hardwood forests since the late 1700s. Ginseng harvest migrated south as plant populations declined in Canada due to over-harvesting. Today, harvesting of wild ginseng in Canada is illegal. American ginseng moves through the market from either wild or cultivated sources. The roots can enter the formal economy or remain as part of an informal economy.

Because American ginseng is listed in appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), harvest data for wild roots destined for export have been collected by state agencies at the county level (table 6.2) since 1978. Market price data are somewhat more difficult to acquire, relying primarily on surveys of local dealers. Davis and Persons (2014) report high and low prices for wild ginseng paid to harvesters from 1982 to 2013

Table 6.1—Estimated wholesale value of wild-harvested nontimber resources in the United States. Assumes Forest Service and Bureau of Land Management (BLM) sales receipts are 10 percent of first point-of-sales value, that U.S. forest sales represent approximately 20 to 30 percent and BLM sales represent approximately 2 to 15 percent of total supply, and that first point-of-sales value is 40 percent of wholesale price. Reproduced from Chamberlain et al. (2018) with authors' permission.

Product category	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	million 2013 U.S. dollars									
Landscaping	29.2	25.7	25.6	25.0	20.1	4.7	9.6	8.2	6.7	6.9
Crafts and floral	124.0*	103.1*	199.9*	234.0*	92.8*	96.8	155.5	150.3	150.6	172.5
Regeneration and seed	3.0	5.4	4.2	2.8	9.1	11.0	4.5	9.3	5.9	12.3
Edible fruits, nuts, and sap	71.4	37.2	47.2	48.7	83.3	45.1	71.1	55.5	62.1	76.8
Grass and forage	29.2*	37.5*	32.8*	30.7*	24.7*	0.02	2.1	0.3	0.5	26.9
Herbs and medicinals	2.5	1.9	1.9	3.0	6.0	3.0	4.3	5.0	5.2	4.2
Subtotal	**259.3**	**210.9**	**311.5**	**344.2**	**236.1**	**160.6**	**247.1**	**228.7**	**231.1**	**299.6**
Posts and poles	49.5	34.3	37.6	30.5	24.1	23.1	21.2	20.9	28.6	23.4
Christmas trees	188.1	196.3	36.5	152.8	133.5	42.7	172.6	126.5	123.9	119.2
Fuelwood	391.9	370.8	418.3	440.7	498.7	564.1	571.6	559.5	517.4	520.3
Non-convertible	11.9	24.4	30.9	18.1	7.3	2.7	4.7	8.0	0.8	0.8
Total[a]	**900.6**	**836.6**	**834.8**	**986.2**	**899.7**	**793.1**	**1,017.1**	**943.5**	**901.7**	**963.3**

[a] Numbers may not add to totals due to rounding.

* 2004–2008 have common beargrass included as grass and forage instead of crafts and floral.

Table 6.2—Wild American ginseng harvest quantity for export from the 19 States certified by U.S. Fish and Wildlife Service (pounds dry weight), 2000–2013. Source: data provided by U.S. Department of the Interior, Fish and Wildlife Service. Low and high prices in 2013 real dollars per dry pound paid to harvesters, as reported by dealers. Source: Davis and Persons 2014.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Alabama	256	874	457	1,025	749	221	760	317	717	1,345	474	453	476	626
Arkansas	534	927	2,073	2,632	1,770	504	927	989	1,190	1,796	1,195	487	238	1,407
Georgia	311	706	266	426	263	402	167	280	406	293	212	158	361	346
Illinois	3,890	2,912	1,895	2,860	2,506	1,157	2,230	2,013	2,845	3,805	3,650	2,890	992	2,636
Indiana	6,273	7,048	3,192	6,915	4,819	1,498	3,325	2,807	4,623	6,478	3,447	3,270	1,883	4,670
Iowa	948	784	798	566	395	—	609	1,473	776	768	798	884	273	299
Kentucky	16,216	22,765	15,085	22,583	16,717	9,392	13,713	11,345	11,839	19,246	15,041	13,176	15,276	20,025
Maryland	2,270	904	110	109	159	96	62	148	74	196	143	141	153	126
Minnesota	1,517	1,303	1,642	1,451	1,224	1,250	735	1,093	485	577	1,184	463	500	602
Missouri	1,585	1,602	2,498	2,362	1,612	2,266	1,580	1,224	1,756	1,916	1,098	1,743	780	1,387
New York	1,149	753	483	684	622	603	287	453	413	401	541	512	351	856
North Carolina	8,415	6,788	8,790	6,548	4,271	5,602	7,060	12,378	11,402	10,513	8,041	9,716	8,765	7,849
Ohio	3,757	3,254	3,059	4,557	3,958	3,311	2,264	3,066	3,626	4,942	3,418	3,752	2,676	5,775
Pennsylvania	1,733	1,441	1,725	927	1,100	1,158	1,448	1,642	1,281	1,719	1,370	827	1,324	1,768
Tennessee	8,164	8,737	5,815	10,826	8,690	5,280	8,153	8,695	8,435	14,642	11,464	9,322	10,145	13,867
Vermont	205	119	184	116	112	49	77	114	127	129	160	147	180	144
Virginia	5,731	3,821	3,810	4,675	3,435	1,571	2,878	3,050	2,918	4,081	3,610	3,856	4,751	4,370
West Virginia	8,612	5,409	5,207	7,175	5,891	4,833	4,590	4,151	4,780	7,646	5,634	4,920	4,659	7,161
Wisconsin	3,685	2,491	2,581	1,690	1,945	1,603	2,145	2,401	2,087	2,495	2,409	1,989	1,290	1,606
Total harvest	**75,251**	**72,638**	**59,670**	**78,127**	**60,238**	**40,796**	**53,010**	**57,639**	**59,780**	**82,988**	**63,889**	**58,706**	**55,115**	**75,892**
Low price	**$433**	**$289**	**$324**	**$380**	**$308**	**$298**	**$347**	**$449**	**$270**	**$380**	**$374**	**$331**	**$406**	**$600**
High price	**$676**	**$526**	**$647**	**$506**	**$617**	**$656**	**$693**	**$1,292**	**$1,082**	**$652**	**$1,175**	**$777**	**$1,268**	**$1,250**

(table 6.2). Chamberlain et al. (2013) estimated the average market value of wild American ginseng at $27 million, annually, for the period 2000 to 2007 (table 6.3).

The 19 states certified to export wild ginseng are the foundation of the market (table 6.2), though most of the volume comes from seven states: Indiana, Kentucky, North Carolina, Ohio, Tennessee, Virginia, and West Virginia (Chamberlain et al. 2013). Most of the wild-harvesting, as reported, happens in about 1,000 counties throughout the region. Harvesters, who live primarily in the local communities, market roots to regional, primary buyers who sort, grade, consolidate, and market larger volumes to national and international buyers. More than 95 percent of the volume is exported to China, making Asia the primary international market for wild-harvested American ginseng. Primary buyers paid wild-harvesters $462 on average for a pound of dried American ginseng root, during the years 2000 to 2007 (nominal $). Reports of three times this price are common. A pound of ginseng in the Chinese retail market could fetch thousands of dollars. The monetary value of cultivated ginseng is significantly less, as the visual value of the wild roots is much preferred (Chamberlain et al. 2013).

There have been regional studies of the impacts of NTFPs to local economies that provide examples of the economic impacts of NTFPs. By documenting the product market chains for several NTFPs in southwest Virginia, Greene et al. (2000) found multiple layers of players; from the producers, who are predominantly in the informal economy, to the international corporations that function in the formal economy. Medicinal NTFPs, such as black cohosh (*Actaea racemosa* L.), that are harvested from southwest Virginia forests support a local to global market (figure 6.5). The greatest demand for many medicinal NTFPs is beyond the borders of the United States. Europe and Asia command the

Table 6.3—Average annual revenue from American ginseng and hardwood timber harvest by State for 2000 to 2007. No data were available to estimate timber revenue for Minnesota. Source: Chamberlain et al. 2013.

State	Average annual ginseng harvest	Estimated ginseng revenue*	Timber revenue
	pounds	*thousand US dollars*	
Alabama	597	254	46,401
Arkansas	1,294	551	30,137
Georgia	353	150	9,401
Illinois	2,485	1,059	30,404
Indiana	5,267	2,244	75,251
Iowa	733	312	9,942
Kentucky	15,977	6,806	78,843
Maryland	482	205	7,079
Minnesota	1,277	544	
Missouri	1,841	784	81,739
New York	639	272	82,157
North Carolina	7,582	3,230	56,968
Ohio	3,458	1,473	55,216
Pennsylvania	1,385	590	228,374
Tennessee	8,045	3,427	137,345
Vermont	122	52	22,986
Virginia	3,632	1,547	73,176
West Virginia	5,736	2,444	150,099
Wisconsin	2,318	987	90,749
Totals	**63,222**	**26,931**	**1,266,266**

*Based on a nominal average price for the period 2000 to 2007 of $462 per pound (dried).

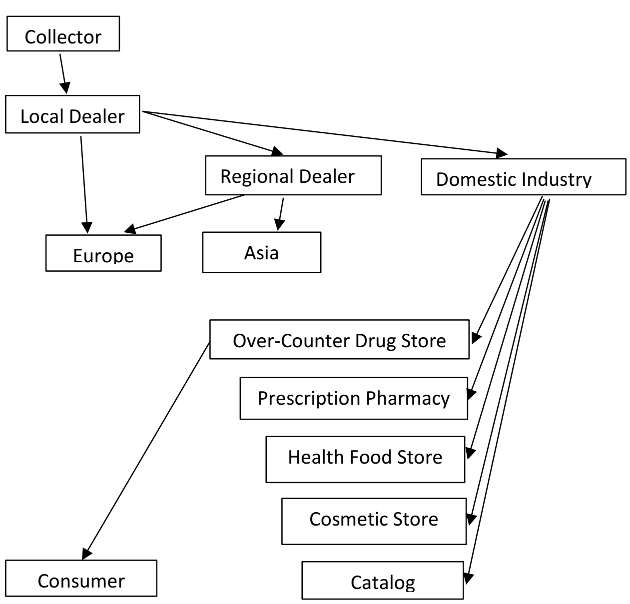


Figure 6.5—Market chain for medicinal and herbal nontimber forest products from southwest Virginia. (Source: Greene et al. 2000.)

largest market share for many medicinal NTFPs. Local dealers market to national and international entities that process market to the final consumer via retail outlets such as health food stores and big-box retailers.

Greenfield and Davis (2003) examined the markets for several medicinal, floral decorative, and culinary NTFPs in western North Carolina. The hardwood forests of southern Appalachia are the source of about half of the 175 native North American plant species, for the nonprescription medicinal market in the United States. Of the 20 or so plants tracked by American Herbal Products Association, more than three-fourths are native to Appalachia. The forests of western North Carolina are the origin for much of the market supply for more than 45 forest botanical products (FBPs) (Greenfield and Davis 2003). The analysis focused on the transitional period from an informal to a formal economy, and identified critical challenging issues. At the time of the Greenfield and Davis (2003) study, 65 dealers of NTFPs established the formal market. 54 dealers bought and sold American ginseng and other medicinal forest products, including approximately five firms located outside of North Carolina. Nine firms marketed galax (*Galax urceolata* (Poir.) Brummitt) and some of those marketed log moss, as well.

The selected western North Carolina NTFP markets originate with about 75 commercial harvesters. Greenfield and Davis (2003) also estimated the North Carolina and United States harvest quantity and market value in 2001 for several NTFPs, based on surveys of North Carolina NTFP buyers/dealers and review of national-level reports. A summary of estimates for four products (bloodroot [*Sanguinaria canadensis* L.], black cohosh [*Actaea racemosa*], American ginseng root, galax leaves) is given in table 6.4 (North Carolina harvest volumes). Much of the harvest volume of black cohosh is bound for Europe, where it is processed and consumed, or exported back to the United States to retail establishments. Similarly, Europe is the primary market for other medicinal NTFPs such as blue cohosh (*Caulophyllum thalictroides* (L.) Michx.).

Galax and three species of log moss (*Hypnum curvifolium* Hedw.; *H. imponens* Hedw.; *Thuidium delicatulum* (Hedw.) Schimp.), which in 2001 was harvested from seven counties in western North Carolina, are an important component of the floral market. Nine firms purchased galax leaves that were

Table 6.4—Estimated 2001 North Carolina and U.S. harvest quantity and value of selected nontimber forest products. Source: Greenfield and Davis 2003.

Product	Scientific name	Estimated NC harvest	Estimated NC harvest value	Estimated U.S. harvest	Estimated U.S. harvest value
		thousand			
		pounds	*2001 U.S. dollars*	*pounds*	*2001 U.S. dollars*
Bloodroot	*Sanguinaria canadensis*	2	20	135	1,890
Black cohosh	*Actea racemosa*	4	10	420	2,250
Am. ginseng	*Panax quinquefolius*	7	1,800	46	12,100
Galax*	*Galax urceolata*	4,000	10,000	4,000	10,000

*In the report, estimates for galax varied somewhat; values cited here are given as a conservative estimate.

picked primarily from public forests. The North Carolina market for ramps (*Allium tricoccum* Aiton) is less formally developed (Greenfield and Davis 2003). In 2001, ramps were marketed in North Carolina through farmers' markets, festivals, and roadside vegetable stands (Greenfield and Davis 2003). In that year more than 2000 pounds of ramps were harvested for annual festivals. Greenfield and Davis (2003) present price data for ramps sold in farmers' markets, but were unable to summarize volumes of the edible forest product marketed through various companies.

In the Southern United States, pine straw from longleaf (*Pinus palustris* Mill.), slash (*Pinus elliottii* Engelm.), or loblolly (*P. taeda* L.) is a valuable nontimber forest product (figure 6.6). These needles are raked, baled, and sold for use as garden mulch or as a landscaping ground cover. North Carolina, Florida, and Georgia are considered to be the leading pine straw states (Mills and Robertson 1991). Estimates for market value range from a 1996 pine straw value of $50 million in North Carolina (Rowland 2003) to a $79 million value for Florida in 2003 (Hodges et al. 2005). The state with the most detailed records regarding pine straw production is Georgia where data for pine straw are actually collected as a separate commodity. In 2012, pine straw accounted for 9.6 percent of Georgia's forest products market at $59 million (Wolfe and Stubbs 2013, p. 109–110).

Casanova (2007) found that landowners often work with a pine straw dealer to have their straw raked. A contract is developed between the two parties that outlines how and when the straw will be raked, along with details of payment. The pine straw dealer then works with a forest labor contractor who arranges for and manages the pine straw harvesters who actually conduct the work on the ground.

Blatner and Alexander (1998) provided prices for some of the most significant commercially harvested fungi in the Pacific Northwest. They estimated that as many as 36 species are traded commercially but *Boletus* spp., chanterelles (*Cantharellus* spp.), morels (*Morchella* spp.), and American matsutake (*Tricholoma magnivelare*) make up the bulk of the industry. The average price per pound paid to harvesters in the Pacific Northwest from 1992 to 1996 was $5.69 for *Boletus*, $3.26 for chanterelles, $5.04 for morels, and $14.08 for American matsutake. The size of the wild mushroom market in Washington, Oregon, and Idaho was estimated at $21.5 million in 1985 (McRobert 1985), and $41.1 million in 1992 (Schlosser and Blatner 1995). Alexander et al. (2002a) estimate a per-acre monetary value for matsutake mushroom fields of $139-$604 in 1997.

Muir et al. (2006) researched the quantity and market value of "moss" (a mixture of mosses and liverworts) harvested commercially from forests in the Appalachian and Pacific Northwest regions of the United States. These regions supply the vast majority of moss harvested for decorative purposes, as opposed to peat moss. The study explored both moss harvest under permits issued from the Forest Service and BLM, and amounts reported in export data. Moss harvest reflected in Forest Service and BLM permits were considerably less than those estimated from export data and assumptions about those data. This is likely due to several factors, including people harvesting from Federal lands without a permit, and harvest from other land ownerships such as private land in the Southeastern United States. Export data suggest the mean annual harvest from 1998 to 2003 was between 5,300 and 20,300 air-dry tons, and sales (domestic plus export) were estimated between $6 million and $165 million per year. The study illustrates how

Figure 6.6—Longleaf, slash, and loblolly pine needles are harvested for pine straw used in landscaping. In 2012, pine straw accounted for almost 10 percent of Georgia's forest products industry. (Photo credit: Becky Barlow.)

little is known about the moss trade in the United States and indicates that policymakers and land managers lack critical information to inform harvest regulation.

At a more local level, such as the village, county, or state level, NTFPs can play a major economic role. There is too much diversity to fully document here, but box 6.2 offers one such example. Given the importance of these products to local economies and the efforts and sometimes the struggles of public land managers and private landowners to manage access to them, we need to learn more about the importance of this highly complex and heterogeneous industry and its role in advancing the standard of living for those engaged in the harvest, processing, and sale of these products. We also need to develop a much more complete understanding of nonmarket values of NTFPs, including the recreational, cultural, and subsistence demand for these products.

6.3 Nonmarket Values of Nontimber Forest Products

While some NTFPs are traded in markets where data on volume and price can be collected, other NTFPs are produced and consumed in household production or traded in informal exchanges where the price and quantity harvested are not readily available. For NTFPs that are consumed by the harvester, or traded locally in an informal market, the value of the product harvested is difficult to estimate and nonmarket valuation techniques must be applied to provide an estimate of the quantity and the value of the harvest. This section provides a discussion of the nonmarket valuation of NTFPs.

6.3.1 Valuation Methodologies

There are a wide variety of methodologies to estimate non-market values from NTFPs. The two main approaches are revealed preference models and stated preference models. Revealed preference models estimate demand from consumer choices regarding nonmarket goods, and are usually based on surveys and/or secondary information on consumer choice such as housing prices. Revealed preference models include: travel cost, hedonic pricing, and household production models (Freeman 2003). Stated preference models estimate demand from surveys and experiments to construct a value for the good. These are based on consumers' reported behavior or simulations of behavior and not on the actual choices consumers make (Freeman 2003).

Research has demonstrated that NTFP harvesting can be an important part of the implicit value that resource users place on visiting forests, whether it is for recreational, subsistence, or other purposes (see Bowker et al. 2005, 2006, 2009; Maher et al. 2013; Starbuck et al. 2006). However, less research has explicitly quantified this value. A well-established method for evaluating and valuing nonmarket service flows from a forest is the recreation demand or travel cost method (TCM). TCM uses data collected from individual visitors, usually from an onsite or mail survey. It is assumed that the ability and preferences of individuals to visit NTFP harvest sites vary between individuals, but that a single person's preferences are consistent and can be measured. Values for the site in question are derived based on the premise that the distance traveled to recreate at the site is the shadow price of recreation to that site. The number of visits taken to the site is a function of prices, money income, and

BOX 6.2
CASE STUDY: **Nontimber forest product values on the Gifford Pinchot National Forest, Washington.**

The Gifford Pinchot National Forest (GPNF) in southwestern Washington is a premier wild berry and mushroom harvesting location, and commercial and recreational harvesting permits are issued for those products as well as plants and plant parts for decorative purposes. Under present rules, a harvester may collect, at no charge, up to 3 gallons per year of huckleberries with no permit and up to 3 gallons per year of mushrooms with a "free use" permit (previously called "recreational" or "personal-use" permit). Other products have different free-use limits. A "charge use" permit (previously called "commercial" permit) may be purchased for collecting larger quantities, or if the harvest will be sold. Hansis (1998) collected information on the number of permits issued by the GPNF for mushroom and huckleberry harvesting between 1992 and 1994; the GPNF issued a total of 2,620 personal-use mushroom harvesting permits and 8,342 commercial mushroom permits; the GPNF issued 25,621 personal-use huckleberry permits, as well as 73 commercial huckleberry permits. Hansis (1998) and Richards (1994) suggest some harvesters use personal-use permits for commercial harvesting activities. Additionally, Hansis (1998) found evidence of unpermitted harvest on the GPNF.

The 12 blueberry-like huckleberry species (*Vaccinium* spp. and *Gaylussacia* spp.) that grow in the U.S. states of Oregon and Washington are prized for their flavor and texture. Huckleberries are eaten fresh or dried whole. Commonly, they are eaten fresh; baked in pancakes, pies, and muffins; canned; frozen; or made into jams and jellies. The leaves can be used fresh or dried to make a tea. In addition to the subsistence harvesting carried out by American Indians and nonnative Americans, commercial harvesting also occurs on the GPNF. These berries are sold in local markets and to wholesalers. Most wild huckleberries are exported from the United States to Canada (Blatner and Alexander 1998, Kerns et al. 2004).

Commercial and noncommercial harvesters gather several species of mushrooms, and one of the more popular species of mushrooms is the morel (*Morchella* spp.). These mushrooms fruit heavily after forest fires, particularly those that burn the duff and understory plants but leave trees standing. Morels are a choice edible mushroom, harvested by people for personal use and for sale. Other popular mushrooms include porcini (mostly king bolete, *Boletus edulis*), chanterelles (*Cantharellus* spp.), hedgehog mushroom (*Hydnum repandum*), Oregon white truffles (*Tuber gibbosum*), American matsutake (*Tricholoma magnivelare*), and lobster mushrooms (*Hypomyces lactiflorum*).

As the GPNF examples illustrate, there is significant value embedded in NTFPs, but there is a substantial gap in the literature and in land owner/manager knowledge. The full value of NTFPs includes the market and nonmarket values. For NTFPs, the construction of the market and nonmarket values is problematic. On the market side, the large amount of illegal and unreported harvesting as well as low-quality inventory data make valuation difficult, and on the nonmarket side, these same issues as well as a lack of funding have all but stopped valuation efforts.

environmental quality. Individuals perceive and respond to changes in the travel expenses of a visit in the same way they would respond to a change in an admission fee. It is this use of travel cost as a shadow price of recreation that allows for the estimation of a recreation demand model (Freeman 2003). However, this use of actual trips precludes the ability to derive policy relevant changes in trip demand associated with differing policy options. If recreation demand questions are structured such that data are collected on actual and intended behavior, then the analyst can evaluate policies beyond the realm of observable levels of a given resource, or over quality and price changes that are policy relevant but historically unobservable (Rosenberger and Loomis 1999).

Increasing awareness of environmental effects associated with timber harvesting has created a need for various land management agencies to begin focusing attention on sustainable extraction of NTFPs, and the combined use of revealed and stated preference methods can provide estimates of the economic value of policy and environmental changes associated with climatic variability. These changes can then be fed into macroeconomic models to estimate the overall economic impact of the policy and/or environmental changes.

6.3.2 Estimates of Nonmarket Values

There is a significant literature on forests and nonmarket valuation, however much of the work is on European forests and other areas outside the United States. For the valuation of products from United States forests, the literature is significantly thinner, with sporadic estimates across different forests and products. Two of the most relevant estimates that highlight the methods and results can be found in Markstrom and Donnelly (1988) and Starbuck et al. (2004).

Markstrom and Donnelly (1988) used TCM to estimate the recreational value of Christmas tree cutting from a site in Roosevelt National Forest, Colorado. They estimated an average consumer surplus estimate of over $4 (in 1984 dollars) per tree, which translated into a recreational value of $15 per harvested tree when compared to trees that could be purchased from sales lots in area towns. Multiplying by the average 2.3 trees harvested per vehicle and the estimated 2,400 vehicle visits, the total recreational value of the site for Christmas tree cutting was approximately $82,000 in 1984.

Starbuck et al. (2004) used TCM to model the demand for recreational berry and mushroom harvesting in two Districts within the Gifford Pinchot National Forest, Washington. The two-step function first estimated their success at harvesting and secondly valued access to harvesting as a function of this success. The combination of a harvesting survey that collected characteristics of the individuals combined with the reported harvest and number of trips taken provided a survey based value of legal NTFP harvesting, and this value could be compared with local market values. This two-step approach combined differences between individuals with the spatial distance aspect of TCM to derive a value for the huckleberries and wild mushrooms in the Pacific Northwest. They found an average consumer surplus of $36 per recreational visitor-day (2003 dollars). This is the equivalent of $93,000 (2003 dollars) in 1996 total consumer surplus for the 1,000 harvesters with recreational permits on the two districts covered in the survey (Starbuck et al. 2004).

These two studies illustrate the types of analyses that can be undertaken regarding the nonmarket values of NTFPs in the United States, and also highlight the thin nature of both the research and the markets for the goods.

6.4 Contribution of Nontimber Forest Products to Farm and Household Finance

So far, we have discussed market and nonmarket analyses at the regional, state, and local levels. In addition, NTFPs have an impact at the micro level, by contributing to farm and household income and well-being (see section 6.5). As shown in figure 6.7, NTFPs vary in terms of both the degree of market integration (the horizontal axis) and the degree of transformation (the vertical axis). The spectrum of value addition on the vertical axis spans products and services consumed as harvested from the forest (e.g., recreational picking and consumption of fresh berries), transformed into other products and services (e.g., baskets and home heating with firewood), and used as inputs into other production process (e.g., acorns to feed pigs). While difficult to illustrate, figure 6.7 could also be complemented with a third axis, representing the degree of management. This would include species with no management (wild-harvested), those that are naturally regenerated but with some management activities (managed wild populations), and those that are forest farmed.

This section considers NTFPs that are eventually sold in formal or informal markets, thus contributing to farm and household finance. While market analyses provide insights into the value of the NTFP sector for a particular geographic area, financial analysis of NTFP production

Processing Continuum	Self-provisioning	Sale in informal markets, gifts, fundraisers	Sale in formal markets
Used as production input	Maple syrup is used as sweetener in sauces, baked goods, and other foods for home consumption	Maple syrup is an ingredient in goods like doughnuts and lemonade sold at bake sales and farm stands	Maple sap is a key ingredient in beverages produced by microdistilleries
Transformed into value-added product	Maple sap is boiled to produce syrup for household consumption	Maple syrup is a key feature of New England pancake breakfast fundraisers	Maple syrup is a source of supplemental income for many small farmers and woodlot owners
Consumed as harvested	Maple syrup makers, large and small, often drink some of the sap just as it comes from the tree	Backyard maple syrup makers sometimes give gifts of fresh sap in season	Maple water (unboiled sap) is bottled and sold as a beverage

Economic Mode

Figure 6.7—Continua of contributions of nontimber forest products to household finance and well-being, using maple sap/syrup as an example. (Source: M.R. Emery, U.S. Department of Agriculture, Forest Service, Northern Research Station.)

systems provide producers with an understanding of the relative worth of an investment, provide insight into producer financial motivations, and contribute to policies to make the NTFP market more viable and sustainable. Financial analysis tools are used to measure production costs and revenues and to determine if NTFP production is profitable compared to alternative investments.

For an evaluation of NTFP finance, it is also crucial to note the difference between wild-harvest and forest farming production methods. Wild-harvesting often involves very little upfront cost, whereas forest farming involves a higher degree of inputs. We consider both in this section.

6.4.1 Financial Analysis Methods and Measures

Enterprise budgeting is commonly used to determine profitability for specific NTFP production systems. For example, using a cash-flow approach, all variable costs and revenues associated with its production are tallied, and then summed up to determine net profit. This approach works well for annual systems' production. Land rents, and all fixed costs such as capital equipment, and depreciation are included in the cash flow. NTFPs requiring multiple years of cultivation (e.g., ginseng) require discounting the costs and revenues using criteria such as net present value, internal rate of return, or break-even pricing to get accurate estimates of profitability (Blatner et al. 2010, Burkhart and Jacobson 2009, Godsey 2010, Godsey et al. 2009).

Detailed financial analyses of NTFP cultivation and harvest, as well as their contribution to household budgets, are scarce. It is not clear how many wild-harvesters and forest farmers in the United States depend on NTFPs for all or most of their farm or household income. Research results often appear contradictory. One study found that the vast majority of NTFP harvesters collected for personal use, while those who collect for income represented only 3 to 4 percent of harvesters (Robbins et al. 2008), and another found that 82 percent of harvesters had some commercial motivations with only 17 percent harvesting for personal use only (Jones et al. 2004). The contradiction likely arises from different samples and different regions: Jones et al. (2004) used a sample of known harvesters from around the United States, whereas Robbins et al. (2008) took a random sample of the general population in New England. In any event, many people utilize NTFPs to contribute to their well-being in ways other than income, which is discussed in section 6.5.

Furthermore, even those having income motivations are faced with few formal markets and prices. Only a few NTFPs such as ginseng have well-documented prices and markets. Frequently, NTFPs are informally traded, and this leads to limited information about quantities harvested and prices received, which creates difficulties in determining monetary value and profitability.

6.4.2 Producers and Production Systems

Collection of NTFPs for income is either based on wild-harvesting or forest farming. Wild-harvesting is the collection of products from unmanaged (or minimally managed) populations of plants. Forest farming, or NTFP cultivation, involves a more active role in propagating organisms (plants, fungi) and managing growing conditions to increase yields (Hill and Buck 2000). See chapter 2 for more details on this distinction and other types of production systems.

While we are unaware of sociological studies comparing and contrasting people who undertake wild-harvesting versus forest-farming activities, it may be that they satisfy different economic needs for the participants. Wild-harvesting can be a low-cost endeavor, often requiring only ecological knowledge, harvest labor time, minimal transportation and equipment, and possibly a permit fee as wild-harvesting often takes place on public lands. Forest farming, on the other hand, involves significant up-front investment of capital, land, and labor, and would be more typical on private lands. For further discussion on factors influencing wild-harvesting and forest farming, see section 6.6.

6.4.3 Business Models

NTFP and timber financial analyses are similar in many ways. Both NTFP harvesters and timber buyers acquire access through a contract with a forest landowner. Since many NTFP producers and gatherers often do not own the land, the producer must negotiate access rights, either through purchase or long-term lease (in the case of forest farming), or harvest permits (wild-harvesting). Some benefits of ownership include the incentive for continuous investments to improve the resource base and the ability to exclude others from harvesting NTFPs from that property (box 6.3). Leasing or permits provide the

BOX 6.3
ILLUSTRATION OF OWNERSHIP AND INCENTIVES

The Manson family in Brunswick, Missouri, produces northern pecans on over 1,500 acres of bottomland hardwoods along the Missouri River. Processing northern pecans is not capital intensive and the family sells pecans as a partnership. Through ownership of a large portion of these acres and negotiated contracts for the purchase of pecans from other landowners, the Manson family has both the incentive to improve the production of pecans on their land and the flexibility to expand their production without the cost of owning additional land.

flexibility to harvest from numerous sites without the cost of ownership. Leased rights may be creatively negotiated to minimize costs; however, leases do not always provide the benefit of excluding others from impacting the harvest of NTFPs or provide an incentive to invest in such a way as to improve the quality of the NTFPs.

Farm and household business structures for NTFPs can be as simple as a sole proprietorship or as complex as a cooperative or limited liability corporation (LLC). In general, we do not know enough about the type of business entities NTFP practitioners use, but for NTFPs that do not require capital intensive processing or can be marketed in their original form, a simple sole proprietorship or partnership may be the most common business model. Such may be the case for wild or cultivated mushroom growers that market their mushrooms directly through farmers' markets and contacts in the restaurant industry. NTFPs that require capital intensive processing to reach the consumer may be organized as a cooperative or LLC. In some cases, such as the black walnut (*Juglans nigra* L.) nutmeat industry, the capital resources for processing are owned by a corporation that procures raw materials for processing through various forms of contracts and spot market purchases from farmers and landowners (Reid et al. 2009). Other NTFP industries, such as the elderberry (*Sambucus canadensis* L.) industry, have established buying cooperatives to aggregate the raw materials and then contract the processing services from a local bottling company (Cernusca et al. 2011).

6.4.4
Factors Influencing Profitability

Important factors that influence NTFP financial investment analysis and profitability can be divided into direct factors of production and external factors, such as markets that influence production and profitability.

Factors of production include labor, capital, and land. The producer should account for labor, whether paid or unpaid. One way to estimate labor costs if the person is not being paid directly is to use the opportunity cost of labor in the analysis. Capital is the investments needed to acquire necessary equipment, plant materials, and other establishment costs. Lease or rental payments for the land are a capital cost. If no lease payment is made, when applicable, financial analysis should take into account the opportunity cost, or value of alternative benefits forgone. Since NTFP production is on forest land, the land value is nearly always based on timber production, though it should be noted that timber and NTFPs can be produced simultaneously and need not always be considered as competing uses. Financial analysis in this setting, where different goods are produced at different times and have both competing and complementary production functions can be quite complex. Very few public appraisals or private forest investments consider NTFP values. However, in most cases, NTFP activities can add additional value to the forest or timber values. Recouping capital costs can take many years, depending on the size of operation, harvest age, yields and prices of the NTFPs. Capital investments may require loans, adding the issue of interest payments to the analysis.

While the costs to wild-harvest are minimal compared to forest farming, there are land (permit fees), labor (harvest time), and capital (transportation and any harvest equipment) costs associated with wild-harvesting. Wild-harvesters often do not consider these costs (Burkhart 2011). Wild-harvesters may consider these costs negligible compared to the recreational or cultural value they place on the activity.

Market access and barriers, product quality, value-added potential, weather and seasonality, and laws and regulations are examples of external factors that affect both production and profitability (Porter 1980). Having reliable markets and the ability to sell the product are critical for any producer. In most cases NTFPs are in competitive markets where the producer is a price taker, i.e., the market determines the price that the producer receives. Burkhart and Jacobson (2009) showed that the price of different botanicals can vary dramatically depending on demand. NTFPs are also very susceptible to market fluctuations. Booms and busts in the NTFP trade are common and one reason is shifts in consumer preferences. Another reason is that many NTFPs are traded in national and international markets and prices are driven in many ways by the state of the economy.

NTFP quality often affects prices. For example there are over 40 different buyer grades for ginseng in the Asian market. NTFP producers may substantially increase profitability by adding value through processing or selling directly to end users. Finally, weather and seasonality of harvest affect markets by impacting the quantity and quality of annual harvests. As these change, prices fluctuate. It is common to find shortages of some NTFPs in drought or abnormally wet years, driving up the market price. These challenges could be exacerbated as climate and related stressors change in intensity and ranges.

Another important driver of production and profitability is resource availability. If NTFPs are being depleted, it will obviously affect profitability through less harvest volume for sale. If the NTFP is in demand, resource shortages may temporarily increase prices paid and possibly lead to cultivation.

6.4.5 Estimates of Income from Wild-Harvesting

Very few studies have estimated the income that typical harvesters receive from wild-harvesting of NTFPs. Income analysis would rely on surveys of harvesters or second-hand information from dealers, both of which are difficult given the secretive and informal nature of the harvest, and the fact that the vast majority of harvesters gather at least in part for personal use (Robbins et al. 2008). Also, as with most surveys, respondents are hesitant to state dollar values for income.

In the Eastern United States, Hembram and Hoover (2008) surveyed harvesters and dealers around Daniel Boone National Forest in Kentucky and found that part-time harvesters may generate $200 to 1,000 per year while full-time harvesters may earn $3,000 to $15,000 per year. These monetary values are revenue only and do not factor out any costs of labor, transportation, or harvest permit fees. Bailey (1999), while not noting exact dollar figures in most cases, found that ginseng harvesters often made only enough income to cover occasional incidental expenses such as hunting/fishing supplies or holiday gifts. On the other hand, one interviewee indicated the ginseng had generated enough cash to help him build a new home.

In the Pacific Northwest, Carroll et al. (2003) similarly described commercial berry harvesters as those that either do so to supplement income, or those that work full time, but did not state dollar values. A survey of wild mushroom processors by Schlosser and Blatner (1995) indicated that approximately 35 percent of harvesters rely on mushroom harvest as their primary source of income during the season. However, review of the literature found no estimates of dollar income values in the Pacific Northwest.

6.4.6 Estimates of Forest Farming Profitability

Burkhart and Jacobson (2009) examined profitability of forest farming of medicinal forest plants in eastern North America. Costs and revenues were modeled for eight FBPs—black cohosh, blue cohosh, false unicorn (*Chamaelirium luteum* (L.) A. Gray), wild yam (*Dioscorea villosa* L.), goldenseal (*Hydrastis canadensis* L.), American ginseng, poke (*Phytolacca americana* L.), and bloodroot—used in the medicinal trade. Data were based on field work; visits and consultation with experienced growers, collectors, and industry (e.g., buyers); and a literature review. Since most NTFP wild-harvesters and forest farmers are self-employed, a wage rate of $13 per hour was used to represent the opportunity cost of time. The results show that under a variety of cost, price, and discount rate assumptions, only forest farming of ginseng is profitable. Even under scenarios with lower discount rates, early harvests, no stock costs, and no annual costs, only ginseng and goldenseal showed break even prices below industry prices (Burkhart and Jacobson 2009). This implies that production costs exceed the market price for most NTFPs analyzed in the study (Burkhart and Jacobson 2009). Based on these results, forest farming of most botanicals is unlikely to occur unless prices increase dramatically. However, there is an active trade, mainly from wild-harvesters who have lower costs than those participating in NTFP forest farming. This is particularly true in areas that lack sufficient employment opportunities—their opportunity cost of labor may be far less than $13/hr. Furthermore, producers may value both wild-harvesting and forest farming for their cultural and recreational benefits, reducing the perceived opportunity cost of labor.

Joint production of timber and tree-based NTFPs has also been analyzed. Blatner et al. (2010) simulated the growth of noble fir to estimate the profitability of management for joint production of sawtimber and boughs for seasonal decorations. The simulation utilized data from inventories of existing fir-hemlock stands in Oregon and Washington. At 4 percent discount rate, managing noble fir for sawtimber was not profitable due to low stumpage values and a 60-year rotation period. However, adding sale of boughs was enough to make management profitable.

Similarly, joint production of longleaf pine sawtimber and pine straw has been found on multiple occasions to be more profitable than sawtimber alone (e.g., Dickens et al. 2011, Glenn 2012, Roise et al. 1991), although possibly less profitable than loblolly pine for timber alone (Glenn 2012). Revenue that landowners receive from pine straw harvesting can vary widely due to species, quality of the straw, and site preparation costs (Dyer 2012). Taylor and Foster (2004) found that landowners in east Texas were paid $0.10 to $0.25 per bale, while landowners in Georgia were paid $0.50 to $0.65 per bale (Casanova 2007). During a similar time period, landowners in Florida were found to have leases that paid between $70 and $100 per acre (Minogue et al. 2007).

We note that the existence of yield models for fir boughs and pine straw is unusual; data sufficient to produce statistical models of yield are lacking for the vast majority of NTFPs. It is likely that the existence of yield models for NTFPs from noble fir and longleaf pine is due at least in part to the fact that these are timber species.

Production of gourmet mushrooms in the woods also may be profitable. Rathke and Baughman (1993) estimated costs and returns based on literature and interviews of producers and found that an outdoor log-grown shiitake (*Lentinula edodes* (Berk.) Pegler) mushroom enterprise of 11,000 logs could generate the equivalent of about $17,000 per year (5.8-percent discount rate) in 1993, the equivalent of $27,600 in 2015, or $8.65 per hour of producer's labor. More recently, Frey (2014) also found positive rates of return, but large expansion of production is limited because the market for shiitake grown on logs on the forest is not large, and more intensively grown mushrooms (e.g., indoors on sawdust blocks) are cheaper to produce.

Other literature has found positive rates of return for cultivation of products that are found in the woods, but in many cases, the production systems involve moving the species out of the forest to an artificially shaded garden as in the cases of black cohosh and bloodroot (Davis and Dressler 2012), or to an orchard as in the case of elderberry (Byers et al. 2012).

6.5 Contribution of Nontimber Forest Products to Household Well-Being

In addition to contributing to household finances, NTFPs contribute directly to household well-being in many ways along the spectrum shown in figure 6.7. Households often can obtain NTFPs for personal use or sale without significant inputs other than their own labor, ecological knowledge, and forest access. This means that household production theory, which recognizes that households are integrated production and consumption units, is helpful for understanding the roles played by NTFPs in the household economy. This theory underlies much of the research on NTFPs in developing countries (Sills et al. 2003) and also has been used to model family landowners in the United States (Pattanayak et al. 2002, 2003; Thornton 1994).

In this framework, we think of households as combining access to forests with their own labor and ecological knowledge to produce valuable goods and services, which they can consume (for personal use or self-provisioning) or sell in the market. In our framework, we consider all of these to be outputs of household production, although standard economic accounts record only those eventually sold in the market and not those that directly support household well-being, perhaps substituting for products that would otherwise have to be purchased in the market.

The horizontal axis of figure 6.7 shows these potential end uses ranging from (1) sale in formal markets; (2) sale in informal markets, barter, gift-giving and fundraising; and (3) direct use by the households who harvest. To make this concrete, we provide examples of how households employ NTFPs to produce goods or services at these three points along the horizontal axis. First, complementing section 6.4 on income generation from NTFPs, we consider how sales of goods or experiences based on NTFPs can help smooth income over seasonal, inter-annual, and life cycle sources of variation, or help meet intermittent needs for cash income, serving as a kind of "natural insurance" (Pattanayak and Sills 2001, Pierce and Emery 2005). Second, NTFPs are also critical for building and maintaining social capital through gift-giving, fundraising for local institutions, and activities such as meet-ups to learn wild-harvesting. Third, they contribute to household well-being through direct consumption, by helping diversify and increase the quality of diet, supplying recreation and decorations, and giving households some autonomy or sovereignty over their food and health care (Emery 2001, Emery and Ginger 2014).

6.5.1 Income Needs and Natural Insurance

Even when NTFPs contribute only a small fraction of household income, they can perform the vital function of smoothing over seasonal fluctuations in labor demand and income from other sources, such as farming (Emery et al. 2006b). NTFPs also may be a critical source of income at particular stages in household life cycles, such as when migrants first arrive in an area or when elders move in with their children (Emery et al. 2003). In both cases, language and legal barriers can make it difficult for recent arrivals to obtain formal employment, but they can get established and contribute to their families' well-being by collecting NTFPs from forests and urban green spaces (Anderson et al. 2000, Emery et al. 2006b).

Households also may turn to NTFPs in times of economic crisis, such as when coal mines temporarily close (Bailey 1999). The natural resource extraction industries that are major employers in rural areas are generally subject to boom-bust cycles. Households can self-insure against the resulting economic risks by building up the knowledge and skills to harvest NTFPs, as long as they also have access to a forest. Of course, households also have other fallback options, including seeking help from family and friends, their own savings, and public unemployment benefits. Access to these varies across households and across different types of economic shocks. For example, crises that affect entire communities (called covariate shocks in the microeconomics literature), such as closure of a coal mine or other key local employer, cannot be weathered by relying on help from neighbors and local family, because they are also likely to be affected. On the other hand, local social networks can serve as an effective safety net for so-called idiosyncratic shocks that affect individual households, such as an injury that results in loss of employment. Collection of NTFPs can help households smooth their income in response to both types of shocks, conditional on having access to a forest and knowledge of NTFPs. There is evidence that households also harvest NTFPs to meet intermittent needs or wants such as car repairs, back-to-school purchases, hunting supplies, or holiday gifts (Bailey 1999, Emery 1998), especially when they do not have access to credit at reasonable rates.

6.5.2 Social Capital

NTFPs also are used to build and maintain social capital, hence indirectly contributing to another household strategy for dealing with risk. This occurs both at the individual household level (e.g. exchange of gifts based of NTFPs, such as mushrooms and jams) to maintain social networks, and at the community level (e.g., fundraising for local volunteer organizations based on NTFPs, such as meals centered on ramps or maple syrup). Both gift-giving and fundraising can strengthen local social capital by demonstrating the value of local culture, tradition, and know-how (Baumflek et al. 2010, Emery et al. 2006a). In other cases, new social networks are built around NTFPs, as in meet-ups to learn about foraging, which is called wildcrafting, or survival training by groups at different ends of the political spectrum (Hurley et al. 2015, McLain et al. 2014).

6.5.3 Direct Consumption

Consumption of NTFPs by the same households that collect them is not well documented, because it is difficult to trace. However, household consumption is considered one of the most important uses of NTFPs in developing countries. There are a few examples of the value of household consumption in the United States, and a need for more research on this subject (Emery and Pierce 2005, Robbins et al. 2008). Potential contributions to household well-being include improved nutritional status (Phillips et al. 2014), access to culturally appropriate food and health support resources (Kassam et al. 2010), low-cost inputs to household maintenance (e.g., firewood for heat), and increased quality of life through recreational activities and decorations that maintain cultural traditions and strengthen sense of place (Schulp et al. 2014, Teitelbaum and Beckley 2006). Further, collection of NTFPs, for personal consumption or for sale, may offer households a type of work that has lower disutility because it allows them to work without supervision in the outdoors, on a schedule compatible with other responsibilities such as child and elder care (Emery 1998, Emery et al. 2003), allowing greater autonomy and gaining more respect for their knowledge and traditions (Gorman et al. 2006).

6.5.4
Conditions for Contribution to Well-Being

To serve these functions, NTFPs must be accessible to households. NTFPs are most likely to effectively "insure" rural households who live near forests with permitting processes adapted to local needs in terms of timing, procedures, and costs (Emery and Ginger 2014). Households must also invest in this type of insurance by learning about NTFPs, including their spatial and temporal distribution as well as harvesting and processing techniques (Pierce and Emery 2005). To generate cash income from NTFPs, households must be familiar with and have access to markets, although these are often informal (McLain et al. 2008). Finally, all these conditions (permission to harvest, knowledge, and market access) must apply to a set of NTFPs for which availability matches the timing of household needs. This could mean a species that can be harvested throughout the year, a bundle of species with harvest seasons that correspond to times of low labor demand in other dimensions of the household livelihood portfolio, or a bundle of species that respond differently to weather shocks.

In sum, multifunctionality and flexibility are key features of NTFPs that give them a unique role in household economies. At any given time and over time, households can mobilize NTFPs for different functions with nearly no entry costs beyond ecological knowledge and access to forests. These features mean that NTFPs and timber play very different roles in the household economy (e.g., NTFPs may help households manage fluctuations in employment in logging and sawmills). Of course, households will rely on NTFPs to smooth income only if (a) they prefer this "natural insurance" over other types of insurance and social safety nets, and (b) they have both sufficient ecological knowledge and access to forests. For example, in the context of hunting, Eliason (2004) suggests that self-provisioning may be preferred by people who are poor but not "poor enough" to qualify for government support and by people who wish to avoid the stigma of welfare. Access includes the abilities to harvest NTFPs with the desired properties without fear of sanctions; to travel to and from forests; and to obtain permits at reasonable cost. This cost is a function of availability of appropriate permits (e.g., for multiple rather than single species), time and place where permits must be obtained (e.g., issues with unfamiliar or uncomfortable venues), and format of application (e.g., digital divide issues).

6.5.5
Building Our Understanding of the Role of Nontimber Forest Products in Household Well-Being

People from many segments of society have found ways to improve their well-being through harvest of NTFPs from diverse forest types, with different levels of disturbance and ownership (Robbins et al. 2008, Teitelbaum and Beckley 2006). NTFPs thus represent an opportunity for forest stewards to demonstrate the contributions of their forests and build a broad constituency for sustainable forest management across a wide range of socioeconomic, demographic, and political groups. These could include wealthy suburban households interested in getting back to nature and learning about wild foods, agricultural workers filling in seasonal gaps between cropping seasons, rural households with a deep tradition of forest harvesting, survivalists interested in feeding their families in case of a major societal breakdown, elderly parents seeking to contribute to household income, women and men, young and old.

To demonstrate their value and effectively manage forests for NTFPs, better information is needed and could be obtained through targeted public participation and more systematic data collection. The full value of NTFPs to households is not captured in standard economic accounts because these exclude (1) their value as a form of risk-mitigation or natural insurance in the face of seasonal variation, unexpected crises, or challenges typical of certain stages of the household life cycle, and (2) their direct value to households who collect but never sell them (Landefeld and McCulla 2000). Further, we have limited understanding of patterns in NTFP use across people and time because most survey research on NTFPs has focused on specific populations in a single time period. Incorporating questions about personal use of NTFPs into nationally representative and repeated surveys will help address this challenge. For example, a representative survey of rural households in Canada found that foraging for wild foods was the only self-provisioning activity accessible to households in all income categories. The Food and Agriculture Organization of the United Nations (FAO) is developing modules on NTFPs to add to household surveys funded by the World Bank in various developing countries (Bakkegaard et al., 2016). A recent review of wild foods in the European Union also identified the need for consistent and representative data (Schulp et al. 2014).

6.6 Factors Driving Nontimber Forest Product Harvest and Adoption of Forest Farming

NTFPs may come from wild-harvesting or forest farming, or from production methods somewhere in the continuum between the two previous. Research on factors that influence wild-harvesting and forest farming is limited. The harvesting literature is dominated by ethnographic studies of specific harvesting communities except for one study (Robbins et al. 2008) that examined harvesting rates of the general population in New England. Research on the adoption of forest farming is nearly nonexistent. This probably reflects the extremely small numbers of landowners engaged in forest farming in the United States. In this section, we review the available literature that examines factors that drive NTFP wild-harvesting and adoption of forest farming.

6.6.1 Wild-Harvesting

NTFP wild-harvesting occurs on private and public lands across the entire United States. Of national forests, 86 percent reported NTFP harvesting on their lands, and 82 percent of State Foresters reported NTFP harvests on state forest lands (Jones et al. 2004). Eighteen percent of nonindustrial private forest landowners in the United States indicated that NTFPs were harvested or collected on their land (Butler 2008).

Studies of NTFP harvesting and harvesters in the United States have focused primarily on conflicts on public lands in the Pacific Northwest that arose with the rapid increase in harvesting of economically valuable NTFPs in the late 1990s. These studies focused primarily on marketable NTFPs and the conflicts and tensions between gatherers and land managers and between different gatherer communities. Examples include harvesting wild mushrooms (McLain 2008, McLain and Jones 2001, Pilz and Molina 2002) and huckleberries in Washington and Idaho (Carroll et al. 2003).

Research on NTFP harvesting has been dominated by ethnographic and case studies of specific harvesting communities. For example, Carroll et al. (2003) studied the social ecology of huckleberry harvesting in Washington and Idaho and conducted 93 semi-structured interviews of harvesters. They described a large degree of social complexity among harvesters, their motivations and uses of huckleberries and identified four major categories of harvesters: native harvesters, (nonnative) household harvesters, those who supplement income, and full-time harvesters. Knowledge, experience, education levels, ethnicity, harvest volumes, and distance traveled varied considerably within and between these groups.

Hembram and Hoover (2008) interviewed 25 NTFP permit holders in six counties near the Daniel Boone National Forest in eastern Kentucky. These geographically isolated counties are characterized by persistent and chronic poverty. Half of the sample reported household incomes of less than $10,000 per year and only 25 percent of respondents had any post-high school education. Participants gathered a wide variety of NTFPs. Forty-three species were sold commercially and 120 species were collected for personal use. Commercial harvesters targeted NTFPs that produced the highest net revenues (market price minus total cost to harvest and market).

Barron and Emery (2012) examined the sociology of morel harvesting in northern Virginia, northwestern Maryland, and northeastern West Virginia. They interviewed 41 harvesters in 15 national parks in the National Capital Region. The majority of participants were male (61 percent), local area residents who harvested morels for recreation and personal consumption, and over 45 years old (ages ranged from 21 to over 80). Only 7 percent of the interviewees had ever sold morels and none reported that earning income was a primary motivation. The most common reasons for participating in harvesting activities were recreation, family tradition, enjoying the outdoors, and for the challenge.

Jones et al. (2004) conducted 143 semi-structured interviews of a nonrandom sample of experienced harvesters (at least 5 years' experience) across the contiguous 48 states. They identified eight types of harvesters based on primary motivation: subsistence, commercial, recreation, spiritual/healing, formal scientific, informal scientific, and education/training. Commercial motivation accounted for 20 percent of the sample, while 17 percent harvested only for home consumption. Harvester characteristics varied widely, with education ranging from preliteracy to postgraduate degrees. Most learned harvesting from family or friends, or were self-taught.

Interviews of 62 West Virginian ginseng diggers, buyers, and resource managers by Bailey (1999) suggested that harvesters of wild ginseng were driven by monetary benefits but non-monetary benefits (such as spending time in the woods) also were important. Bailey (1999) compared West Virginia's annual ginseng harvest to climate and unemployment rates between 1980 and 1996 and found that unemployment and drought accounted for 72 percent of the variability in the ginseng harvest.

Ethnographic and case studies provide a rich background for gaining insights into the NTFP harvester lifestyles, motivations, challenges, and conflict management. These studies, however, are not capable of shedding light on NTFP harvesting amongst the general population due to sampling methods. Determining whether harvesting is predominately an economic, recreational, cultural, or social activity; the demographic profile of harvesters; and the proportion of the population engaged in harvesting requires random-sample surveys of the general population. We could only find two surveys of NTFP harvest among the general population in the United States: Robbins et al. (2008), a random-sample survey of 1650 households in New England; and Bailey (1999), a survey of 992 households in West Virginia. Robbins et al. (2008) discovered that 26.3 percent of New Englanders had gathered within the last 5 years and 17.9 percent in the last 12 months, implying that 17.9 percent were regular harvesters and 8.3 percent occasional harvesters. Socioeconomic characteristics were poor predictors of who gathers NTFP in New England. At least in New England, harvesters come from all parts of the demographic spectrum crossing income, race, gender, education, and geographic boundaries. Urbanites comprised 56 percent of harvesters (but only 32 percent of all survey respondents). Harvesters tended to be more educated than average and represented a wide range of income classes similar to the entire population. Eighty-eight percent of harvesting was for home consumption, primarily edibles and decorative/floral products. Bailey (1999) reported that 25 percent of West Virginians surveyed had previously gathered wild plant foods and 4 percent had gathered medicinals.

Work in other countries has attempted to determine NTFP harvesting rates among broad populations. Similar participation rates have been found in Scotland where 24 percent had gathered NTFPs in the previous 5 years, and 19 percent in the previous 12 months (Emery et al. 2006a). Rates were even higher for Great Britain (27 percent) according to a survey by the Forestry Commission (2005). In Canada, as part of the New Rural Economy project, Teitelbaum and Beckley (2006) surveyed households in 20 representative rural communities and found that 52 percent of rural households reported foraging edibles. FAO is developing household survey modules for developing countries that will ask about NTFP collection and use (Bakkegaard et al. 2016).

6.6.2 Forest Farming

Forest farming (chapter 2) is an agroforestry system in which NTFPs are cultivated under a forest canopy. Typical crops include medicinals (e.g., ginseng), food (e.g., shiitake mushrooms), and ornamental plants (e.g., ferns). Economic theory predicts that landowners adopt agroforestry systems when the expected returns from the new system are higher than all other alternatives for the use of their land, labor, and capital. A large body of empirical literature (primarily in developing countries) has found that a host of other factors also determine the extent of agroforestry adoption. These include household preferences, resource endowments, market incentives, biophysical factors, and risk and uncertainty (Mercer 2004, Mercer and Pattanayak 2003). Adoption of forest farming in the United States is not perceived as widespread (Mudge 2009), and we were unable to find any studies of factors correlated with adoption of forest farming in the United States. The more general agroforestry adoption literature in the United States suggests that nontraditional landowners with multiple objectives, interest in stewardship, higher incomes, and more education are more likely to experiment with agroforestry systems. There have been a handful of studies that examine landowner potential interest in adopting forest farming, which we review in the following paragraphs.

Workman et al. (2003) conducted a survey of 742 landowners in Florida and Alabama and found that 77 percent of respondents were unfamiliar with the term "forest farming" and 67 percent had not heard of "nontimber forest products." However, 14 percent reported having practiced forest farming which included managing forests for pine straw, mushrooms, ferns, saw palmetto, plant ornamentals, honey bees, and native medicinals. Pine straw and honey bees were the most common. In terms of general agroforestry practices, Workman et al. (2003) found that Florida landowners ranked the potential benefits of aesthetics, shade, wildlife habitat, and soil conservation higher in importance than economic returns. Obstacles to agroforestry adoption were perceived as competition between system components, lack of information, and lack of markets. Burkhart (2011) surveyed a sample of 383 individuals in Pennsylvania who had previously sold ginseng to buyers licensed by the Pennsylvania Department of Conservation and Natural Resources. Seventy-eight percent of respondents had planted ginseng for an average of 19 years primarily on "forest lands that someone else owns."

Strong and Jacobson (2006) surveyed family forest owners in Pennsylvania and found that 36 percent of the respondents reported an interest in forest farming. Women who had off-farm income or income from forest harvests, relatively smaller forest parcels, and an interest in environmental and aesthetics benefits were more likely to express interest in forest farming than the typical family forest owner. Valdivia and Poulos (2009) surveyed 358 landowners and found that knowledge was the most important variable for predicting interest in adopting forest farming and that younger, more educated landowners were more interested. Although having a diversified household portfolio of income had no effect, conventional farmers were less likely to express interest in adopting forest farming in riparian buffers. Similarly, Trozzo et al. (2014) found that livestock producers were less likely than nontraditional landowners to express interest in adopting riparian buffers in Virginia.

McLain and Jones (2013) used a random survey of 567 family forest owners in 16 states in the Northeast, Adirondacks, Ozarks, Appalachians, Great Lakes, and Pacific Northwest to examine characteristics and motivations of landowners interested in adopting forest farming. Only 13 percent had harvested NTFPs from their lands. More than two-thirds of the respondents were not familiar with NTFPs, although three-quarters were interested in learning about cultivating NTFPs in their forests. Younger and better educated landowners, who actively managed their forests, had incomes between \$35,000 and \$100,000, larger landholdings, and longer tenure, were more likely to be interested in forest farming. Those interested in forest farming were more likely to harvest NTFPs on their land (15 percent) than those not interested in forest farming (8 percent).

6.6.3 Motivations and Drivers of Nontimber Forest Products Production and Harvest

Although the literature is limited, we can draw a few conclusions concerning participation in wild harvesting and forest farming of NTFPs. Wild-harvesting of NTFPs appears to be a common activity in all parts of the United States that crosses numerous socioeconomic boundaries including income, education, race, gender, and class (Butler 2008, Jones et al. 2004). Motivations are as diverse as the actual harvesters themselves and likely vary depending on local socioeconomic and ecological conditions (Barron and Emery 2012, Carroll et al. 2003, Jones et al. 2004). Many harvesters are motivated by the potential to earn income from selling high-value medicinals, edibles, floral decoratives, and landscaping. However, surveys of the general population suggest that most NTFP collectors are motivated by the nonmarket, noncommercial aspects of harvesting (e.g., recreation, spiritual, cultural, family tradition, and for subsistence/home consumption) (Robbins et al. 2008). However, this says nothing about the quantity of NTFPs collected by those individuals, which may be quite small on a per-capita basis. Almost nothing is known about the extent of forest farming and the factors driving adoption of the practice. Although it appears that forest farming may be increasing in some parts of the country (McLain and Jones 2013, Strong and Jacobson 2006), it is practiced by a small percentage of forest landowners (Butler 2008). The handful of studies examining landowners interested in potentially adopting forest farming suggest that adopters would tend to be younger landowners with higher education, income, and landholdings, and who tend to be engaged in nontraditional land management systems (McLain and Jones 2013, Strong and Jacobson 2006, Trozzo et al. 2014).

Given the very small body of literature on drivers affecting NTFP gathering and forest farming adoption in the United States, a great deal of research is needed to understand the processes involved. While a number of excellent ethnographic studies have provided detailed descriptions of NTFP communities (Bailey 1999, Barron and Emery 2012, Carroll et al. 2003, Hembram and Hoover 2008, Jones et al. 2004, McLain 2008, McLain and Jones 2001, Pilz and Molina 2002), they are rarely generalizable beyond the specific study area. Quantitative studies of random samples from different regions in the United States would be needed to fully understand who the NTFP collectors are, their characteristics and motivations, and what portion of the population they include, as well as the benefits derived from NTFPs and their economic impacts.

6.7 Potential Impacts of Climatic Variability on Nontimber Forest Product Economics

NTFPs contribute to the broader economy through market and nonmarket channels, and for many NTFP harvesters and producers, these products represent an important, even if sometimes small, portion of their livelihoods. This includes direct contribution to income through sales of products (section 6.4), or other contributions to well-being such as cultural or recreational use (6.3 and 6.5), management of risk (6.5), and more.

As biological systems, forests will adjust naturally to environmental pressures of climatic variability. Biological risk to organisms and ecosystems translates into economic risk for consumers and producers harvesting or farming NTFPs. Income or consumption may increase or decrease as induced changes in forest productivity of NTFPs are realized. Depending on aversion to risk (the degree to which a user wants to avoid this variability), individuals and user groups experience the impacts of climate change differently.

Climate change assessments of biophysical effects on ecosystems have been delineated in several contexts. Adapting from a discussion of climate change effects on fisheries by Sumaila et al. (2011), it is possible to distinguish among organism changes, population changes, community/ecosystem changes, economic changes (harvesting patterns, prices, yields, management, technology), and global issues (social networks, trade in NTFPs). An important consideration in evaluating the economic impact of climate change is that some users could gain, new uses or new NTFPs could become available, and scarcity-driven price increases could offset additional costs of harvest.

To our knowledge, a comprehensive review of climate change impacts on NTFP economies in the United States has never been undertaken. Much research is still needed on the impact of climate change on populations and range of NTFP species (for a summary of research to date, see chapter 3). Also, data on household and community use of and dependence on NTFPs are limited, and literature on impacts of climate change specific to rural communities is scarce (Lal et al. 2011). For those reasons, there is a great deal of uncertainty in what may be the true economic impact of climate change on NTFPs. In this context, we attempt to identify possible ways in which a future with a changing climate may impact the communities and individuals who utilize NTFPs.

Clearly, the impact of climate change varies by species and region, and it is beyond the scope of this assessment to detail potential impacts for each specific product, although we use illustrative examples. We consider the relevant aspects of risk that could affect NTFP economics and potential impacts on communities or individuals.

6.7.1 Risks and Uncertainties

Knight (1921) provided the first classic distinction between risk and uncertainty: risks create positive or negative outcomes with known quantifiable probability, whereas uncertainties are not quantifiable. If we accept that distinction, then NTFP harvesters and users may face numerous risks in their economic activities—such as the probability of a flood or drought destroying a population of plants for harvest. Climate change adds a layer of uncertainties—we have no way of quantifying how climate change will affect the probability that certain negative (or positive) outcomes will come to pass.

There is much we can learn from the discussion of risk and uncertainty in the agricultural and forestry economics literature. Material is drawn from Goodwin (2009), Goodwin and Ker (2002), Just (2003), Just and Pope (2003), Just and Weninger (1999), Ker and Goodwin (2000), Pasalodos-Tato et al. (2013), and Yin and Newman (1996) to create the following list of economic risk factors:

Yield risk:

- Unpredictable year-to-year and seasonal variation in production.
- Stochastic and potentially drastic variation due to catastrophic weather events.
- Shift in species' ranges as conditions become less suitable.

- Permanent decline in populations within natural range, with a harvest rate greater than population regeneration so that the breeding stock is reduced, exacerbated by environmental sub-optimality.
- More time for recovery and regeneration of desired NTFP species between intensive harvests.

Price risk:

- Yield risks described above may result in supply scarcity, driving prices higher.
- In the short term, higher prices when yields are already low may lead to unsustainable harvest as a result of harvesting as much as possible to take advantage of price increases.
- In the long term, higher prices could lead to development of alternatives such as forest-cultivated varieties, synthetic products, or different products with similar characteristics.
- Lower prices could occur in the very short run as overharvesting moves immature, less desirable NTFPs onto the market.

Costs and input risk:

- Loss of ecological knowledge associated with species range shifts or plant association changes as knowledge of where and when to harvest becomes obsolete, forcing a greater investment in obtaining new knowledge.
- Upward pressure on access/user could occur as the lands being harvested are put to other uses or require new management regimes for climate change, such as fuel treatments that disrupt the plant communities supporting NTFPs.
- Higher labor costs, more time, and greater inconvenience as NTFPs become more sparsely allocated, and harder to find.

Social and community risk:

- Disruption of traditional activities associated with NTFP collection and use, such as sacred rituals or family-based harvesting.
- Loss of subsistence and food security components for low-income users, forcing greater reliance on government and nonprofit nutritional services.
- Greater distrust of outsiders and nonlocal harvesters as competition increases for scarce NTFPs possibly leading to more permitting and other regulations governing access and use.

Assessing the effects of climate change on risk requires knowledge of baseline risk. For some NTFPs, generating baseline values can be challenging due to lack of knowledge about the organism and ecosystem and the dynamics of changing harvesting conditions. An example of a tool for evaluating overharvesting risk at any point in time was proposed by Castle et al. (2014). Using scores ranging from -2 to +2 per response, a series of multiple choice questions is used to calculate a comprehensive baseline risk. This approach, applied to wild medicinal botanicals, scores species according to their life history and vulnerability, the effects of harvest on recovery and resilience, population abundance and range, habitat vulnerability, and demand, substitutability, and possibility of cultivation. At the forest level, Matthews et al. (2014) proposed a calculation of vulnerability of individual species and communities that incorporates high risk species expected to lose more than 20 percent of the individuals in the population, stability of gains to losses, change potential, and proportion of loss to top five species on a site. The resulting forest related index of climate vulnerability can be used to project changes in tree associations, which has implications for NTFPs. Baseline data collection and ecological cataloguing of species can support predictions of climate change impacts and management responses.

6.7.2 Potential Impacts on Individuals and Communities

People collect NTFPs in many ways for many economic purposes. Research has suggested potential socioeconomic typologies or categorization of harvesters, and have found that these categories do not necessarily correlate with traditional demographic categories such as race, education, class, age, or even urban/rural (Robbins et al. 2008). Still, it is possible to classify harvesters by their methods, purposes, level of dependency, and frequency. Research that has illuminated various categories of harvesters includes Carroll et al. (2003), Dyke (2006), Jones et al. (2004), and Robbins et al. (2008). This work suggests two broad categories of harvesters, with further differentiation in each. Forest farmers include those who produce NTFPs for commercial sale, as well as those who cultivate small quantities for personal use. Full-time harvesters collect NTFPs as a main source of income and may harvest numerous NTFPs throughout the year. For part-time commercial harvesters, supplemental income may be a primary motivator. Those who collect NTFPs for personal use are another group of wild-harvesters. These may include frequent harvesters, who collect for reasons including traditional, cultural, or spiritual purposes; self-provisioning and subsistence; and to obtain items to use as gifts or for barter. For others, harvesting may be a strictly recreational activity and/or an opportunistic practice engaged in when they observe NTFPs during the course of other activities. Finally, other motivations for wild harvesting include scientific and educational purposes (Poe et al. 2013).

In addition to harvesters, many others are involved with NTFPs, particularly in the commercial realm. To perhaps oversimplify, these can include forest landowners, buyers/dealers/aggregators, processors, wholesalers, retailers, and consumers (Schlosser et al. 1991). All people involved in all aspects of NTFPs will be economically impacted by climate variability.

As discussed in section 6.5, perhaps one of the most important contributions of NTFPs to community economies is as a buffer or safety net in times of economic downturn or crisis. Pierce and Emery (2005) document numerous instances of reliance on NTFPs during crises in developing countries. The use of NTFPs in crises in developed countries is less well documented, but existing evidence in the United States (Bailey 1999, Emery 2001) suggests that they provide an opportunity for income and/or subsistence when employment opportunities are thin or erratic.

Acute economic impacts that are short in time but strong in magnitude may be precipitated by extreme weather events. More frequent extreme climatic events can have negative impacts on peoples' livelihoods, infrastructure, access to trade and services, and overall economic activity (Romero-Lankao et al. 2014). During more frequent crises, communities may rely more heavily on NTFPs. Yet, communities may lose access to nontimber forest resources if NTFP species populations diminish or their geographic ranges change drastically. There is risk of an economic "double-whammy" that negatively impacts communities in crises that depend on nontimber forest species.

Some communities in the United States have developed with NTFPs as a central component of the economy. For example, the maple syrup industry in the Northeastern United States was a traditional winter activity for farmers, and is now practiced by a broad class of people in those rural communities who otherwise may have less winter work, such as construction workers (Hinrichs 1995, 1998). The effects of climate change on maple syrup are the subject of debate (see, e.g., Huntington et al. 2009, Skinner et al. 2010). If climate change were to negatively impact maple syrup production, or alter the range of sugar maple, some communities will face long-term impacts. While neither maple syrup (Hinrichs 1998) nor probably most other NTFPs (e.g., Bailey 1999, Hembram and Hoover 2008) provide the largest portion of income for communities, a long-term decrease in NTFP production may cause an uptick in seasonal unemployment and lower average income, and increased dependence on social safety-net programs.

In the Pacific Northwest, NTFPs are often collected and traded by companies that employ several employees, such as processors, and purchase NTFP materials from independent harvesters (Schlosser et al. 1991). Many of these companies may be diversified into various NTFPs; companies that are not diversified may face greater long-term risks from species reduction, product deterioration, or changes in range or harvest timing due to climate change. For example, noble fir boughs benefit from a cold period before harvest to aid needle retention, and warmer temperatures may favor diseases that increase needle casting.

Within communities that rely on NTFPs for subsistence or cultural and spiritual use, the availability of certain species may increase or decrease due to climate change, or change timing during the year. In association with climate change, American Indian groups have noted the loss of specific species of medicinal plants, reduction in maple syrup output, and impacts on native species from exotic invasive species (NTAA 2009). While numerous potential negative impacts have been identified, the lack of comprehensive research means the net effect is still unknown. Still, traditional ecological knowledge systems will need to adapt to changes in the ecology, or communities may face shortfalls in NTFPs.

The risks faced by an individual would be similar to those faced by communities, though perhaps more keenly felt for particular individuals. Some evidence suggests that most harvesters rely on NTFPs for a small part of total livelihood, either working full time during small parts of the year (e.g., maple syrup producers in the Northeast), or for small amounts of time spread throughout the year (e.g., Appalachian harvesters who spend single days through the year harvesting different products) (Bailey 1999, Emery 2001, Hinrichs 1998, Robbins et al. 2008), although full-time harvesters do exist in the Pacific Northwest and other regions (Carroll et al. 2003, Hembram and Hoover 2008, Schlosser and Blatner 1997). Regardless of region, full-time harvesters, who typically shift from species to species throughout the year, would be the hardest hit by climate change effects on NTFPs. Full-time harvesters also tend to be among the poorest individuals in those regions, and rely on government safety-net programs (Hembram and Hoover 2008, Schlosser and Blatner 1995). Reduction in NTFPs from climate change may push even more of these people to rely on government programs, and make the status of those who already do even more precarious. In addition to direct reductions in abundance of various species, harvesters may be affected by changes in harvest calendar, if species that previously occupied different periods now overlap. Still the total impact on these harvesters is unknown and unclear since most harvest multiple species and losses in one species could potentially be offset by gains in another. As noted in chapter 3, a significant portion of species respond to climate change in unexpected ways.

While the number of people who depend on NTFPs for the majority of their livelihood is likely small relative to the total U.S. population, NTFPs do supplement the livelihoods of a great many people and play an important role in risk mitigation and diversification (Hinrichs 1998, Robbins et al. 2008). Given the fact that much of these livelihoods involve subsistence or personal use, which is largely hidden from economic data, estimating and tracking impacts will be difficult.

6.8 Key Findings

- There is a basic understanding of the overall NTFP industry, markets, and distribution channels, however, there is limited understanding of market dynamics or influencing factors and there is a general perception of an unwillingness for harvesters, buyers, and companies engaged in the industry to share detailed information.
- The lack of data impedes the ability to provide a comprehensive and dynamic analysis of the market and nonmarket economic valuation of forests for the many nontimber products harvested and traded through formal and informal markets.
- No one classification scheme adequately summarizes production of this "sector" and to get a better understanding of the patterns of NTFP production, it is necessary to combine data from different statistical service sources which creates gaps in the data.
- NTFPs play a unique role in household economies, which provides households opportunities to mobilize for different functions with little or no entry costs beyond ecological knowledge and access to forests.
- NTFPs contribute to the broader economy through market and nonmarket channels, and for many NTFP harvesters and producers they are important contributors to the household and community livelihoods.
- Generating baseline values for NTFPs can be challenging due to lack of knowledge about the organism and ecosystem and the dynamics of changing harvesting conditions; hence predicting how climate change may impact economies is challenging but necessary.

6.9 Key Information Needs

Basic and applied economic research should be undertaken with a general goal in mind—how the knowledge gained can help society. We propose three long-term strategic goals, or desired impacts, of future economic research in NTFPs.

Improve resource management—To manage resources sustainably for maximum long-term benefit to society, and to weigh tradeoffs between various possible benefits of forests (NTFPs, timber, wilderness recreation, etc.), it is imperative that land managers be able to quantify the value of these resources. This includes the value of existing inventory of NTFPs on private and public lands (stock), and the annual harvests of these species (flow). The gaps that impede our knowledge of economic value that would aid land managers and resource-use policymakers include:

- Time series of prices and quantities of NTFPs traded in markets.
- Recreational, cultural, and subsistence values.
- Valuation of NTFPs preharvest in-forest.
- Growth and yield models.
- Costs and returns of potential forest farming systems.
- Comparison of management regimes for NTFPs and joint management with other goods and services (e.g., timber, recreation) to alternatives.

Increase economic development—Continued rural economic development based on NTFPs is possible. However, to make informed decisions, entrepreneurs, harvesters, and processers need information about market characteristics and trends. The gaps that impede rural economic development include:

- Time series of prices and quantities of NTFPs traded in markets.
- Characterization of formal and informal harvest and market chains.
- A uniform classification scheme to summarize production of the NTFP sector.

Address economic vulnerabilities—Some households and communities may be particularly reliant on NTFPs for their well-being. A proper accounting of utilization of and dependence on NTFPs by United States households is necessary for economic policymakers, educational institutions, and nonprofits to determine vulnerabilities to potential future shocks and possible future reliance on safety-net programs if vulnerabilities are not addressed. Also, a better understanding of household and community well-being, including NTFP contributions above and beyond simple measures of monetary income, assists in making comparisons between communities to target interventions such as assistance, development, and educational programs. We lack data including:

- Time series and trends of collection and use of NTFPs by United States households.
- NTFPs' role in advancing the standard of living of those engaged in their harvest, processing, and sale.
- Identification of communities (geographic, cultural) that are particularly vulnerable to NTFP species loss/change in distribution.
- Motivations and influences of people to undertake wild-harvesting and forest farming.

6.10 Conclusions

NTFPs contribute to national, state, local, and household economies through monetary income or other economic benefits. NTFPs are highly diverse, as are the people who collect, produce, buy, trade, and consume them. It is clear that NTFPs serve a number of economic functions such as recreation, seasonal income, and subsistence. Similarly, market channels, level of market formality, and production methods are diverse. Economic impacts may be spread over a broad geographic region (e.g., pine straw) or relatively local (e.g., galax). They may be nearly strictly commercial (e.g., ginseng) or largely for personal use.

There is more unknown about NTFP economies than is known. Partially, this reflects the fact that a large portion of the NTFP economy is for personal use or traded in informal markets, and that NTFP market values are small compared to timber (table 6.3), where the forestry profession has traditionally placed emphasis. Many harvesters choose to remain hidden for various reasons. There are some parts of the informal and secretive NTFP economic world that we are likely to never fully understand. However, the numerous gaps in our knowledge may contribute to poor resource management, less than optimal economic development, and misguided strategies. We proposed three long-term strategic goals, or desired impacts, of future economic research in NTFPs: (1) improve resource management, (2) increase economic development, and (3) identify and address economic vulnerabilities. We identify some gaps in knowledge that impede meeting those goals.

To manage resources sustainably for maximum long-term benefit to society, and to weigh tradeoffs between various possible benefits of forests (NTFPs, timber, wilderness recreation, etc.), land managers need to be able to quantify the value of these resources. This includes the value of the existing inventory of NTFPs on private and public lands (stock), and the annual harvests of these species (flow). Several factors impede the ability to estimate the economic value of NTFPs. The lack of growth and yield models for most NTFP species does not allow for estimating the amount of biomass produced during a period of time. Knowledge about the in-forest monetary value or market prices for most NTFP species is lacking, and is needed. In general, the true costs and returns of forest farming systems are unknown. Nonmarket values (e.g., recreational, cultural, and subsistence) of these products have not been quantified. Further, management regimes for joint production of NTFPs and other goods and services (e.g., timber, recreation, water) have not been estimated. These need to happen to allow land managers to better understand economic tradeoffs.

Some households and communities may be particularly reliant on NTFPs for their well-being. A proper accounting of utilization of and dependence on NTFPs by United States households is necessary to determine vulnerabilities to potential future shocks and possible future reliance on safety-net programs if vulnerabilities are not addressed. Also, a better understanding of NTFP contributions above and beyond simple measures of monetary income to household and community well-being will help in determining interventions such as assistance, development, and educational programs. Time series and trend analysis is lacking for the collection and use of NTFPs by households. The role of NTFPs in advancing the standard of living of people engaged in harvest, processing and sale is not fully understood. There is not a clear understanding of the communities (geographic and cultural) that are particularly vulnerable to NTFP species loss or change in distribution. A comprehensive understanding of what motivates and influences people to wild-harvest or forest farm NTFPs is needed.

6.11 Literature Cited

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CHAPTER 7

Laws, Policies, and Regulations Concerning Nontimber Forest Products

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7.1 Overview

The United States regulatory landscape for managing nontimber forest products (NTFPs) is as complex as the broad spectrum of harvesters, consumers, species, and products that make up this category. This overview briefly highlights some of the important historical foundations of United States natural resource laws and introduces more recent concepts and attitudes to management and resource access that are affecting current approaches toward regulation of NTFPs in the United States, which are discussed in this chapter. For a more in-depth discussion of the evolving relationships between people, policies, and NTFPs in the United States and in the global context, see Emery and McLain (2001), Jones et al. (2002), Laird et al. (2010), and Shackleton et al. (2011).

Regulations and policies that address access, management, extraction, trade, and conservation of nontimber forest products exist at multiple governmental levels in the United States (George et al. 1998, McLain and Jones 2002). The basis for these regulations is found in the U.S. Constitution, which defines the authorities between state, Federal, and tribal governments: States are the chief stewards of the wildlife within their borders (U.S. Constitution, Amend. X); the Federal Government has authority "to regulate commerce with foreign nations, and among the several States, and with the Indian tribes" (U.S. Constitution, Art. 1); and, States must regard United States law and treaties as the "supreme law of the land" (U.S. Constitution, Amend. VI), including those clauses that guarantee access for gathering in traditional territories. These underpinnings influenced the early development of United States natural resource laws, creating legal and administrative frameworks that vary within and between local, state, Federal, and tribal jurisdictions and international obligations. The result is that the overall legal framework for NTFPs is often disjointed and ambiguous, with different levels of laws varying in scope, intent, and interpretation. This is a common occurrence with NTFP law and policy around the world (Antypas et al. 2002, Guldin and Kaiser 2004, Jones et al. 2005, Laird et al. 2011, McLain and Jones 2002, Wynberg and Laird 2007).

With the Federal nexus for national natural resource management grounded in jurisdiction and commerce, early approaches to management and access to plants and fungi were aimed at restricting access to resources based on protected status (e.g., state- or Federal-listed species), preventing the spread of plant diseases or invasive species in certain commodity categories (e.g., food or horticulture), or assessing taxes for interstate or international commerce based on the purpose of the extraction (e.g., subsistence, personal, or commercial) (Bean and Rowland 1997). Thus, many of the legal and administrative frameworks that today impact access to and oversight of NTFPs were not promulgated to manage sustainable *use* of these resources; controlling their harvest led to the tendency for laws and policies to be written in reaction to a real or perceived threat of overharvest (Emery and McLain 2001; Laird et al. 2010, 2011; Peyton 2013).

The scope of the earliest natural resource protection laws focused primarily on animals, which has contributed to a disparity in conservation of plants and fungi that has impacted NTFP management. Reflecting the general tendency to focus on animals, plants and fungi were originally excluded from the statutory definition of "wildlife" under the Endangered Species Act (ESA) and the Lacey Act, both of which were amended to include plants, though these acts still differentiate plants as separate entities from wildlife and fungi are not explicitly included in the legal definition of "plants" under these acts (Davoodian 2015, Dunlap 1989, FWS 2015b). As a result, U.S. laws pertaining to the conservation of plants and fungi have not kept pace with animal conservation laws, and the national infrastructure for funding and research is closely associated with game species and other animals (Bean and Rowland 1997, Gilliam 2007, McMahon 1980, Sparling 2014). Bound by the Constitution to uphold Federal laws, state laws and policies often mirror the national regulatory frameworks and state wildlife laws and enforcement efforts have also tended to focus on animals, especially game species (Bean and Rowland 1997, Blevins and Edwards 2009, George et al. 1998, Stein and Gravuer 2008). Although certain Federal legislation exerts authority over animals on nonfederal lands, only state law defines protections for plant species on nonfederal lands (e.g., state, local) and on private property—even for plant species protected under the ESA (Haig et al. 2006). In 1998, of the 45 States with state-level endangered species legislation, only 15 included plants in the definition of "species." By 2008, an additional 17 states had enacted legislation to cover rare or endangered plants, bringing to 32 the number of states that include plants under state conservation laws, though these laws are often weaker than those afforded to animals (George et al. 1998, Stein and Gravuer 2008).

Today, the major principles shaping NTFP regulations and policies in the United States stem from the shift to ecosystem-based management on Federal lands that began in the 1990s and recent steps toward more inclusive approaches to conservation that value NTFPs (Antypas et al. 2002, Bean and Rowland 1997, Laird et al. 2011, Sills et al. 2011). Though the early years of ecosystem-based forest management focused mainly on timber species, the principles of sustainable forest management have raised the visibility of other species, including NTFPs, as integral parts of forest ecosystems and the livelihoods and traditions of forest-dependent human communities (Antypas et al. 2002, Jones and Lynch 2002, McLain and Jones 2002). During this time, NTFPs were incorporated into forest policies (Laird et al. 2011) and to distinguish them from existing policies pertaining to timber became one of the only natural resources defined by what they are not: timber (USDA Forest Service 2008). However, the development of sustainable use and access policies is complicated by lack of species-specific biological information to determine sustainable harvest levels for most NTFP species (Alexander et al. 2002, 2011; Crook and Clapp 2002; Emery and McLain 2001; Guldin and Kaiser 2004; Jones et al. 2002; Mallet 2002; Vance et al. 2001; von Hagen et al. 1996).

In addition to ecological data, development of sound policy also requires solid socioeconomic and market data. The supply chain for botanical raw materials is characterized by multiple actors and institutions that operate at multiple levels of society with linkages across multiple policy domains (Folke et al. 2005, Hayes and Persha 2010, Laird et al. 2010). United States-based studies of the socioeconomic, sociocultural, and domestic and international market-drivers provide important background information for policies on access, resource use, and conservation, however these data are patchy and inconsistent, including for species with significant markets (Alexander and Fight 2003, Danielsen and Gilbert 2002, Emery and McLain 2001, Fisher 2002, Goodman 2002, Jones et al. 2002, London 2002, McLain and Jones 2005, Schroeder 2002). A case study of the floral greens industry exemplifies the complex governance systems that have developed for certain NTFPs in the Pacific Northwest and the unintended inequities and potential consequences for unsustainable management resulting from regulations made in the absence of understanding socioecological aspects of this harvest system (box 7.1). It illustrates how regulations meant to reduce unpermitted harvesting on state lands shifted control of harvest access and sale of the plant resources to the hands of a few, large leaseholders, generating little incentive to harvest sustainably and greater motivation to poach on public lands. It underscores the importance of considering other sectors that may not seem directly related to NTFPs, such as laws and policies dealing with water, labor, or agriculture that impact access or harvest of NTFPs (Laird et al. 2010, 2011; Mitchell 2014).

International policy dialogue and developments around sustainable use and environmental justice have ushered in new policies relating to NTFPs (Bélair et al. 2010; CBD 2004; CITES 2014b, 2014f, 2014h, 2014i; Crook and Clapp 2002; Emery and McLain 2001; FAO 1985; ITTO 1992; ITTO/IUCN 2009; Jahnige 2002; Jones and Lynch 2002; MPSG 2012; MPWG 1995; Weigand 2002a, 2002b, 2002c, 2002d, 2002e). These policy processes have led to:

- Greater recognition of the value and importance of NTFPs.
- Health, livelihood, and economic benefits provided by nontimber forest resources.
- An understanding of the valuable role of traditional ecological knowledge in developing systems to sustainably use and manage biodiversity.
- Growing awareness that ecosystem goods and services of standing forests are greater than destructive values.
- Recognition of the merits of community stewardship and community-based conservation of natural resources.
- Increased awareness and commitments to conserve biodiversity and address conservation challenges on a global scale.

The following sections in this chapter describe specific laws and policies that impact the harvest and management of NTFPs in the United States on the Federal, tribal, state, local, and international levels and the authorities and context within which they are administered. These sections also illustrate some of the differences between laws and policies that directly impact NTFPs and those that indirectly impact NTFPs but that can often have a greater impact than NTFP-

BOX 7.1
CASE STUDY: **Floral greens industry in the Pacific Northwest**

Nontimber forest product policies and regulations exist within complex and dynamic socioecological governance systems. These systems are characterized by the presence of multiple actors (e.g., agencies, private firms, and nongovernmental organizations) (Folke et al. 2005); institutions that operate at multiple levels of society (e.g., local, State, national, and international) (Hayes and Persha 2010); and connectivity across multiple policy domains or sectors of society (Laird et al. 2010). The following example from Washington State's floral greens industry illustrates how NTFP regulations made without considering the broader governance context may have unintended ecological or social consequences (Laird et al. 2010).

Washington State's moist coniferous forests have supplied global and domestic markets with a variety of floral greens since the early 1900s. Leafy branches from salal (*Gaultheria shallon*) are the primary product, but western swordfern fronds (*Polystichum munitum*), common beargrass leaves (*Xerophyllum tenax*), California and red huckleberry branches (*Vaccinium ovatum* and *V. parvifolium*), and a variety of evergreen boughs (i.e., noble fir, *Abies procera*; western redcedar, *Thuja plicata*; etc.) are sold as well. State, Federal, and private land managers in western Washington began regulating the floral greens harvest through permit or short-term lease systems during the mid-20th century. Additionally, State law RCW 76.48 requires harvesters to have written permission from landowners when harvesting or transporting special forest products, including floral greens.

Washington's floral greens sector underwent rapid transformation in the 1990s as product and labor markets became increasingly globalized. The price of floral greens dropped as alternative products became available in countries with lower labor and environmental regulation costs. Unable to compete in the new market conditions, numerous small buying companies went out of business. A handful of large buying companies soon dominated the floral greens export market, where most of Washington's floral greens are sold. At the same time, immigration and trade reforms, notably the 1986 Immigration Act and the 1994 North American Free Trade Agreement, created incentives for residents of Mexico to come to the United States and disincentives for Latino immigrants in the United States to return to their home countries. By the late 1990s, Latino immigrants—many of them lacking documentation to be or work in the United States—comprised the majority of the floral greens labor force.

Lower prices paid to pickers, combined with an excess labor supply associated with restructuring of the floral greens sector, resulted in more intensive harvesting of salal in long-established harvest sites, as well as expansion of harvesting into new areas. As harvesting pressure on salal resources increased, public land managers, as well as private landowners and some pickers and buyers, voiced concerns about overharvest. Here, it is interesting to note that, "Foresters have tried unsuccessfully for decades to eliminate salal, which competes with tree seedlings, from the forests of the Pacific Northwest" (McLain and Lynch 2010:283). Nevertheless, in the subsequent debates over how to address perceived overharvesting of salal, floral greens stakeholders framed the problem as a poaching problem. For State-managed lands, the solution the Washington Department of Natural Resources (DNR) offered was to consolidate numerous small leases into a small number of larger leases, which it then auctioned off to the highest bidder. Under the State lease system, leaseholders may transfer harvesting rights to one or more other persons. However, the primary leaseholder remains responsible for any damages incurred from harvesting activities. From the Washington DNR's standpoint, administration and enforcement for a small number of large leases is less costly and more efficient than for a large number of smaller leases.

Although intended to reduce unpermitted harvesting on State lands, the DNR's shift to larger leases had the opposite effect. Few harvesters or small buying companies had the financial wherewithal to compete against the large floral greens buying companies in leasehold auctions. As a result, the large buying companies acquired exclusive access to the most productive salal grounds on State lands. To gain legal access to those sites, harvesters typically had to agree to sell their salal to the company holding the lease, often at lower prices than they could obtain elsewhere. Under such circumstances, harvesters with legal rights to harvest on company-held leaseholds had no incentive to harvest less intensively. Incentives for poaching on State lands increased as harvesters sought to retain flexibility in where they could sell their products.

If policymakers had understood better the socioecological governance system in which floral greens harvesting was embedded at the turn of the 20th century, they might have identified other, potentially more effective, solutions. Some examples include the following:

- Setting aside some highly productive salal grounds where bidding would be restricted to small firms or harvester associations could reduce the power of large buying companies to control access.
- Economic development policies aimed at improving the capacity of small buying companies to compete in the NTFP sector could increase market competition, and potentially improve the terms of trade for pickers.
- Immigration and labor policy reforms could provide Latino harvesters with a stronger bargaining position vis-à-vis the large buying companies.
- Land use policies aimed at reducing the rate of forest conversion to residential or industrial development would help ensure that an adequate supply of floral greens remains available.

specific laws. Section 7.2 describes three Federal laws that are the primary influences, with some indirect consequences, on NTFP governance across our country and explores access and specific regulations and policies of the five largest land management agencies, responsible for managing more than one quarter of the United States land area. Section 7.3 explores policies that are applicable to indigenous and tribal peoples of the United States and U.S. territories, on Federal, state, and local levels. This section briefly examines the indigenous and tribal peoples' reserved rights to gather and manage traditionally and culturally significant plants and fungi, including NTFPs, and the progress and impediments to fully implementing and incorporating these rights into land management policies and practices. Section 7.4 draws upon examples from several states to look at the diversity of state-level laws and policies impacting NTFPs, which depend largely upon the existence, strength, and scope of state plant conservation laws or upon the agencies enforcing them. Section 7.5 considers additional regulations and policies specific to a city, district, or township, with examples drawn from a variety of localities, that often directly address NTFP access and management with a tendency toward protecting (i.e., limiting access to) resources. Section 7.6 focuses on United States participation in five international forums that have afforded opportunities to engage in a wider array of policy discussions related to NTFPs and which have and could continue to strengthen United States efforts to better manage NTFPs for their important ecological, cultural, and economic value.

7.2 Federal Laws and Administrative Dimensions

The Federal Government manages over 635 million acres of land, 28 percent of the 2.27 billion acres of land (Gorte et al. 2012). Four agencies administer 609 million acres of this land: the Forest Service in the U.S. Department of Agriculture (USDA), and the National Park Service (NPS), Bureau of Land Management (BLM), and U.S. Fish and Wildlife Service (FWS) in the U.S. Department of the Interior (DOI) (Gorte et al. 2012). Federal land ownership is concentrated in the western states and Alaska. In addition, the Department of Defense (DoD) administers 25 million acres in military bases, training ranges, and more. Numerous other agencies administer the remaining Federal acreage (DoD 2016, Gorte et al. 2012). A synopsis of the regulations relevant to NTFPs across agencies, and the policies that shape agency policy with respect to NTFPs is provided for these five major Federal landholding agencies.

7.2.1 Regulations and Policies

The statutes with relevance to nontimber forest resources that apply across agencies include the ESA, the Lacey Act, and the National Environmental Policy Act (NEPA) (Antypas et al. 2002, Sparling 2014).

The Endangered Species Act of 1973, as amended, is one of the most successful United States environmental laws for conserving rare species. It may also be the best known and probably one of the most debated laws that influence NTFP regulation, policy, and management (Antypas et al. 2002, Peyton 2013).

Two factors used to determine the listing of species under the ESA are "overutilization for commercial… purposes" and "inadequacy of existing regulations" (ESA 1973). It follows that regulations and policies that ensure sustainable management of such resources should preclude the need to list species that are harvested as nontimber forest products under the ESA because of those two factors. The ESA also provides a mechanism for protecting "critical habitat": the geographical areas occupied by a species, or physical or biological features that are essential for its conservation, and can include the area that may lay outside the species range that may be needed for special protection and species management (ESA Sec.3.5.A.). These requirements could protect ESA-listed species that are the sources of nontimber forest products and their habitat that may be at risk from exploitation by unsustainable harvesting methods, over harvesting, and habitat degradation. We are not aware of any analyses to determine how many ESA-protected species are harvested as NTFPs. The FWS maintains a database of all ESA-listed species (FWS 2017). Two examples of plant species that are harvested as nontimber forest products and are listed as "threatened" under the ESA are: Appalachian spirea (*Spiraea virginiana* Britt), relatives of which are used in horticulture, and is threatened by habitat alteration and invasives; and Price's potato-bean (*Apios priceana* B.L. Rob), the root of which is used for food, and is threatened by cattle grazing, clearcutting, and herbicide applications along highways. The ESA provides a regulatory framework for the conservation of threatened and endangered plants and animals.

Animals and plants are not treated the same under the ESA, as the ESA defines the term "plant" separately from "wildlife" (ESA Sec. 3.C.8; ESA Sec. 3.C.14). This has indirectly influenced NTFPs as United States plant conservation laws and funding mechanisms to support research and conservation have lagged behind those for animals (Bean and Rowland 1997, Blevins and Edwards 2009, Dunlap 1989, FWS 2015b, George et al. 1998, Gilliam 2007, McMahon 1980, Negrón-Ortiz 2014, Sparling 2014, Stein and Gravuer 2008). Moreover, fungi are not explicitly encompassed in the statutory definition of "plants," which "…includes any member of the plant kingdom…". In practice, fungi have been included under the general term "plants" by FWS (Federal Register 1993b), and two species of lichens (an association between fungi and algae) are ESA-listed as "endangered": rock gnome lichen (*Gymnoderma lineare* (A. Evans) Yoshim & Sharp) (Federal Register 1995) and Florida perforate cladonia (*Cladonia perforata* A. Evans) (Federal Register 1993a). However, the exclusion of fungi from the legal definition of plants has been cited as a hindrance to their conservation (Davoodian 2015). In addition, the ESA prohibits the unauthorized removal or take of listed species which means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (ESA Sec. 3.19). However, unlike the case for animals, the ESA only protects listed plant and fungal species on Federal lands, not on private lands (ESA 1973).

The Lacey Act of 1900 was the first legislative effort to protect wildlife against illegal possession, transportation, and trade (both exporting and importing). Initially, it was enacted to curtail the commercial exploitation and transport of animals in the United States in the early twentieth century (Dunlap 1989, Lacey Act of 1900). Amendments to the Lacey Act in 1981 expanded the law to include *plants* that are taken, transported, or sold in violation of any *state* or *Federal* law. Amendments to the 2008 Farm Bill broadened the purview of the Lacey Act to include plants and plant products obtained in violation of *foreign* laws (generally meaning state- or Federal-listed species) (APHIS 2014, Bean and Rowland 1997, FWS 2014c). Thus, the Lacey Act can be applied to plant species that are protected under state law, under the ESA, or under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Here again, the legal definition of "plants" excludes fungi, although the Lacey Act would enforce violations against any legally protected species (such as the aforementioned lichens). The Lacey Act has been successfully used to prosecute violators involving nontimber forest products, such as CITES-listed American ginseng (*Panax quinquefolius*), which is also regulated under state laws (FWS 2014a). The USDA Animal and Plant Health Inspection Service (APHIS) is responsible for enforcing the Lacey Act and dealing with violations pertaining to plants and plant products. Special permits are required to move regulated plants and their products and a product declaration is necessary to transport plants across domestic and international borders. Similarly, FWS oversees the transport of wildlife parts and products, including animals, fish, birds, and their products that may come from United States forests or forests abroad. For further discussion of the Lacey Act prohibitions related to plants, including violations of U.S. law or tribal law and violations of State or foreign laws, see Alexander (2014).

The National Environmental Policy Act of 1969 establishes specific environmental goals and procedures for the protection and maintenance of the environment and identifies how to implement these goals in Federal policy and management (NEPA 1969). NEPA directly affects Federal agency management of nontimber species, including NTFPs, by mandating detailed environmental analyses prior to inception of activities that may impact federally managed lands. For example, the Forest Service routinely conducts environmental assessments (EAs) for timber projects and prescribed burns; this may include assessment of the impacts on the harvest of an individual NTFP and/or the harvest of multiple products. In the case of the Forest Service Willamette National Forest in Oregon, an EA may include the potential impact of allowing harvesters to access burned areas to collect morels or the EA may detail how boughs may be collected after thinning of a noble fir stand. Certain Forest Service ranger districts may also ask to use categorical exclusion documentation and approval for instances where there is no significant impact, such as the "hand gathering of a variety of special forest products (SFPs) within 150 feet of roads open to public access" (USDA Forest Service 2014).

7.2.2 Federal Agencies That Manage Nontimber Forest Products

The Forest Service is a multiple-use agency that protects and manages 154 national forests and 20 grasslands in 44 states and Puerto Rico, encompassing 193 million acres of land. The Forest Service's mission is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations (USDA Forest Service 2015a). The Forest Service has a long-standing history of managing limited-scale NTFP harvest (Brown 1950, McLain and Jones 2005, Shaw 1949, USDA Forest Service 1928).

The Forest Service's authority to develop and administer rules governing NTFP harvesting on national forest lands stems directly from the "use and occupancy" and "protection" provisions of the Organic Administration Act of 1897 (McLain and Jones 2005). The Organic Administration Act initiated management of the national forests and directed that forests be established to "improve and protect the resources, to secure water, and to furnish a continuous supply of timber" (Chamberlain et al. 2002). Additionally, the act authorizes the Secretary of Agriculture to protect the forests from destruction (USDA Forest Service 2009).

Other major laws that mandate how the Forest Service manages the natural resources under its jurisdiction include:

- The Multiple-Use Sustained-Yield Act of 1960 recognizes timber as one of five major resources for which national forests are to be managed. This act directs the Secretary of Agriculture to develop and administer the renewable surface resources of national forests for multiple use and sustained yield of the many products and services obtained from these resources (USDA Forest Service 2009).
- The Forest and Rangeland Renewable Resources Planning Act of 1974 (as amended by the NFMA), directs the Secretary of Agriculture to periodically assess the forest and rangeland resources of the Nation and to submit to Congress at regular intervals recommendations for long-range Forest Service programs essential to meet future resource needs (USDA Forest Service 2009).
- The National Forest Management Act of 1976, sets forth the requirements for land and resource management plans for the National Forest System (NFS). It also amends several of the basic acts applicable to timber management. It specifically addresses most aspects of timber management and how it is related to other natural resources. It is the primary authority governing the management and use of natural resources on NFS lands (USDA Forest Service 2009).

In addition, Title 36 of the Code of Federal Regulations (CFR 36)—Parks, Forests, and Public Property— is the principle set of rules and regulations issued by federal agencies of the United States regarding parks, forests, and public property.

In the last 15 years, the Federal Government has taken some action toward managing national forests for NTFPs. The Forest Service refers to NTFPs as special forest products and botanicals, which are defined, in Forest Service Handbook (FSH) 2409.18, Chapter 80 [see section 87.05] (USDA Forest Service 2017). In 2000, Congress directed the Secretary of Agriculture to initiate a pilot program to charge, collect, and retain a "fair market value" fee for the harvesting and selling of forest botanical products (FBPs) (Pilot Program 2000). The Pilot Program Act defines FBPs as "any naturally occurring mushrooms, fungi, flowers, seeds, roots, bark, leaves, and any other vegetation (or portion thereof) that grow on NFS lands." This definition has been further refined in Forest Service policy to include "naturally occurring special forest products, including, but not limited to bark, berries, boughs, bryophytes, bulbs, burls, cones, epiphytes, ferns, fungi (including mushrooms), forbs, grasses, mosses, nuts, pine straw, roots, sedges, seeds, shrubs, transplants, tree sap, and wildflowers." FBPs do not include animals, animal parts, Christmas trees, cull logs, derrick poles, fence material, firewood, house logs, insects, mine props, minerals, non-sawlog material removed in log form, posts and poles, pulpwood, rails, rocks, sawtimber, shingle and shake bolts, small roundwood, soil, telephone poles, water, and worms (FSH 2409.18, chapter 80; USDA Forest Service 2017).

Under the Forest Botanical Products Pilot Program, the permit fees collected should cover at least a portion of the fair market value of the product and a portion of the costs incurred by the Forest Service in administering the Pilot Program. The funds collected may be used on the Forest Service unit where collected, for the costs of conducting inventories of FBPs, determining sustainable levels of harvest, monitoring and assessing the impacts of harvest levels and methods, conducting restoration activities, including any necessary vegetation, and covering the costs of the USDA described in the law (USDA Forest Service 2017). Additionally, the pilot program directs the Forest Service to permit limited free use of FBPs and establish a personal use harvest level for each product, below which no fees would be charged. The Pilot Program has been reauthorized several times and currently extends through September 30, 2019 (DOI Appropriations 2000, 2004, 2010, 2014).

American Indian tribes, with treaty or other guarantees, retain their rights to gather plant materials and fungi in accordance with the terms of those agreements and subsequent case law. In administering its obligations to Native Peoples of the United States, the Forest Service engages in public processes to refine policies pertaining to access to forest products that have special cultural and traditional significance, including NTFPs (USDA Forest Service 2017). Section 8105 of the Food, Conservation, and Energy Act of 2008 (also known as the Farm Bill) provides that the Secretary of Agriculture may provide, free of charge to federally recognized Indian tribes, trees, portions of trees, or forest products from NFS lands for traditional and cultural purposes (Cultural and Heritage Cooperation Authority of 2012, Farm Bill 2008). However, section 8105 prohibits Indian tribes from using any of the products provided for commercial purposes (Farm Bill 2008; Cultural and Heritage Cooperation Authority of 2012, Farm Bill 2008). The Forest Service issued an Interim Directive providing short-term direction regarding tribal requests for forest products for traditional and cultural purposes (USDA Forest Service 2015b, Federal Register 2014), and published, for public notice and comment, a proposed rule in the Federal Register on July 31, 2014 (Federal Register 2014). The final rule was published in the Federal Register on September 26, 2016 (Federal Register 2016), which became effective on October 26, 2016. The Forest Service issued a Final Directive, in the Forest Service Handbook (FSH) 2409.18, Chapter 80 [see section 82.5] regarding tribal requests for forest products for traditional and cultural purposes, which became effective January 7, 2017 (USDA Forest Service 2017).

The Forest Service provides public access to NTFPs primarily through its timber sale regulations and policies on the sale and disposal of National Forest System timber, special forest products, and FBPs (CFR 36, section 223). In general, Forest Officers may sell other forest products under the timber regulations (CFR 36, section 223.1) when it would serve local needs and meet management objectives (USDA Forest Service 2002). Fair market value is estimated and a permit or sale contract is required when product supply is limited, the product has value, the permittee intends to sell the product, or when issuing a permit constitutes a special benefit not generally available to the public (USDA Forest Service 2017, 2015b). Fair market value is determined by appraisal estimates or other approved methods authorized by the Forest Service Chief through issuance of agency directives (CFR 36, section 223.60). Additionally, timber regulations provide for free use of timber and other forest products under conditions as set forth at Title 36 of CFR, sections 223.5–223.11. Furthermore, Title 36 CFR, section 261.6, describes the Secretary of Agriculture's prohibitions associated with sale and disposal of timber and other forest products.

As a result of the Forest Botanical Products Pilot Program, the Forest Service in 2001 developed a national strategy for SFPs that "sets forth Forest Service strategic goals and suggests key actions for managing renewable resources associated with SFPs within the framework of ecosystem management" (USDA Forest Service 2001). Additionally, the 2012 NFS land management planning final rule (CFR 36, section 219), "is designed to ensure that plans provide for the sustainability of ecosystems and resources; meet the need for forest restoration and conservation, watershed protection, and species diversity and conservation; and assist the Agency in providing a sustainable flow of benefits, services, and uses of NFS lands that provide jobs and contribute to the economic and social sustainability of communities" (Federal Register 2012). Rather than rely solely on the timber sale regulations for the sale and disposal of SFPs and FBPs, in 2007 the Forest Service developed a regulation that would govern commercial harvest and sale of SFPs (Title 36 CFR, section 223) and revise the regulations for their limited free use and personal use (CFR 36, section 261.6) (Federal Register 2007, 2008, 2009a, 2009b, 2009c). Additionally, it would establish the Pilot Program for Forest Botanical Products and contain regulations governing their free, personal use (Title 36 CFR section 223, adding subpart H). Though these amendments were originally intended to go into effect January 2009 (Federal Register 2008), the comment period was instead reopened in early 2009 and implementation was delayed twice (Federal Register 2009a and Federal Register 2009b), before being delayed indefinitely citing the need to have more time for the Forest Service to properly respond to the comments and to consider any potential changes to the rule (Federal Register 2009c).

The Bureau of Land Management, part of the U.S. Department of the Interior, is charged with managing approximately 245 million acres of land mostly in the Western United States and Alaska (BLM 2014). The BLM uses the term "special forest products" and describes the products as "vegetative material found on public lands that can be harvested for recreation, personal use, or as a source of income" (BLM 2015b). The BLM includes in the term grasses, seeds, roots, bark, berries, mosses, greenery (e.g., galax, fern, fronds, salal, and huckleberries), edible mushrooms, tree seedlings, transplants, poles, posts and firewood. The BLM manages SFPs under any of three resource-use categories: incidental, personal, and commercial use. NTFP management, administration, and monitoring on BLM lands often occurs at the district or unit level. District managers and other resource area managers may administer collection permits and conduct inventories, sales of projects, and law enforcement to prevent NTFP theft (Antypas et al. 2002). The BLM typically provides guidelines to the public for appropriate harvesting techniques and may include specific information for restrictions on where and how much of the NTFP may be harvested. They also keep track of common products that are permitted and sold. NTFPs are typically sold by the BLM through negotiated sales, advertised sales, and leases (Alexander 2011, Antypas et al. 2002). Because harvesting for personal consumption may not require a permit on some BLM lands, the available permit data are less than a perfect estimate of actual harvest (Alexander 2011).

The BLM works closely with other Federal agencies, such as the Forest Service, to administer collection permits for NTFPs and to address conservation and restoration needs. BLM chairs the Federal Native Plant Conservation Committee, comprising twelve Federal agencies that collaborate on conservation needs for native plants (including fungi) and their habitats and coordinate implementation of programs to address those needs (BLM 2014). This group is currently developing a national seed strategy to guide development, availability, and use of seed needed for timely and effective restoration (BLM 2015a), and has a standing working group on the sustainable use and conservation of medicinal plants, called the Medicinal Plant Working Group (Heywood and Dulloo 2005).

The National Park Service manages 401 parks encompassing 84.5 million acres of public land in the 50 states and four territories (NPS 2014). The NPS mission is to "preserve unimpaired the natural and cultural resources and values of the national park system," so lands are managed for ecological integrity and non-consumptive recreation (Antypas et al. 2002, NPS 2014). The NPS recognizes the cultural and economic value of plant and fungal species on parklands and the importance of preserving their biodiversity for conservation and restoration of all species native to park ecosystems (NPS 2014). Thus, national parks can serve as refugia for nontimber forest product species and populations.

The sale and commercial use of natural products is prohibited on parklands (Federal Register 1983). Parks may issue written authorization for the public to harvest "certain fruits, berries, or nuts" where specifically authorized by the park unit for personal consumption and for cultural purposes, so long as the consumptive use does "not adversely affect park wildlife, the reproductive potential of a plant species, or otherwise adversely affect park resources" (Federal Register 1983, NPS 2006). Similar to the Forest Service, NPS units are managed with a certain degree of autonomy, giving discretion to park supervisors to decide whether or not permits or fees are required for consumptive harvest of plant resources, where and how much may be gathered, or to restrict possession of natural products altogether (Antypas et al. 2002; CFR 36, section 2.1(c); Federal Register 1983).

Park Service policy requires data collection to assess native plant population trends. In addition to conserving and preventing detrimental effects to ESA-listed species, Park Service policy is to inventory, monitor, and manage species listed by states and local institutions to the extent possible and to work with surrounding landowners to suggest mutually beneficial harvest regulations for populations that range outside of park boundaries (NPS 2006, 2014). Many Parks make this information available through their websites or otherwise provide this information upon request. The NPS maintains the Forest Health Advisory System, which monitors and projects risks to tree species in forest ecosystems (NPS 2017).

Poaching is one of five categories of threats to resources on national park lands (GAO 1996, NPS 2014). Many NTFPs are illegally harvested and removed from Park Service lands, including mushrooms, mosses, slippery elm bark, galax, cacti, and American ginseng (GAO 1996, NPS 2014, Pokladnik 2008). The NPS has increased the level of awareness, prevention, and law enforcement investigative efforts directed toward environmental crimes, including illegal harvest of NTFPs (NPS 2003, 2004, 2014). Significant effort has been given to protecting certain plant species that are harvested as nontimber forest products on park lands, including the use of dyes to mark American ginseng roots (Bolgiano 2000, Corbin 2002) and inserting microchip identification tags into saguaro cacti (Small 2014, Thornton 2008). NPS does not maintain comprehensive records of poaching information in their parks.

The National Park Service opened a public comment period, in April 2015, on a proposed rule to authorize agreements between the National Park Service and federally recognized Indian tribes to allow the gathering and removal of plants or plant parts (including mushrooms) by designated tribal members for traditional purposes (Federal Register 2015). The agreements would facilitate continuation of tribal cultural traditions on associated lands included within units of the National Park System without a significant adverse impact to park resources and values. The proposed rule respects tribal sovereignty and the government-to-government relationship between the United States and the Tribes, and would provide systemwide consistency to this aspect of National Park Service-Tribal relations. The proposed rule would provide opportunities for tribal youth, the National Park Service, and the public to understand tribal traditions (Federal Register 2015).

The U.S. Fish and Wildlife Service manages more than 150 million acres of public lands, including 562 National Wildlife Refuges and 6 National Monuments, and is the third largest Federal land management agency after the BLM and the Forest Service (Antypas et al. 2002, FWS 2014c). The Service's major landholding is the National Wildlife Refuge System. The Refuge System is administered for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats and includes a suite of habitats ranging from wetlands and prairies to temperate and boreal forests (FWS 2014c). Though NTFPs and species management are not specifically mentioned, several Refuge mandates, authorities, and policies pertain to management and access to nontimber forest product management (Antypas et al. 2002; FWS 2012, 2014b):

- The Alaska National Interest Lands Conservation Act of 1980 (ANILCA) added or consolidated legislation for the refuges in Alaska, requiring comprehensive conservation plans, and providing for subsistence use and other traditional activities (ANILCA 1980).
- The National Wildlife Refuge System Administration Act of 1996, as amended by the Refuge Improvement Act of 1997, has a key aspect that authorizes the Secretary of Interior to "permit the use of any area within the System for any purpose, including but not limited to hunting, fishing, public recreation and accommodations… whenever he determines that such uses are compatible with the major purposes for which such areas were established" (NWRSA 1966).
- Executive Order 12996 of 1996 defines a conservation mission for the Refuge System and four guiding principles, including providing opportunities for appropriate public use; ensuring the maintenance of the biological integrity and environmental health of the System; and cooperating with other Federal and state agencies, tribes, organizations, industry, and the public in the management of refuges (EO 12996).
- The Refuge Planning Policy of 2000 establishes requirements and guidance for refuge planning, as implemented in Part 602 of the FWS Policy Manual, and includes plant species and their habitats in the considerations of target species and issues of interest (FWS 2015b).
- Compatibility Policy of 2000 defines compatible use as "a use of a national wildlife refuge that will not materially interfere with or detract from the fulfillment" of the refuge mission or purposes, and describes responsibilities associated with the mandate to sustain, restore, and enhance wildlife and plants to include protection, research, census, law enforcement, habitat management, propagation, live trapping and transplantation, and regulated taking, as implemented in 603 FW 2 (FWS 2015b).
- Biological Integrity, Diversity, and Environmental Health Policy of 2001 describes how populations are managed to maintain and restore biological integrity, diversity, and environmental health on refuges, as found in 601 FW 3 (FWS 2015b).

The FWS Office of Law Enforcement (OLE) plays a leading role in protecting wild resources in the United States (Blevins and Edwards 2009). Much of the OLE efforts focus on investigating Federal crimes against endangered species and regulating interstate and international trade in species listed in CITES (Blevins and Edwards 2009, FWS 2014c). The OLE purview includes violations of the ESA as well as the Lacey

Act, and requires collaboration across local, state, and Federal jurisdictions and agencies (Wyler and Sheikh 2013). The FWS maintains a team of Federal Wildlife Officers that patrol the 150 million acre Refuge System, and is experiencing an increase in violent crime against persons and a resultant decrease in detection of natural resource crimes (FWS 2014c). Enforcing, investigating, and prosecuting environmental crimes requires coordination among other Federal agencies (e.g., FWS-Office of Law Enforcement, Department of Homeland Security-Customs and Border Patrol, APHIS, and the Department of Justice-Environmental and Natural Resource Division) as well as local, state, and district entities (e.g., state police, sheriff, and the state court system) (Wyler and Sheikh 2013).

The Department of Defense (DoD) manages 25 million acres of public land (DoD 2016). The major legislation concerning natural resource management on DoD lands is the Sikes Act, as amended, directing the Secretary of Defense to carry out conservation and rehabilitation programs on military lands (DoD 2016, USAEC 2015). All DoD components develop mandatory ecosystem-based Integrated Natural Resource Management Plans that address natural resource management in relation to mission requirements and land use activities (DoD 2013, USAEC 2015). DoD's Natural Resources Program has national policies on the management of "forest products," defined as including, *but not limited to* [emphasis added], standing timber/trees, downed trees, and pine straw (DoD 2013), and so would include nontimber forest products.

The DoD generally allows public access on its land, though such access was curtailed or prohibited after the terrorist attacks in 2001 (Emery et al. 2004). DoD policy indicates that forest products "shall not be given away," that marketable products must be appraised at "fair market value," and that "Forest products may be commercially harvested to generate electricity, heat, steam, or for other" uses that are consistent with the mission, laws, and management plans (DoD 2013). Like other agencies, actual fees and harvest requirements are managed at the installation level. Proceeds from forest products sales are remitted to the installation to cover the costs associated with the production and sale of the products. Of any net proceeds, 40 percent is distributed as "State entitlements" for use on county roads or schools. The remaining 60 percent of net proceeds goes to a DoD Forestry Reserve Account general fund to be reallocated for forest-related management activities or equipment (DoD, n.d.; USAEC 2015).

DoD (2013) environmental regulations allow use of lands by American Indians for traditional and subsistence purposes as long as such uses do not compromise department interests and mission. In addition to the national laws, policies, and authorities followed by all Federal agencies DoD has numerous directives, instructions, and policies aimed at implementing procedures for DoD interactions with federally recognized tribes (DoD 2006). Some research has been conducted on military lands to serve as models for assessing ethnobotanical resources (Anderson et al. 1998, 2001; Rush 2012).

7.2.3 Summary of Federal Regulations and Policies

Federal agencies implement national programs, manage lands, and collect data that include or relate to nontimber forest products, and taken together the policies and institutions involved have significant capacity for managing nontimber forest products. However, other bodies of law indirectly impact NTFP management and use, including land tenure and resource rights law, and can create complexity in the regulatory landscape. At the same time, as noted earlier, inconsistencies in local, state, and Federal approaches persist, although efforts exist to coordinate NTFP harvesting and management strategies for selected species across the Nation. Challenges remaining in NTFP regulation at the Federal level include: resolving permit ambiguities; prioritizing and obtaining the resources and data to develop sustainable harvest plans; reconciling chain-of-custody issues for commercial species; poaching; incorporating market and socioeconomic considerations into planning; and a better understanding of the role that tribal and cultural uses of NTFPs play in stewardship of the resource. Raising the visibility of nontimber forest products within the Federal infrastructures and enhancing interagency coordination of natural resource management could greatly improve management and conservation of nontimber forest species.

7.3 Policies Applicable to Indigenous Peoples

Four canons of United States law guarantee access to NTFPs for cultural and material purposes for specified populations, including indigenous peoples: (1) subsistence provisions of the Alaska National Interest Lands Conservation Act of 1998 (rural Alaskans), (2) the Hawai'i State constitution (Native Hawaiians; Article 12 sec. 7), (3) Native Hawaiian Health Care legislation (42 U.S. Code Chapter 122 sec. 11701), and (4) Federal Indian Law, including the Federal Indian trust responsibility (See Seminole Nation v. United States, 1942). The Federal Indian trust responsibility is a "legally enforceable fiduciary obligation on the part of the United States to protect tribal treaty rights, lands, assets, and resources" of federally recognized American Indian and Alaska Native tribes and villages (Bureau of Indian Affairs 2015). The trust responsibility has been reaffirmed through Congressional treaties, Presidential executive orders, judicial rulings, and other legally binding agreements that establish a Federal/tribal government-to-government relationship on par with United States relations with foreign countries (Bean and Rowland 1997, Fisher 2002, George et al. 1998, Goodman 2002, Gross 1981, Sparling 2014). Indigenous peoples of the affiliated territories of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI) are party to other treaties or agreements that provide for unique relationships with the United States Government (Trask 1991). Palau, the Federated States of Micronesia, and the Marshalls are former United Nations trust territories, now sovereign nations, which have signed treaties called "Compacts of Free Association" with the United States ("Freely Associated States"). Multiple international and Federal policies apply to these indigenous groups' access to and utilization of nontimber forest products derived from public, private, and tribal lands within the jurisdiction of the United States (Allen 1989), including conservation of such resources (Schmidt and Peterson 2009). The regulatory and policy interplay at the state-tribal levels is beyond the scope of this report. However, Jones et al. (2002) explores NTFP tenure issues on Federal land and across governmental jurisdictions in chapters by Danielsen and Gilbert (2002), Fisher (2002), Goodman (2002), London (2002), and Schroeder (2002).

7.3.1 National Laws and Authorities

A number of laws and authorities may be particularly germane to U.S. indigenous peoples' access to NTFPs in an era of changing climates. The rights of American Indian, Eskimo, Aleut, and Native Hawaiians to harvest sacred plants is included under the American Indian Religious Freedom Act of 1978 (McLain and Jones 2005). Any NTFPs used for religious purposes would be subject to this authority. Under the National Historic Preservation Act (NHPA) of 1996, the Government is required to consult with any American Indian tribe or Native Hawaiian organization that attaches religious and cultural significance to properties (see section 101(d) (6) (B) of NHPA). Traditional gathering or ceremonial sites or areas (e.g., Traditional Cultural Property districts) in which NTFPs are harvested and/or processed may be covered by this act.

A number of provisions specific to USDA pertain to indigenous peoples' access to NTFPs. The American Indian Agricultural Resources Management Act (1993), pertains to "agricultural products" including crops, livestock, forage and feed, grains, and *other marketable or traditionally used materials*, with the latter applicable to some NTFPs (italics added). Under the act, resource management plans on Indian agricultural lands must "produce increased economic returns, enhance Indian self-determination, promote employment opportunities, and improve the social and economic well-being of Indian and surrounding communities" (Cultural and Heritage Cooperation Authority of 2012, section 3055). The Farm Bill of 2008 (technically known as the Food, Conservation, and Energy Act) gives broad discretion to the Secretary of Agriculture to provide Indian tribes access to forest products in the National Forest System free of charge for traditional and cultural purposes, as long as the products are not used for commercial purposes (Cultural and Heritage Cooperation Authority 2012). In addition, the Forest Service, Sale and Disposal of National Forest System Timber, Special Forest Products and Forest Botanical Products policy "respects treaty and other reserved rights retained by Tribes, and recognizes the importance of traditional and cultural forest products in the daily lives of Indians." The Forest Service also has regulations specific to the use of forest products on national forest lands by American Indian and Alaska Native tribes for traditional and cultural purposes (25 USC 32.3055). Section 8105 of the 2008 Farm Bill creates an exception to a National Forest Management Act requirement to sell certain forest products. Section 8105 provides the Secretary of Agriculture with discretionary authority to provide trees, portions of trees, or forest products to federally recognized Indian tribes, free of charge, for noncommercial traditional and cultural purposes. Additionally, section 8105 has been codified in the Cultural and Heritage Cooperation Authority. After due process, The Forest Service issued a Final Directive in the Forest Service Handbook (FSH 2409.18, Chapter 80 [see section 82.5]) regarding tribal requests for forest products for traditional and cultural puposes.

Executive Order (EO) 12898 was issued in 1994 to “address environmental justice in minority and low-income populations (EO 12898). This order created an interagency working group on environmental justice and required the development of agencywide environmental justice strategies (US CCR 2003). Section 6-606 of EO 12898, entitled “Native American Programs,” requires that each Federal agency responsibility set forth under this order shall apply equally to American Indian programs. In addition, the Department of the Interior, in coordination with this working group, and, after consultation with tribal leaders, shall coordinate steps to be taken pursuant to this order that address federally recognized Indian tribes. In late 1994, the USDA formulated a plan to ensure that environmental justice principles and initiatives were incorporated into Departmental programs, policies, planning, public participation processes, enforcement, and rulemaking (USDA 2012). In the initial years after the EO 12898 was issued, forest plans included an environmental justice analysis as part of Environmental Impact Statements (USDA 1994). By 2000, forest planning guidance specified particular coordination, consultation, and interactions required with American Indian tribes and Alaska Natives, including the consideration of tribal data and resource knowledge (Code of Federal Regulations, Title 36; see section 219.12-18). In its 2012–2014 Environmental Justice Action Plan, USDA references specific activities under way, including consulting and coordinating with tribal governments as set forth in Executive Order 13175 (EO 13175, USDA 2012). The 2010 USDA Consultation Action Plan identifies “Forest Products, Forest Management, and other Forest-Related and Conservation-Related Issues” as topics for issue-specific regional consultations (USDA 2009).

Regulatory mechanisms and policies since the 1990s have provided greater opportunities to employ TEK in land management. For example, the National Indian Forest Resources Management Act of 1990 directed the Secretary of Agriculture to “undertake forest land management activities on Indian forest land, either directly or through contracts, cooperative agreements, or grants under the Indian Self-Determination Act (1975). “Indian forest land” means Indian lands, including commercial and noncommercial timberland and woodland, that are considered chiefly valuable for the production of forest products or to maintain watershed or other land values enhanced by a forest cover, regardless of whether a formal inspection and land classification action have been taken. Land management activities specifically covered by this act include forest product marketing assistance, including evaluation of marketing and development opportunities related to Indian forest products and consultation and advice to tribes, tribal and Indian enterprises on maximization of return on forest products. Under this act, “forest products” include bark, berries, mosses, pinyon nuts, roots, acorns, syrups, wild rice, herbs, and other marketable material. This act led to the formation of the Indian Forest Management Assessment Team, which has since produced three periodic assessments of Indian forest land management in the United States (IFMAT 1993, 2003, 2013). These assessments have shown that Indian forest lands are among their most valuable resources. Of particular interest with regard to NTFPs, the allotment system created in the 1880s to transfer ownership of parcels of land from tribes to individual Indians has contributed to an increasingly fragmented land ownership structure today that “increases management costs, limits forest products marketability, frustrates landscape-level management, results in an uneven distribution of management constraints between allotment owners, and reduces the economic development potential of Indian forest assets” (IFMAT 2013).

The Tribal Forest Protection Act of 2004 (TFPA), authorizes the Secretaries of the Interior and Agriculture to enter into an agreement or contract with Indian tribes meeting project selection criteria established in the act to carry out projects on NFS lands to protect Indian forest land, rangeland, or tribal communities when the NFS lands are bordering or adjacent. An Indian tribe may enter into a contract or agreement to achieve land management goals for Federal land that is under the jurisdiction of the Secretary, bordering or adjacent to the Indian forest land, or on rangeland under the jurisdiction of the Indian tribe. A 2013 analysis of the TFPA, conducted jointly by the Intertribal Timber Council in collaboration with the Forest Service and Bureau of Indian Affairs (BIA), found that it had been underutilized in the time since the passage of the act, with only six of eleven proposals that were accepted having been successfully implemented. Among the findings were that perceptions differed among tribes, the BIA, and Forest Service on implementing the TFPA; Tribes were reticent to enter into agreements due to concerns about the approval process and duration; and funding for the TFPA relied largely on Congressional appropriations because of a decline in value for forest products (ITC 2013).

7.3.2 Native Peoples of Alaska, Hawai‘i, and U.S. Territories

Alaska Natives are unique in that many tribes have governments and corporations that have entered into agreements with the United States that reaffirm Alaska Native access to and utilization of resources, including a range of nontimber forest products for traditional, subsistence, and commercial uses. Approximately 52 percent of the land area of Alaska is managed as public lands, and another 124 million acres as state lands (Schroeder 2002). Most Federal lands in Alaska are managed by the BLM (74.7 million acres) followed by FWS (69.4 million acres), NPS (53.8 million acres), Forest Service (21.9 million acres) and DoD (2.2 million acres). The Alaska National Interest Lands Conservation Act of 1980 (ANILCA) establishes that all rural residents be given “reasonable access to subsistence resources on the public lands” (ANILCA 1980). Thus, under ANILCA, subsistence is open to native and nonnative rural residents of Alaska (PEER 2010). Federal and state agencies are also required to undertake research on fish, wildlife, and subsistence use on public lands, including seeking information and data from those engaged in subsistence uses. Federal agencies and the state of Alaska have developed policies and manuals to facilitate collaboration, consultation, and planning to implement programs under this act (AK DNR 2010; Antypas et al. 2002; FWS 2012, 2014b).

Native Hawaiians retain some rights applicable to nontimber forest product use for traditional and cultural purposes under Federal and state authorities and policies. Regulations and policies pertaining to indigenous and tribal peoples of the Pacific Islands and affiliated territories include acts or proclamations that allow the religious or ceremonial take (i.e., harvesting and gathering) of park natural resources, as under the National Park Service’s regulations on the “Preservation of natural, cultural, and archeological resources” (36 CFR 2.1(a), (d)). For example, in Volcanoes National Park of Hawai‘i, persons of Native Hawaiian ancestry may collect “natural products…in keeping with the traditions that are rooted in the aboriginal religious practices of the Native Hawaiian people” (PEER 2010). In the National Park of American Samoa, “gathering uses shall be permitted in the park for subsistence purposes if such uses are generally prior existing uses…and if such uses are conducted in the traditional manner and by traditional means” (16 U.S.C. 410qq-2). In American Samoa, the national park is unique—the land is not Federal; it is still owned under the traditional, communal, chiefly system, but is about 20 years into a 50-year lease with the National Park Service (Forestry Program 2010). The National Park Service also implements a Park Ethnography Program, which was integrated into Park Service policy through NEPA and the American Indian Religious Freedom Act of 1978 (Crespi 2003). This program has produced a variety of information on cultural uses of Park resources by American Indian, Alaska Native, Pacific Islander, and other indigenous peoples.

In Guam, regulation for access to and use of NTFPs is covered in part under the Endangered Species Act of Guam (2006), which specifies different uses of habitats and resources by the residents of Guam, many of whom are indigenous people. Section 63304, Forestry Program, recognizes that “trees provide materials for carving and for weaving and which are needed to teach these arts to the future generations of Guam.” Under this act, “the Department of Agriculture shall be responsible to protect, develop and manage the Territory’s public lands in a manner that will conserve the basic soil resources, and at the same time produce continuous yields of water, wood fiber, forage, recreation and wildlife for the use and benefit of the greatest number of people of Guam. The Department shall also endeavor to encourage and assist private land owners to do the same with their land, and establish an urban and community forestry program with village commissioners and civil groups.” Licenses are required for cutting, removal or “mutilation” of live trees on all public lands. Written requests for such licenses are reviewed and granted by the Director of Agriculture, when satisfied “that such cutting or removal will not materially injure the forest resources of Guam.” Guamanian law sets aside some land exclusively for Chamorros (indigenous peoples of the Mariana Islands).

The Constitutions of the Territory of American Samoa and CNMI define rights and privileges of indigenous peoples with respect to land ownership (OTA 1987). Palau, the Marshall Islands and the Federated States of Micronesia are eligible for Forest Service financial and technical assistance as if they were domestic states (Cooperative Forestry Assistance Act 1978). The Constitutions and laws of these countries address land tenure and other rights of their own citizens, including indigenous peoples and local land tenure systems.

7.3.3 Summary

American Indians, Alaska Natives, Native Hawaiians, and indigenous and tribal peoples of U.S. territories have different regulations, authorities and policies governing their access to and harvest of nontimber forest products, or more fundamentally, governing the nature of land tenure encompassing such resources. The right to gather has been described as a “reserved property right” (Goodman 2002), and these access rights vary on ceded and reserved territories, across land management agencies, and from state to state (Allen 1989, Bean and Rowland 1997, Danielsen and Gilbert 2002, Fisher 2002, Goodman 2002, IFMAT 2013, London 2002, Schroeder 2002, West 1992). Some American Indian tribes with ceded and reserved lands that span multiple Federal and state jurisdictions have formed Commissions or Corporations to enhance their self-regulatory rights to manage and access natural resources (Danielsen and Gilbert 2002, Fisher 2002, London 2002). Statutes and Executive Orders have laid the groundwork for more inclusive approaches to management and access, and are being built into state and Federal agency policies to facilitate implementation (AK DNR 2010; Antypas et al. 2002; FWS 2012, 2014b; USDA 2009). Assessments of some of these laws and policies related to American Indians, Alaska Natives, and Native Hawaiians have gauged progress and demonstrated successes in engaging Indians and Indian cultural knowledge into forest management (IFMAT 1993, 2003, 2013; ITC 2013). These assessments also highlight areas where more work is needed and provide tangible targets for improvement. Recent management policies also have created mechanisms for wider use of traditional and local ecological knowledge in the management of forested lands, although the lack of contemporary research documenting these practices hampers progress in this area (Charnley et al. 2008).

7.4 State Laws and Administrative Dimensions

State regulations must comply with Federal regulations, but otherwise states may regulate NTFPs at their discretion. It is important to consider how NTFPs are defined under state law to understand the impact and scope on plants that are harvested as NTFPs. While NTFPs are generally understood to be plants, they are often defined more broadly (USDA Forest Service 2008). State policies and regulations vary widely, with some states having no specific policies or regulations governing NTFPs (e.g., Idaho), while other states specifically mention NTFPs (e.g., Arizona, Washington). State laws that impact plant or fungal species that are harvested as NTFPs generally do so in one of four ways: (1) as plants in general, (2) by species, (3) by activity or product, or (4) by habitat. The agencies that oversee NTFPs are as varied as the diversity of policies and regulations.

7.4.1 State Regulatory Agencies

Almost all laws and policies directly related to NTFPs are efforts to conserve or sustainably manage these resources (Laird et al. 2010). Nontimber plant and fungal resources may be managed by a variety of agencies, including the State Departments of Natural Resources, State Forestry Departments, and State Departments of Agriculture. Other agencies, such as State Parks and Recreation Agencies, Fish and Wildlife Agencies, Water Management Districts, may also be involved in implementing policies that impact species that are harvested as nontimber forest products (Mitchell 2014). The number of management agencies involved in NTFP regulation creates a complex set of issues when seeking to coordinate management strategies within and between states. Policies generated from diverse State regulations related directly or indirectly to NTFPs vary for each State. State regulations range from few specific NTFP regulations (Utah) to highly regulated NTFP environments

(Oregon, Washington). Further, regulations may address only one or some NTFPs or encompass all NTFPs categorically. The variability and degree of management is reflected in examples of different State strategies.

State forests are mandated to manage resources for multiple-uses and some states recognize and incorporate NTFPs as a permitted use and as an income producing strategy. With this mandate, states could integrate NTFPs within forest management for multiple-use, sustainability, biodiversity, conservation, enhanced ecosystem functions, restoration, and recreation and tourism. The wide range of NTFPs collected and harvested for personal and/or commercial use makes managing for these products a challenge for states. Some State forests that allow the harvest of NTFPs use a permit system to generate income and/or to track and monitor harvests. For example, Florida issues permits for a variety of forest products. Saw palmetto (*Serenoa repens*) berry harvest permits cost $10 per day per person with no harvest limit (Mitchell 2014), while grunting (worm harvesting) permits are $55 per site per year (FDACS 2016). How each state manages income from NTFP permitting is as variable as the agencies that manage them and the regulations that define them. Some states (e.g., Oregon, Washington) use the revenues from harvest permits to support schools (ODF 2009, WA DNR 2013).

The Oregon Department of Forestry (ODF) has administrative responsibilities for the harvesting of NTFPs from state forest lands. The ODF established different guidelines for personal and commercial use of these products and has designated allowable harvest volumes for the products since 2006. Personal use collection does not require a special permit, and amounts are limited depending on the NTFP, and are regulated per vehicle, not per person. For example, 1 gallon of mushrooms may be harvested for personal use, while 16 grocery bags of common beargrass (*Xerophyllum tenax*), boughs, ferns, and huckleberry can be harvested for personal use as well (ODF 2015a). Commercial NTFP collection requires permits that vary in cost depending on the product. For example, common beargrass permits are based on district policy, which are variable, while huckleberry plants or cuttings will cost $100 per 130 plants, with permit conditions including a $100 minimum, permits of 1 month duration, and available only in $100 increments (ODF 2015b).

In Pennsylvania, the Bureau of Forestry has management responsibilities for NTFPs on state lands. The Bureau is responsible for overseeing the state's moratorium on the permitted harvest of American ginseng from state forests, and permits for NTFPs with potentially critical management issues such as rare clubmoss/princess pine and clubmoss (both *Lycopodium* spp.) and goldenseal (*Hydrastis canadensis*) are judiciously issued by district foresters (Pennsylvania Bureau of Forestry 2003). NTFPs are directly included in the State Forest Resource Management Plan, with emphasis on understanding the issues surrounding NTFPs and developing effective strategies for managing these resources (Pennsylvania Bureau of Forestry 2016). The concern for the sustainability of the target species and impacts on forest health are the primary motivations behind these management plans and determine which species and how much can be harvested from state lands. Recently updated, a notable change in the Pennsylvania State Forest Management Plan was to subsume NTFP management into the chapter on timber management because "we felt that nontimber forest products are not critical enough in State forest management to warrant their own chapter" (Pennsylvania Bureau of Forestry 2015, page 2). The state's goals for NTFP management include: (1) manage harvest of NTFPs through permits; (2) develop mechanisms to determine the sustainability of nontimber forest product consumption at the district level; (3) develop and implement guidelines for harvest restrictions and remedial activities of nontimber forest products; and (4) build and strengthen relationships with partners interested in the conservation of ginseng and other nontimber forest products (Pennsylvania Bureau of Forestry 2016).

Some State Departments of Natural Resources have regulations for the collection of nontimber forest products from State lands. According to the Iowa Department of Natural Resources (DNR), which administers harvesting of certain "plant life" on State parks and recreation areas, unless otherwise posted State parks and recreation areas are open to the harvest of many species that would be considered NTFPs (e.g., mushrooms, berries), and American ginseng, in particular, cannot be harvested from Iowa State parks (IA DNR 2015). The Washington State DNR offers opportunities for personal and commercial harvest of NTFPs on lands managed by that agency. There are harvest limits for personal use consumption of a variety of plant or fungal materials on

State lands. Limits have been established for the personal use harvest of mushrooms, fiddlehead ferns, cones, common beargrass, conks, and firewood (WA DNR 2015). Washington DNR distinguishes between personal and commercial use, with commercial harvest requiring permits issued by DNR. Most funds generated from these permits in Washington go to State educational trusts. Washington defines SFPs within State statutes and further legislates quantities that define personal or commercial use and directs how harvesters may access products (from landowners, permission through permit or not), and further how one may harvest, possess, and transport plants and products (Washington State Legislature 2015).

In Florida, lands managed by the Florida Fish and Wildlife agency do not permit the harvesting of NTFPs, while some State-managed forests in Florida allow harvesting but implementation of the policies varies and is dependent on individual forest management plans and forest managers. While Florida State regulation requires that State forest management plans include income producing activities, NTFPs are not often directly considered. For example, Florida's Wakulla State Forest includes multiple-use potential and income producing activities (i.e., recreation, grazing, rentals, timber sales, and apiaries), but the collection of saw palmetto berries is absent from the plan even though this NTFP is a resource on the forest (Florida Division of Forestry 2005). Meanwhile, Florida's Goethe State Forest Management Plan specifically includes NTFPs as an income producing activity within its goal of sustainable forest management, specifying that these miscellaneous forest products include "palmetto drupes (berries), firewood, pine straw, apiary leases," and more (Florida Division of Forestry 2013). NTFP definitions, policies, and associated regulations vary not only within states and agencies but across all states.

The Utah Division of Forestry, Fire, and State Lands directs people wanting permits to harvest Christmas trees or firewood to the USDA Forest Service or the BLM. The State's Forest Resource Assessment and Strategy Guide (UT DNR 2010) mentions forest products but is not specific about the harvesting or income potential of NTFPs. In Puerto Rico, State wildlife and forestry laws prohibit collecting any plant part on State lands without a collecting permit from the Puerto Rico Department of Natural and Environmental Resources, and these permits are usually allowed for scientific purposes only (Commonwealth of Puerto Rico 1999, 2000; PRDNER 2005).

7.4.2 Regulation of Plants on State Lands

The variability between resource management agencies and their definition and regulation of NTFPs on State public lands creates challenges. Native and protected plant laws are variable by State. Not all states have plant protection laws. As of 2008, 32 states include plants under State conservation laws (George et al. 1998, Stein and Gravuer 2008). Some states have broad native plant protection laws. In Arizona, for example, native plants may not be legally possessed, taken, or transported from the growing site (even on private land) without a permit issued by USDA. Protected plants include highly safeguarded species, salvage-restricted species, export-restricted species, salvage-assessed species, and harvest-restricted species (including cacti and common beargrass). Arizona has laws and official guidelines for the removal and transportation of protected native plants (even if the plants enter Arizona from another state) and all State law enforcement agencies are involved in monitoring the native plant law activities (Arizona Department of Agriculture 2015, McReynolds 2010).

Regulations that impact plant and fungal species that are harvested as nontimber forest products also vary from State to State depending on the product being regulated. Some states regulate certain plants as harvested species whereas other products are regulated as nursery stock. For instance, Connecticut and Arizona have special State listing categories for native plants that are known to be harvested ("species of special concern" and "harvest-restricted species," respectively) (Connecticut Department of Energy and Environmental Protection 2014, McReynolds 2010). In Florida, the rapid growth of the saw palmetto berry industry since 1995 resulted in legislation meant to directly control the wild-harvest of berries. Legislation declared the saw palmetto berry an agricultural crop and protects it from unauthorized harvesting anywhere it is found (Florida State Legislature 1997, Mitchell 2014). The legislation authorizes sanctions against those found harvesting berries without permission from the landowner. A study commissioned by the Florida House of Representatives (2000) found that unauthorized wild-harvesting of berries continued and would likely continue due to the confounding structure of the saw palmetto berry industry. Many commercially harvested

NTFPs are sold for cash to product dealers after collection, and the informal, and often secretive, nature of the NTFP trade is difficult for states (or any level of government) to understand and regulate (Mitchell 2014).

In comparison, some states regulate NTFPs indirectly as live plant materials and nursery stock or based on the purpose of the harvest. These regulations sometimes address transport within and across State lines as well as the licensing of nurseries, wholesalers, and growers (AZ). Many States, such as Washington, differentiate between individuals harvesting for personal and commercial use and regulate the harvest accordingly (Washington State Legislature 2015). Similarly, states must honor indigenous traditional and customary access to resources for subsistence, cultural and religious purposes (ANILCA 1980, Hawai'i Legislative Reference Bureau 2015). How these materials are regulated depends on the context in which these regulations were established and the purpose of the legislation at the time it was enacted. Often, species-specific regulations are enacted due to conservation concerns and the threat of over collection (e.g., American ginseng), but as a result they may be rushed and poorly considered, or may require modification over time as the threats to species diminish (Emery and McLain 2001; Laird et al. 2010, 2011).

Most states that regulate specific species, such as American ginseng, usually have enacted legislation to protect the species. Any State and Tribe wanting to export wild American ginseng must have its program approved by FWS, as the agency charged with implementing CITES in the United States (50 C.F.R. 23.68). Nearly all wild-harvested American ginseng is exported to Asia. Nineteen states and the Menominee Indian Tribe of Wisconsin have American ginseng programs (table 7.1) approved by the FWS to export American ginseng (FWS 2015a). The states and tribe have statutes for American ginseng regarding the harvest, selling, certification of roots, and required recordkeeping and reporting. Most of the States with approved ginseng programs prohibit the harvesting of American ginseng on State land.

7.4.3 Summary of State Regulations

Intra-agency and interagency coordination among resource managers is important to successfully manage NTFPs. States employ botanists, foresters, wildlife biologists, and other experts but their expertise is seldom directed toward coordinated management of NTFPs. Coordination is most often found when a NTFP is listed as rare, endangered, or of special interest on a State or regional level. Increased coordination

Table 7.1—State ginseng regulation websites.

State	Ginseng program
Alabama	http://www.agi.alabama.gov/divisions/plant-protection
Arkansas	http://plantboard.arkansas.gov/PlantIndustry/Pages/LawsRegulations.aspx
Georgia	http://www.georgiawildlife.com/GinsengProgram
Illinois	http://www.dnr.state.il.us/Law3/Ginseng%20Regulations.htm
Indiana	https://secure.in.gov/dnr/naturepreserve/8235.htm
Kentucky	http://www.kyagr.com/marketing/ginseng.html
Maryland	http://mda.maryland.gov/plants-pests/Pages/ginseng_mgmt_program.aspx
Minnesota	http://www.dnr.state.mn.us/forestry/um/index.html
Missouri	http://mdc.mo.gov/discover-nature/outdoor-regulations/american-ginseng-harvest-regulations
New York	http://www.dec.ny.gov/animals/7130.html
North Carolina	http://www.ncagr.gov/plantindustry/plant/plantconserve/ginseng.htm
Ohio	http://wildlife.ohiodnr.gov/licenses-and-permits/specialty-licenses-permits#tabr2
Pennsylvania	http://www.dcnr.state.pa.us/forestry/plants/vulnerableplants/ginseng/index.htm
Tennessee	http://www.tn.gov/environment/natural-areas/ginseng.shtml
Vermont	http://agriculture.vermont.gov/plant_pest/ginseng_certification
Virginia	http://www.vdacs.virginia.gov/plant&pest/ginseng.shtml
West Virginia	http://www.wvforestry.com/ginseng.cfm?menucall=ginseng
Wisconsin	http://dnr.wi.gov/topic/EndangeredResources/Ginseng.html

between State resource managers and private forest owners could enhance management efforts to ensure that NTFPs are managed sustainably, as part of wider biodiversity, species, and ecosystem sustainability.

States generally lack the biological information and harvest data needed to make management decisions about NTFPs (Alexander et al. 2011, Jones et al. 2002, McLain and Jones 2005). Basic ecological descriptions and summaries of NTFPs are needed to construct baseline inventory of species on State lands. States may need assistance identifying what NTFPs occur on public lands and coordination and collaboration is critical when NTFPs cross State boundaries. Data concerning the resilience of plant species to harvest are critical to identify where efforts should begin to preserve most at-risk species.

States also generally lack mechanisms to track the harvest and movement of species across State lines and borders. For example, though saw palmetto berries are one of the most widely harvested commercial NTFPs by volume (AHPA 2012), Florida does not track the international export of this species, nor is there a species-specific Harmonized Tariff Schedule of the United States that would assist in tracking such exports. Identifying and tracking important NTFPs is a critical step toward monitoring trade and consumption and developing plans for the sustainable use of a species. While the regulatory framework that was established for American ginseng is highly coordinated between the states and the Federal Government, this is the only CITES-listed plant species regulated in this manner. For most other native plant species that are harvested as nontimber forest products, a few states have implemented tracking mechanisms within their boundaries (e.g., AZ) (AZ Department of Agriculture 2015, McReynolds 2010). For most other plant and fungal species that are harvested as NTFPs (including some listed species), there are no mechanisms to track their harvest or interstate commerce, or to preclude commercial overexploitation (Stein and Gravuer 2008). Licensing requirements (e.g., for harvesters or dealers) that lack sufficient ability to track the harvest and movement of NTFP resources are inefficient as a management tool. Laws and policies aimed at harvesters that do not fully incorporate why people harvest NTFPs may also have negative impacts on harvesters (Emery and Pierce 2005), as exemplified by the case study about the floral greens industry in the Pacific Northwest (box 7.1).

7.5 Local and Municipal Laws and Administrative Dimensions

At the local level, counties and municipalities are expected to comply with the overarching Federal, tribal, and State regulations previously mentioned in this chapter. Some localities have additional regulations and policies that are specific to a city, district, or township. These regulations may stem from laws that pertain to land conversion of forest to other types of land uses (or vice versa), under which timber and nontimber products are specified. Local laws may also be written to address the removal of NTFPs from county or public parks. Typically, the local regulations that affect NTFP harvest are administered and enforced by land managers, foresters, or law enforcement officials. These individuals may work in different county or city departments such as natural resources, land planning, or parks and recreation. Laws and policies that affect NTFPs at the local level are often detailed in policy documents such as land or forest management plans. Some county natural resource departments may work with their counterparts at the Federal or State level and with nonprofit organizations to assess NTFP use and sustainable management (Jacobson et al. 2005). The Washington state Forest Practices Board is an example of efforts to manage natural resources through formalized collaborations among public and private entities (WA DNR 2017). Contacting the designated local managers or rangers within these departments is a good starting point for obtaining a collection permit or learning more about the sustainable use and harvest of NTFPs, or the impact of a land-conversion project on access and use of NTFPs in their municipality.

7.5.1 Local Rules and Regulations

District and city laws in urban areas tend to have strict regulations and penalties for NTFP harvesting. This is partly because local authorities consider park resources as needing protection, not as resources that could be sustainably collected and used (McLain et al. 2014). Many examples in this section pertain to the regulatory aspects of foraging. Foraging is explored in more detail in chapter 5 and to a lesser extent in chapters 2 and 4.

The East Bay Regional Park District in California manages 65 parks and over 119,000 acres of land spanning multiple counties in the San Francisco Bay Area (East Bay Regional Parks 2015). Within these district parks, NTFPs are considered to have intrinsic value as part of the ecosystem, being important intrinsic features of the natural landscape, along with other geographical features and wildlife. NTFPs are mentioned under the Park Feature Protection Rules, Plant Section, "No person shall damage, injure, collect or remove any plant or tree or portion thereof, whether living or dead, including but not limited to flowers, mushrooms, bushes, vines, grass, turf, cones and dead wood located on District parklands. In addition, any person who willfully or negligently cuts, destroys, or mutilates vegetation shall be arrested or issued a citation pursuant to Penal Code Section 384a (Section 804, Plants, East Bay Regional Parks Rules 2014)." Noncompliance with these rules is considered a misdemeanor or infraction and is enforced by district park rangers. Permits are not given for foraging, but "special permission (Section 103) may be granted to remove, treat, disturb, or otherwise affect plants or animals or geological, historical, archaeological, or paleontological materials for research, interpretive, educational, or park operational purposes" (Section 807, East Bay Regional Parks 2014).

The City of Boston, MA, oversees 1,100 acres of land divided into a series of parks, wooded corridors, and waterways and green spaces referred to as Boston's Emerald Necklace (City of Boston 2014a). The city does not allow the removal of plants, and interestingly, plants are cited together with rules about property defacement: "No person shall, in any public park (including any boundary road thereof), or other public place (including any parkway) under the control of the Parks and Recreation Commission, except under the auspices of public authority… (e) dig up, cut, break, remove, deface, defile, or take any tree, bush, plant, turf, rock, gravel, building, structure, fence, railing, sign or other thing connected with such park of place (Section 2; City of Boston 2014b). The regulatory language does not specify other types of NTFPs such as mushrooms, moss, lichens, or downed wood, and it is unclear if these products are included under this rule. Violators may be fined up to $50 for each offense (City of Boston Park 2014b, Section 10).

In New York City, the Administrative Code prohibits "destruction or abuse of trees, plants, flowers, shrubs and grass." Furthermore, "no person shall deface, write upon, sever, mutilate, kill or remove from the ground any plants, flowers, shrubs or other vegetation under the jurisdiction of the Department without permission of the Commissioner" (NYC Parks Administrative Code 2014). Although the city acknowledges the importance of recreationists' values and interest in NTFPs, the city does not offer special permissions or permits for collection. "While we recognize that some patrons do forage within New York City parkland, officially such activity is illegal and not condoned by the agency. Documented, repeated instances of foraging on parkland are subject to prosecution" (Foderaro 2011, NYC Parks Administrative Code 2014).

In the case of Portland, OR, the city considers removal of plant or fungal material from city parks as vandalism, under the "protection of park property" rules. However, Portland allows permitted harvesting. "No person shall remove, destroy, break, injure, mutilate, or deface in any way in any Park any tree, shrub, fern, plant, flower, or other vegetation without a permit from the Forester under the provisions of Chapter 20.40" (City of Portland 2014). Recently, Seattle and Philadelphia have acknowledged the importance of urban foraging. Seattle has included foraging as a legitimate use in its urban forest stewardship plan (City of Seattle 2013). Philadelphia encourages people to pick fruit from trees in public green spaces as part of its revitalization efforts (McLain et al. 2014).

In rural areas, land-planning regulations can affect access and harvest of NTFPs on forested lands. For example, counties may strive to engage in sustainable forestry practices that enhance the landscape, which may indirectly affect nontimber forest product harvesting activities. In Pierce County, Washington, land conversion from forest to other land-use types falls under local land development regulations (Pierce County, Washington 2014). The vast majority of land in this county is considered, "non-conversion" or forested land where timber extraction and human-assisted reforestation can occur. In these forests, Christmas trees and potentially other NTFPs may be harvested. Both timber and NTFP activities on local lands are therefore primarily regulated through the Washington State DNR, while specific regulations for forest land (conversion and non-conversion) are detailed at the county level. Certain NTFP activities do not require formal approval: "Class I forest practices that result in the cutting and/or removal of less than 5,000 board feet of timber for personal use (e.g., firewood and fence posts) in any 12-month period, the cutting and/or removal of Diseased, Danger, and/or Hazard trees as defined in Chapter 18.25 of Title 18

PCC, Development Regulations—General Provisions, the culture and harvest of Christmas trees and seedlings, and/or emergency fire control or suppression shall not be required to obtain any forest practices approval from Pierce County (18H.20.040 Class I Forest Practices, Section A)" (Pierce, Washington 2014).

7.5.2 Local Administrative Dimensions, Policy, and Management

Different departments and officials at the county and city level typically administer all aspects of NTFP management. These include Land Planning Departments; Forestry, Parks and Recreation Departments; and/or Law Enforcement Offices. Tasks and responsibilities may include determining which NTFPs are present in their jurisdiction, developing rules and regulations for NTFPs, and enforcing these rules, often through a permitting system when appropriate and allowed. For example, in Lewis County, Washington, the sheriff's office administers permits for harvesting cedar bark, huckleberries, mushrooms, and other NTFPs (Lewis County, Washington, n.d.).

Policy documents such as land-management and forest plans can directly affect the management of NTFPs at the county level. The land-management plan for Itasca County, Minnesota, addresses the harvest of nontimber resources (Itasca County 2010). The plan details the permitting system for collecting commonly used products such as balsam boughs and fuelwood or other products such as tree-bark, maple sap, Christmas trees, cones, and moss. Clubmoss (*Lycopodium* spp.), for instance, is designated for "personal use" as opposed to "commercial harvesting" to control for and minimize the amount of moss taken from local forests (Itasca County 2009).

Itasca, Beltrami, and St. Louis Counties in Minnesota partnered with other governmental agencies and organizations to create "Guidelines for Sustainable Harvest of Balsam Boughs" (Balsam Bough Partnership, n.d.). These guidelines are designed to inform resource managers as well as commercial harvesters on good practices. In another collaborative effort, Minnesota county, State, and Federal managers contributed toward a market study of balsam fir boughs (Jacobson et al. 2005). The study combined field observational data together with bough buyer and wreath producer market survey results to report where and how much of the resource is used at the county level as well as statewide harvesting amounts. Such studies can serve as a template for other counties and states that are interested in quantifying NTFP occurrence and managing the sustainable harvest of NTFPs at local and regional scales (Jacobson et al. 2005). State universities can play a role in providing information to harvesters or county foresters in the form of workshops or handbooks that may be useful for managing plant species that are harvested nontimber forest products (University of Minnesota Extension 2013).

7.5.3 Summary

Local laws differ by region, county, or city. The variability in regulation and policy is in part due to the autonomy that local government entities possess allowing them to address the specific needs and issues that surround natural resource use that are unique to their jurisdiction. NTFPs may be listed under different sections of local regulatory codes, sometimes under the park protection provisions or even under vandalism or defacement subsections. Within these codes, NTFPs may be lumped under umbrella categories, such as "plants" to include plant products and fungi, or NTFPs may be explicitly outlined. The penalty for noncompliance can differ between cities and municipalities ranging from misdemeanors to monetary fines. One of the challenges for effective regulation and management of nontimber forest resources is the tension between local governmental entities and their efforts to protect and prevent vandalism of NTFPs while simultaneously allowing park recreationists to harvest NTFPs. Typically, land planning, natural resources, or parks and recreation departments are charged with enforcing regulations and administering permits where foraging is allowed. These departments may write policies, such as land or forest plans, that may detail NTFP use. Finally, local governmental entities can partner with nonprofits and universities to research and in some cases, create sustainability standards and management resources such as harvester handbooks which can aid harvesters to navigate the often complex and sometimes hard-to-find NTFP rules and policies in different localities.

7.6 International Law and Administrative Dimensions

The United States is signatory to several legally binding international treaties and also participates as a non-party or non-binding partner in multi-lateral environmental agreements that impact or could inform policies and regulations for nontimber forest product harvest and management. Different Federal agencies lead United States participation in most of these multilateral environmental agreements, which has increased awareness related to NTFPs more broadly across the United States Government. Years of international policy dialogue has increased our understanding of the developments around sustainable use and environmental justice and their importance in addressing the global challenge to conserve biodiversity. This section summarizes several international agreements, with brief descriptions of the authorizing and implementing legislation. It discusses whether and how nontimber forest resources and products are explicitly or implicitly considered in these international agreements. Also, the section identifies how the agreements contribute to sustainable use and conservation of such resources within the emerging principles of community-based conservation, the importance of TEK, the value of NTFPs as important biological resources, and the contribution of NTFPs to human health and livelihoods.

7.6.1 International Laws, Policies, and Authorities

The Convention on International Trade in Endangered Species of Wild Fauna and Flora is a treaty with 180 member countries that work together to ensure that international trade in certain plants (including fungi) and animals, and parts and products derived from them, whether live or dead, are legally harvested and are sustainably harvested (CITES 2014k, Department of State [DOS] 1976, FWS 2014a, UN 2014, Wijnstekers 2011). The United States has been a party to CITES since it entered into force in 1975, and the FWS implements the Treaty under Section 8 of the ESA, as amended (DOS 1976, ESA 1973). The CITES preamble acknowledges the ecological, aesthetic, scientific, cultural, recreational, and economic values of wild species (DOS 1976). Parties to CITES have developed guidance on the sustainable use and conservation of certain CITES-listed species, the role of commercial trade in conservation, the importance of livelihoods that are based on the use of natural resources, and the role of traditional medicine and sustainable harvest (CITES 2014b, 2014e, 2014f, 2014h, 2014i, 2014j; CONABIO 2008; Rosser and Haywood 2002). CITES is unique among conservation treaties by providing a mechanism to forbid trade with noncompliant countries (Brack and Gray 2003, Kerr 2007, Wijnstekers 2011). Because non-CITES countries are required to provide CITES-equivalent documentation to trade with CITES parties, this Treaty effectively pertains to every country in the world (Brack and Gray 2003).

Nontimber forest products such as orchids (family: Orchidaceae), American ginseng (figure 7.1), goldenseal, aloes (*Aloe* spp.), and cacti are CITES-listed species that are native to the United States and are traded internationally as medicines, waxes, foods, fragrances, and horticultural species (CITES 2014a). In 2002, CITES members officially agreed that fungi were generally considered to be included in the term “flora” when the CITES Convention was initially drafted, such that fungi are also covered by this Treaty (Resolution Conf. 12.11; https://www.cites.org/eng/res/12/12-11R16.php). CITES-listed species are identified in one of three Appendices (I, II, and III), which convey different levels of protection and determine how the Parties apply import and export controls (DOS 1976, FWS 2014a, Sparling 2014). Species are listed in CITES appendixes I and II based on a decision by the Parties, and proposals to list species must include information on distribution, biology, morphology, and population size and trends, as well as uses, sustainable harvest, regulations, and protections, and legal and illegal trade must be documented (CITES 2014c, 2014d). A listing may cover an entire family (e.g., Cactaceae, Orchidaceae) or any lower taxonomic level (e.g., species). Permits for appendix-I and appendix-II species require two key findings to assist in the conservation of the species: (1) Nondetriment finding—a science based risk assessment to determine whether the export of specimens of the particular species will be detrimental to its survival; and (2) Legal acquisition finding—a determination that the specimen(s) was obtained in accordance with national laws for the protection of wildlife from the country which it originates (DOS 1976, FWS 2014a). Because CITES permits must use scientific names, the scientific names of species are formally agreed upon when species are listed (CITES 2014g). A common misunderstanding is that CITES regulates the harvest

Figure 7.1—The roots of American ginseng (*Panax quinquefolius*), harvested from hardwood forests of the eastern United States, are exported predominantly to China. The export has been regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora since 1976 when it was listed on Appendix II of the Convention. (Photo credit: Gary Kauffman, U.S. Department of Agriculture, Forest Service.)

of listed species, whereas CITES regulates the export of specimens of listed species (FWS 2014a).

The International Tropical Timber Agreement (ITTA) is an agreement among the governments of 70 tropical timber consumer and producer countries. It entered into force in 1985 and established the International Tropical Timber Organization (ITTO) to cooperate on sustainable and legal harvest of tropical timber (Sands et al. 2012, UN 2014). The ITTA was revised in 1994 and 2006, and now specifically refers to the contribution of nontimber forest products to sustainable forest management (Sands et al. 2012). The United States belongs to ITTO as a consumer country, and the lead Federal agency representing the United States is the Office of the U.S. Trade Representative (ITTO 2006, U.S. International Trade Commission 1991).

Nontimber forest products figure prominently in ITTO, with permanent committees on forest industry and on economics and markets, and guidance documents for conducting forest inventories that include a valuation of present and potential nontimber forest products (ITTO 1992). ITTO has funded a number of projects on sustainable harvest, chain of custody systems, and projects to support local stewardship and conservation of nontimber forest resources (ITTC 2014, ITTO 2014, Ma 2002, Panayotou and Aston 1992). None of these projects have been based in the United States or its territories, despite the more than 1 million acres of tropical forests on Hawai‘i, American Samoa, CNMI, Guam, Puerto Rico, and the U.S. Virgin Islands, and an additional nearly 154,000 acres on the Freely Associated States of Palau and the Federated States of Micronesia (Brandeis and Turner 2009; Liu 2007; Weigand 2002a, 2002b, 2002c, 2002d, 2002e).

7.6.2 Nonbinding International Agreements and Collaborations

The Montreal Process, also known as the Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests, was formed in 1994 (MPWG 1995). The 12 member countries include Argentina, Australia, Canada, Chile, China, Japan, Mexico, New Zealand, the Republic of Korea, the Russian Federation, the United States of America, and Uruguay, representing 83 percent of the world’s temperate and boreal forests (FAO 2014c). These countries assess progress toward sustainable forest management based on criteria and indicators, several of which pertain to NTFPs (MPWG 1995, 2000, 2009). Note that the Montreal Process uses the term “nontimber forest products” and includes “game” among the products in this category (Alexander et al. 2011). Acknowledging the general lack of quantitative data, the indicators use both qualitative and quantitative information and provide some mechanisms to drive quantitative data gathering (MPWG 1995, 2000; Jones et al. 2002). The first United States country report was primarily qualitative and included some examination of the numerous plant and fungal species and user groups involved in NTFP harvest (Guldin and Kaiser 2004). The second report provided extensive quantitative data based on harvest permits and contracts issued on Forest Service and BLM lands, generating some of the first national statistics for temperate and boreal forests. The report demonstrated that harvesting NTFPs in the United States is a significant activity. It further illustrated that international trade is a significant driving force for the harvest of these resources in the United States. The report concluded that there is a lack of critical information that policymakers and land managers need to effectively regulate these species, without imposing barriers to subsistence use (Alexander et al. 2011).

The Convention on Biological Diversity (CBD) takes a comprehensive approach to sustainable use and conservation of each Nation's biological resources (Glowka et al. 1994, UN 1992). The Convention entered into force in 1993 and the Secretary-General of the United Nations assumes the functions of Depositary for this Convention (CBD 2014). There are 194 parties to this Convention (CBD 2014); although the United States has not ratified the CBD, it attends all meetings (NOAA 2014), and plays a substantial role in policy deliberations. The objectives of the CBD are the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of benefits derived from the use of genetic resources (Article 1; CBD 2014). As part of its work to promote sustainable use, the right of indigenous peoples, and biodiversity conservation, the CBD addresses the management of nontimber forest resources, emphasizing *in situ* conservation, recognizing the role of indigenous and local communities in conservation (CBD 2001, Glowka et al. 1994). More recently under the Nagoya Protocol, NTFPs have come to receive attention as "biological resources" (CBD 2001, 2004, 2011). CBD's Global Strategy for Plant Conservation is a worldwide initiative to establish outcome-oriented global targets for plant conservation with relevance to NTFPs (CBD 2002, 2010). Several of the 16 targets pertain to NTFPs, such as Target 12: *All wild harvested plant-based products sourced sustainably* (CBD 2010), and United States agencies and nongovernmental organizations (NGOs) collaborate to gauge progress on this Strategy in the United States (BGCI 2006, CITES 2014h, Galbraith and Kennedy 2006, Miller et al. 2013). Here again, it is generally interpreted that fungi are implicitly included in the term "plants" (Plantlife International 2012).

The International Union for the Conservation of Nature (IUCN) focuses on conservation, equitable governance, and addressing the global challenges of climate, food, and development (IUCN 2014). A variety of IUCN activities pertain to nontimber forest resource use and conservation. The IUCN is best known for the Red List of Threatened Species, which assesses the conservation status of species based on science-based criteria (IUCN 2014). "Biological resource use," including gathering and harvesting of plant and fungal resources, is one of the 12 potential categories of threats that can be assigned to species. Many United States governmental and nongovernmental experts belong to IUCN Specialist Groups, a network of nearly 11,000 experts that focus on a range of species and issues (IUCN 2015). The Medicinal Plant Specialist Group (MPSG) was founded in 1994 to increase awareness of conservation threats and to promote sustainable use and conservation of medicinal plants (MPSG 2012). In 2007, this group developed the International Standard for the Sustainable Collection for Medicinal and Aromatic Plants (ISSC-MAP), incorporating principles of sustainability, adaptive resource management, the role of traditional knowledge, and access and benefit sharing (MPSG 2007). The ISSC-MAP has since been incorporated into the FairWild Standard, a third party certification ensuring fair and sustainable trade in wild plant and fungal products (Brinckmann and Hughes 2010). Another initiative, the Bonn Challenge, was established in 2011 to restore 371 million acres of deforested and degraded lands by 2020. Supported by the Global Partnership on Forest Landscape Restoration (GPFLR 2013), this voluntary network of governments and international and nongovernmental organizations (NGOs) facilitates information exchange, generates new knowledge and tools, and mobilizes capacity and expertise to address landscape restoration. As partners in this effort, the USDA Forest Service has pledged to restore 15 million ha of forest across the United States by 2020 (Tidwell and Karr-Colque 2012).

The Food and Agriculture Organization of the United Nations (FAO) was established in 1943, as a permanent specialized agency, with more than 180 member countries (FAO 2015). FAO uses the term "non-wood forest products" (NWFPs), and its definition excludes all woody products (e.g., fuelwood, carvings made from wood) and includes all goods of biological origin, including animals (FAO 1999b). NWFPs figure prominently in FAO's permanent Forestry Committee, which coordinates activities and projects for sustainable use and wise management of NWFP resources to improve income generation, create food security, and address timely issues such as climate change and genetic resources (FAO 2013, 2014a, 2014c; Jones et al. 2002). NWFPs have not figured prominently in United States FAO country reports, however. Absent formal tracking systems, there has been a lack of information to demonstrate the value of nontimber forest products in the United States (Alexander et al. 2011). United States country reports have also excluded information from U.S. territories in the Caribbean, where NTFP diversity and usage are higher, especially for food and healthcare (FAO 1997, 1999a, 2014b; Weigand 2002e). There is also a broad international view of the United States as a primary consumer, rather than a producer of NTFPs (Jones et al. 2002). This is partly due to the general lack of valuation and tracking mechanisms for these commodities (Alexander et al. 2011). In the late 1990s, the FAO Non-Wood Forest Products Program announced what would have been the first FAO North American NTFP workshop. Though the workshop did not take place, it spurred the publication of "Nontimber forest products in the United States" (Jones et al. 2002)—a wide-ranging, contemporary assessment with case studies on a broad range of issues and a strong focus on policy that has served as a basis for further discussion and consideration in the United States and abroad (Alexander and Fight 2003, Laird et al. 2011, White and Danielsen 2002).

The Ramsar Wetlands Convention is an environmental treaty that coordinates voluntary local, national, and international cooperation to conserve and sustainably use wetlands (Matthews 1993, UNESCO 1971). The treaty was adopted in 1971 (UNESCO 1971) and currently includes 168 member countries (Ramsar 2014a). The United States joined the Convention in 1987, with the FWS as the technical and scientific lead (Gardner and Connolly 2007). Under this Convention, countries designate "wetlands of international importance" and, though it was promulgated especially for the conservation of waterfowl, Ramsar recognizes the importance of wetlands to food security and for their provision of nontimber forest products (Ramsar 2010, 2012, 2014b; UNESCO 1971). Ramsar recognizes that wetlands may be of substantial value for their role in "supporting human communities by the provision of food, fiber or fuel; maintaining cultural values", and that such use should not undermine the sustainability and conservation of the habitat nor change the ecological character of the site (Matthews 1993). Guidelines on "wise use" of wetlands emphasize developing management plans and programs to inventory, monitor, and research at wetland sites (Ramsar 2010). Efforts have focused on conservation of wetlands for sustainable agricultural development (FAO SAFR 1998) and, more recently, on understanding the costs and benefits of changes to wetland ecosystems, such as salinization and inundation (Ramsar 2010, Russi et al. 2013).

United States wetlands are the source of familiar plant products such as wild and cultivated foods (e.g., rice, cranberries), floral greens (e.g., peat moss), fiber (e.g., cattails, rushes), and ornamental plants (e.g., Venus flytrap [*Dionaea muscipula*]) (Alvarez 2007, Porter 1990, Ramsar 2014b, Smith et al. 2007). Of the more than 110 million acres of wetlands in the conterminous United States (Dahl 2011), 95 percent are freshwater and include bogs, swamps, fens, marshes, and wet meadows (Alvarez 2007, FGDC 2013). Half of the freshwater wetlands are classified as "forested wetlands," which lost nearly 393,000 acres, mainly from conversion to agriculture, development, and silvicultural treatments between 2004 and 2009 (Alvarez 2007, Dahl 2011, FGDC 2013). To date, 36 sites in the United States have been designated under Ramsar, including sites in Alaska and Hawai'i. However no sites have been designated in the U.S. territories (Ramsar 2014a). Ramsar designation in the United States has increased the visibility of the wetlands, opened new funding opportunities, and has resulted in increased research and ecotourism (Gardner and Connolly 2007).

7.6.3 Summary

Prior to the 1980s, NTFPs did not figure prominently on the international forestry policy agenda. However, in recent decades, policies and regulations concerning the management of NTFPs have emerged in the international arena and grown in importance at home. These settings provide a global context for discussion and an opportunity to address the difficulties faced by many countries in shaping policies that balance sustainable use and conservation of these natural resources, alongside ensuring benefits for harvesters, producers, and knowledge-holders. In the international arena, the United States generally has been perceived as a consumer of others' NTFPs, and the United States has contributed to this perception, likely due to a lack of information and awareness of the many economically and culturally significant NTFPs found here. U.S. Government participation in these international networks provides opportunities for a broader Federal understanding of the conservation and management of NTFPs, and their importance and value as a forest product. National assessments and reports carried out to meet international obligations are becoming more comprehensive and increasingly underscore the importance of NTFPs to the U.S. economy, livelihoods, and culture. However, the use of this information to effect change in U.S. regulations and policies on a national scale has been slow. Factors that contribute to this are the number of State and Federal agencies involved; the range and complexity of NTFP management; and the compartmentalization of agency roles, responsibilities, and influence on available resources.

7.7 Nontimber Forest Products and Climate Change Policy

This section explores climate change policy pertaining to NTFP management, and the extent that policies and tools could be used to inform NTFP management in the face of climate change. It is not possible to review all climate change policies relative to NTFPs in this synthesis. Notably omitted from this section, but having bearing on NTFPs, are policy research, strategies relative to food systems, and changing land-use pressures. The section only briefly touches upon ecosystem-level impacts and sociocultural-economic considerations.

There is little in the way of U.S. climate change policy that explicitly pertains to NTFPs as a natural resource or commodity category. There are a few examples of nontimber forest products being considered in regional or State-level climate change assessments. Janowiak et al. (2014) and Handler et al. (2014), respectively concluded that climate change will have implications for nontimber forest products in the Great Lakes region and the Laurentian Mixed Forest Province due to changes in temperature, hydrology, and species assemblages. NTFPs, however, are rarely taken into consideration in national climate change research and discussions, and often are not represented in policies.

This is likely correlated with the dearth of actions in U.S. natural resource policies specific to managing, conserving, or protecting native flora that are harvested for economic, cultural, and personal uses. Although the late twentieth century shift to ecosystem-based management on Federal lands has led to the incorporation of NTFPs into forest policies and has raised the visibility of NTFP species as integral parts of forest ecosystems and the livelihoods and traditions of forest-dependent human communities (Antypas et al. 2002, Bean and Rowland 1997, Jones and Lynch 2002, Sills et al. 2011), NTFPs have yet to be recognized from a Governmentwide policy perspective as a class of natural resources requiring specific management. Rather, the focus on plants in U.S. natural resource policy has emphasized invasive species eradication, sustained timber yields, or threatened and endangered species conservation (Antypas et al. 2002, Bean and Rowland 1997, Jones and Lynch 2002, Laird et al. 2011, McLain and Jones 2002, Sills et al. 2011).

Contributing to the dearth of national climate change policies focused on NTFP management is the fact that development of national climate policies as they pertain to natural resource management in the United States is largely a recent phenomenon (Joyce et al. 2006, Lawler et al. 2009, West at al. 2009). Additionally, the accumulation of information to support decisionmaking capacity and the ability of natural resource managers to incorporate new climate concepts into management practices and to incorporate new technologies that take larger scale data into account take time (Staudinger et al. 2013). International policy documents should be viewed as sources of policy considerations that are being undertaken (Laird et al. 2009, 2010).

Nontimber forest products should be included in assessments that outlined in national climate change planning documents that could be applied to NTFP management. A thorough review of the various Federal, State, and Tribal climate adaptation policies and planning documents would be useful to determine the extent that NTFPs are or still need to be included in the considerations.

"Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options," a climate analysis and planning guidebook produced by the Pacific Northwest Region of the USDA Forest Service, provides common sense approaches to climate adaptation planning that could be applied to NTFPs: (1) become aware of basic climate change science and integrate that understanding with knowledge of local resource conditions and issues (review), (2) evaluate sensitivity of specific natural resources to climate change (rank), (3) develop and implement strategic and tactical options for adapting resources to climate change (resolve), and (4) monitor the effectiveness of adaptation options (observe) and adjust management as needed (Peterson et al. 2011).

The report "Strategic Plan for Responding to Accelerating Climate Change" (FWS 2010) provides opportunities to include plant and fungal species that are harvested as NTFPs. The plan embraces landscape-level planning, the use of native plants in restoration, and conservation goals that, for instance, recognize the importance of forest diversity. Importantly, the strategy notes that plants are implicitly included in its use of the term "fish and wildlife," and acknowledges the importance of ecological diversity and social, cultural, and economic benefits of our American ecosystems. Fungi are not explicitly mentioned.

A nationally focused climate strategy that could be particularly relevant to NTFPs is the National Fish, Wildlife, and Plants Climate Adaptation Strategy (NFWPCAP 2012). The strategy was developed with input from a broad array of Federal, State, and Tribal partners, as well as from nongovernment organizations, industry, and private landowners. An implementation working group promotes coordination across sectors to implement the plan. The seven goals and actions are broad enough to encompass NTFPs and could be used to guide more specific considerations for climate change and nontimber forest resources and products.

7.7.1 Sociocultural and Socioeconomic Impacts of Climate Change Relative to Policies and Regulations

Formulating NTFP climate change policy will require a fundamental understanding of the circumstances under which this natural resource functions. As the previous chapters demonstrate, the biological, ecological, social, and economic context of the NTFP sector is complex, but not wholly intangible. Such has been the topic of discussion in the international arena for decades and there is much to learn from this international policy dialogue, as described in section 7.6 of this synthesis.

Importantly, several recent publications focused specifically on the U.S. NTFP sector and natural resource management explore approaches to policy development that take these sociocultural and economic nuances into consideration (Alexander et al. 2011; Antypas et al. 2002; Jones and Lynch 2002; Jones et al. 2002, 2005; Peterson et al. 2013). Such information lays the groundwork for incorporating NTFPs into climate change policy.

Few policies and assessments to date address the dependence of forest-based communities on NTFPs and the vulnerability of social, cultural and economic systems regarding NTFPs and climate change. Recent publications describing adaptation options for managing forested ecosystems in the face of climate change illustrate some of these important policy drivers that could impact forested systems, and so too, NTFPs (Joyce et al. 2009; Kemp et al. 2015; Lawlor et al. 2009; Peterson et al. 2011, 2013).

The effects of climate change on American Indians and affiliated indigenous people are not well studied and resource managers, scientists, and the public may not understand which policies or Federal authorities may be applicable (Cordalis and Suagee 2008). In addition, some governmental climate change policies have implications to these indigenous and tribal peoples. Whyte (2014) contends that as climate change policies are developed, they should be understood and tied to existing tribal policies and authorities when and where possible. Of particular concern is the effect of climate change on the spatial distribution of nontimber forest resources and how changes in distribution could affect indigenous peoples' access to traditionally harvested NTFPs.

There are a few examples of Federal policies or authorities pertaining to tribes and climate change. For instance, Section 6 (b) (vi) of Executive Order 13653 (2013) "Preparing the United States for the Impact of Climate Change" includes some guidance concerning tribal issues. Two secretarial orders from the Department of the Interior also provide general guidance for tribes on climate change (DOI Secretarial Orders No. 3285 and 3298). Native Hawaiians and Pacific Islanders of U.S.-affiliated territories may have other local authorities. Other regulations, policies, and guidance pertaining to tribal consultation, land management planning, and natural resource protection could also be interpreted to include climate change (e.g., Executive Order 13175 [2000], USDA 2012, National Indian Forest Resources Management Act of 1990).

Some states have climate policies for some tribes, while others do not. For instance, the 2009 California State Climate Adaptation Strategy specifies that "State agencies will also interact with California Indian Tribes respectfully and on a government-to-government basis. Because traditional knowledge will have a role in combating climate change, indigenous communities should be involved in climate change adaptation actions that will directly impact their people, waterways, cultural resources, or lands; all of which are intimately associated" (California Natural Resources Agency 2009).

7.7.2 Tools That Can Inform Climate Change Policy Pertaining to Nontimber Forest Products

Some climate change tools could be useful for managing plant and fungal species that are harvested as NTFPs. NatureServe developed the Climate Change Vulnerability Index (CCVI) for species; the index integrates projections for temperature and moisture changes with habitat and natural history traits for aquatic or terrestrial plants and fungi within a specified geographic area. The scoring mechanism produces an index of vulnerability using the magnitude of projected climate change to rank each species in a vulnerability category ranging from extremely vulnerable to not vulnerable (Young et al. 2014). The NatureServe database contains entries for many plant and fungal species and includes sections on management, stewardship, threats, and harvest. It is not clear how many of these species have been assessed using the CCVI. NatureServe, with the BLM, has also developed climate change vulnerability indices for major natural community types, called the Habitat Climate Change Vulnerability Index (HCCVI) (Comer et al. 2012). The community-level HCCVIs are useful at regional and national levels, while the species-level assessments of the CCVI provide useful insights for local managers. Conservation and policy decisions can be improved by using this assessment tool (Comer et al. 2012).

The ForWarn—National Resilience Toolkit was developed by the Forest Service and was recently launched as a national climate resilience toolkit (EFETAC, n.d., Workman 2014). This tool is a satellite-based forest disturbance monitoring system, which shows near-real-time changes to vegetation coverage to help detect changes in the landscape (e.g., insects, extreme weather), although it is not clear how informative this tool might be for nontimber forest resources.

Information on the impact of climate change to NTFPs can also be gleaned from national level reports. As discussed in section 7.6, the United States generates national reports in association with international responsibilities that could provide information focused on NTFPs. Examples include the United States country reports under the Montreal Process (Alexander et al. 2011, Guldin and Kaiser 2004) and the FAO State of the Forest reports (FAO 1997, 1999a, 2014b, 2014c).

The Environmental Protection Agency (EPA) compiled decades of data observations from a range of governmental and nongovernmental sources, and recently released its third peer-reviewed report on climate change indicators in the United States. The report uses 30 climate change indicators, including first leaf dates per EPA 2014. The timing of phenological events, such as first leaf dates, is influenced by changes in climate and can indicate sensitivity of ecological processes. Evidence suggests that first leaf dates in lilacs (*Syringa* spp.) and honeysuckle (*Lonicera* spp.) from 1981 to 2010 are happening earlier in the North and West but later in the South. Based on over 90 years of data, the cherry blossoms in Washington, D.C., reach their peak nearly a week earlier. Phenological shifts have also been noted in fungal species. Kauserud et al. (2008) reviewed 60 years of phenological records on the autumnal fruiting date of mushrooms in Norway and concluded that since 1980, the average fruiting time has generally been delayed by nearly 13 days coinciding with changes in weather associated with climate change, with differences noted between normally early-fruiting and later-fruiting fungi. Another analysis of fruiting records in southern England over a 55-year period indicated that deciduous mycorrhizal species were fruiting more often and longer in the season than those associated with coniferous woods (Gange et al. 2007).

7.8 Challenges

This section discusses the broad challenges to regulations and policymaking for nontimber forest products. In doing so, we highlight some of the major themes or issues across the sectors explored in the previous sections, including climate change.

7.8.1 Recognition as a Natural Resource

The ultimate challenge to sustainable use and conservation of nontimber forest resources is to recognize that they are important natural resources and to fully integrate them into natural resource policy and management, at local, state, national and international levels. NTFPs are poorly understood relative to timber and other natural resources, and, except where federally mandated, are rarely considered in land management policy. Few regulatory mechanisms are species-specific and most species that occur in multiple jurisdictions are not managed consistently across their range. The species' population status and sustainable harvest levels are unknown for most NTFPs and the effects of market and other socioeconomic pressures are challenging to gauge. Forest management agencies generally do not perceive NTFPs as significant sources of revenues or concern and often lack the necessary botanical, socioeconomic, and market information.

7.8.2 Complexity

The diversity of rules, regulations, laws, legislations, and treaties that affect how NTFPs are understood, addressed, and managed presents a confounding complexity that requires in-depth knowledge. The legal and administrative structures governing NTFPs are often fragmented, not well defined, and vary widely between and within agencies and jurisdictions. Most policies were not created to address sustainable management and conservation of nontimber forest resources directly, but rather, when addressing them, do so as part of multiple-use strategies. In general, regulations pertaining to protected status (e.g., State- or Federal-listed species), commodity type (e.g., food versus horticulture), or the purpose of the extraction (e.g., personal versus commercial) often apply to NTFPs "by default." Existing laws or policies associated with nontimber forest products may not be known or understood by the many Federal, State, and other government agencies, much less by those who seek to access NTFPs.

Adding to the complexity are the many terms, definitions, and perspectives that embrace nontimber forest products. Products that are harvested from forests, other than timber, are referred to by many names. Some of these terms are incorporated into legislation. In 2000, the U.S. Congress directed the Secretary of Agriculture to implement a program to collect fees for the harvest and sale of FBPs. BLM and the Forest Service use the term "special forest products." Other terms used internationally, such as non-wood forest products, may include animals. The integration of these into forest management should be looked at as an opportunity to expand and embrace total ecosystem management.

7.8.3 Diverse Stakeholders within Largely Informal Economies

One of the major challenges in NTFP management is how to incorporate the diversity of stakeholders into facilitated conversations with the goal of considering and accommodating the many views, concerns, and people who are affected by the policies that impact access to these products. Efforts to incorporate all stakeholders into policy dialogue and development are challenged to address intellectual property rights regarding the use of and application of traditional knowledge when developing climate change mitigation and adaptation strategies.

The effects of climate change on NTFPs and indigenous people who benefit from them, and the applicability of Federal policies or authorities to address these impacts are not well understood (Cordalis and Suagee 2008). This challenge can be extended to other stakeholders, as well. Formal, structured processes to access NTFPs may present serious challenges for harvesters who may not have the knowledge of how to apply for permits or cash to pay permit fees. This can leave already vulnerable harvesters at greater risk of being taken advantage of by others or experiencing sanctions for harvesting. For example, many Guam residents depend on trees and related products for construction materials, yet applications can make the permitting process cumbersome. Harvesters may have negative perceptions of involvement and may be distrustful of outside organizations. This is compounded for some harvesters whose citizen status is other than United States.

Special challenges are evident in providing consistent policy to address indigenous people's rights for access to NTFPs. Legal conditions and history complicate the relationship of the Federal Government to American Indians, Alaska Natives, Native Hawaiians, and other indigenous-tribal peoples of the U.S.-affiliated territories for NTFPs, and make planning for the impacts of climate change extremely challenging. Many tribal governments are developing their own regulations for NTFPs and climate response strategies, and coordination among all governments is a critical challenge that must be overcome to provide more consistency across jurisdictions.

7.8.4 Federal Agencies

Efforts in the United States to consider NTFPs as part of integrated landscape management planning have been highly localized, with little opportunity for sharing and learning. Ashe (2014) points out in discussing the challenges with implementing Ramsar that "the U.S. extends from the subtropics to the Boreal zones and includes continental as well as insular settings, terrestrial and marine domains in the Pacific and Atlantic Oceans. There are 85 distinct ecoregions found within the continental United States alone. Implementing NTFP management strategies requires harmonization of efforts across Federal agencies, State agencies, localities, and NGOs that are responsible or involved in the management of the different types of resources within each of these geographical areas."

United States Federal agencies are adapting to changing environments and developing approaches to assess the sustainability of NTFP harvesting. In an era of declining budgets, Federal agencies are finding ways to collaborate on issues of mutual interest and concern but these collaborations are inconsistent across the country. The suspected magnitude of the harvesting of some highly commercialized NTFPs may be greater than current support can address, and baseline data for commercial NTFPs is critical information needed to address climate change impacts. Regional differences in land ownership, ecology, and culture will require different, adaptive approaches and policies at multiple scales that are consistent and understandable across regions and landscapes. More support for collaboration and cooperation on NTFP research and management can substantively address this challenge.

The Forest Botanical Products Pilot Program that guides how national forests address NTFPs has potential to improve management of these products. It provides a framework for managing nontimber forest resources on public forest lands. Fees collected from the issuance of harvest permits are supposed to reflect fair market value, though there are no national-level instruments to aid in estimating fair market value. Fees collected can be used on the specific units (e.g., national forest, ranger district) whence they originated, but not on other units. This presents a challenge for units that do not have many permitted harvests. Management efforts are thus limited to units that have a great deal of permitted harvesting, though other units may need management efforts. Further, the technical expertise may be lacking to conduct inventories, determine sustainable harvest levels and monitor harvest impacts. More proactive management that integrates nontimber forest resources as objectives, with desired future outcomes, is needed to address the challenge of ensuring sustainable management of these resources.

7.8.5 International Agreements

More is known about American ginseng than any other medicinal forest product because of its listing in appendix II of CITES. The data provided through the ginseng program are invaluable in assuring the sustainable management and conservation of this important forest herb. CITES databases provide international trade data for many NTFP species (e.g., American ginseng, goldenseal, and candelilla [*Euphorbia antisyphilitica* Zucc]) and spur interest from conservation and research institutions to study species (UNEP-WCMC 2014a, 2014b). Further, efforts to circumvent the requirements of CITES present serious challenges to law enforcement. Accurate recordkeeping, as well as the use of proper channels to export ginseng roots is necessary to meet the responsibilities and obligations of the Convention. Although it is possible to obtain trade information for taxa listed in the CITES appendixes, many species, both CITES listed and not listed, do not have taxon-specific International Harmonized Tariff Schedule codes that allow for tracking of trade volumes. This presents a significant challenge in determining harvest and trade volumes, estimating the importance of NTFPs, and ascertaining if international trade is having detrimental impacts on these resources. There are several other international agreements that could enhance efforts to address the challenges of sustainable management of NTFPs, including those faced by climate change.

7.9 Opportunities

There are clear links between rural livelihoods and sustainable ecosystem conservation, and countries worldwide are struggling to ensure that natural resource management strategies allow for continued use of these natural species, while ensuring the long-term survival and availability of the resources. Recent United States laws and trends in natural resource policy and management are pointing toward more holistic approaches to conservation and sustainable use of NTFPs. Commercialization of NTFPs can enhance economic opportunities without detriment to the environment or culture (Belcher and Schreckenberg 2007). By open communication with all stakeholders, policy interventions can be developed that enhance returns to local collectors and contribute to sustainable management of nontimber forest resources (Green et al. 2000). There are plenty of opportunities to enhance nontimber forest resource management in the United States (Vaughan et al. 2013).

7.9.1 Federal-Private Partnerships

Partnerships for conservation of nontimber forest resources present opportunities to leverage expertise, experience and expenses. For example, NatureServe working with BLM and other entitities conducted a climate change vulnerability assessment of major natural community types (Comer et al. 2012). The project tested an HCCVI that would provide measures of a plant community's sensitivity and resilience to climate-induced stressors. The overall index scores for each community are useful at regional and national levels, while the results of individual analyses provide useful insights for local managers. Conservation and policy decisions will be improved by this forecasting tool (Comer et al. 2012). Similarly appropriate initiatives with industry (e.g., botanicals, horticultural) and Federal management agencies could advance medicinal plant and fungal conservation. Partnering with the National Association of Conservation Districts presents opportunities for education and community service.

7.9.2 Indigenous Peoples

Opportunities exist to improve consistency in how Federal and State agencies address the rights of access and use of nontimber forest resources by indigenous peoples. In particular, regional or territorial approaches to confront the impacts of climate change on nontimber forest resources and harvester groups, and development of applicable policies and guidance will foster sustainable use of these natural resources. The incorporation and respectful use of indigenous knowledge and adaptation strategies for the management of nontimber forest resources and identification of the threats and stressors of climate change to natural resources and the people who depend on them could guide and inform the development of applicable policy and regulations. Additionally, two important points should be addressed. First, more consistent laws and policies for the use of NTFPs by indigenous groups and better respect for traditional knowledge and practices are critical. Second, the impact of climate change on culturally and economically important NTFPs for indigenous peoples should be evaluated, and the role of tribal knowledge in mitigating the effects of climate change, or assisting with adaptation, studied and incorporated into policy formulations.

7.9.3 International Agreements

International agreements to which the United States is party (and those which it is not, like the CBD) provide opportunities to advance the sustainable management and conservation of NTFPs, and their equitable commercialization. For example, there are mechanisms through CITES whereby tracking international trade of NTFPs is possible for listed species. Likewise, Ramsar evaluation guidelines for wetlands may be useful for informing sustainable use and conservation of NTFPs (Ramsar 2010, 2014b). Developing these in the United States would advance NTFP management worldwide. Reports generated in association with United States international responsibilities, such as the United States country reports under the Montreal Process (Alexander et al. 2011, Guldin and Kaiser 2004) and the FAO State of the Forest reports (FAO 1997, 1999a, 2014b, 2014c), may not be widely available or known in the policy realm and could be disseminated more widely amongst policymakers. Additional topics in the international arena that merit further attention include: the role of certification as a nonbinding tool for NTFP management; aspects concerning intellectual property rights and the role of TEK; and nongovernmental contributions that contribute to stewardship and industry norms.

7.10 Key Findings

- The body of laws and regulations governing NTFPs is complex and involves jurisdictions from local to international levels.

- The plethora of laws and regulations that apply to NTFPs generally were not created to address sustainable management and conservation of these important resources.
- The diversity of NTFP stakeholders represents a challenge for their incorporation into policy dialogues.
- Special legal responsibilities and challenges are present when addressing indigenous people's rights of access to NTFPs.

7.11 Conclusions

There are many United States laws and policies influencing access to nontimber forest products and management of these plant and fungal resources. Early domestic law set the conservation of plants and fungi on a different path than that of animals. Subsequent legal and administrative frameworks were founded on the need to prevent the spread of plant or fungal disease and invasive species, to assess taxes for interstate and international commerce, or to protect imperiled species as a means to conservation. Such regulations have tended to restrict access to NTFPs and obscured the focus on factors that influence extraction and impeded development of sustainable use policies. As a natural resource that has been largely invisible to modern-day public land managers, however, these regulations provide some of the few measures of tracking and management that exist for these important plant and fungal species. Recent policy developments have set the stage to manage these species as renewable natural resources. More uniform laws and policies are needed that balance the sustainable use and conservation of NTFPs, especially in the face of climate uncertainty.

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CHAPTER 8

Conclusions: Nontimber Forest Products in an Era of Changing Climate

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Nontimber forest species, resources, and products in U.S. forests and rangelands provide a range of ecological, social, cultural, and economic goods and services. This diversity creates challenges and opportunities for management and governance in an era of accelerating climatic variability. Climate variability and change will likely affect forest ecosystems with potentially increasing risks of negative consequences to natural resources and associated social-ecological systems (Ryan and Archer 2008). Drought, insect and disease outbreaks, and fire, as well as extreme events are expected to impact species extent and composition of forests as species respond to climatic variability and change. There is also the potential for loss of species and biological diversity if environmental changes outpace species' ability to adapt. This may in turn adversely affect the potential of NTFPs to provide a buffer for impacted human communities as sources of food, medicine, and other uses. As this report demonstrates, the scientific literature about U.S. nontimber forest products (NTFPs) is considerable. Significant gaps, however, remain in the state of the knowledge about these natural resources and how the social-ecological systems that characterize them may respond to climatic variability.

8.1 Nontimber Forest Product Ecologies and Climatic Variability

Climatic variability is likely to affect the ecological conditions necessary to support nontimber forest species from individual organisms to the landscape level, influencing the presence of wild plants and fungi and their biophysical properties. Because NTFPs are derived from a diverse array of species that span taxonomic and environmental boundaries, understanding the nature and spatial distribution of those effects requires extensive effort (see chapter 3). Effects on NTFP species will vary spatially and temporally. Life history traits may provide insights into likely demographic, evolutionary, and spatial responses to climatic variability for species with shared characteristics. Knowledge about habitat responses also will grow, especially as many NTFPs are understory species that are strongly influenced by the effects of disturbance and management on the forest overstory (see chapter 2). Some predicted long-term climate effects on forest ecologies with implications for NTFPs include altered frequency and intensity of disturbances such as wildfires, storm damage, flooding, invasive species incursions, insect and disease outbreaks and changes in forest productivity.

Projected shifts in forest types for the United States suggest potentially significant changes in forest structure and composition that will affect NTFPs (Melillo et al. 2014, Prasad et al. 2007). Increase in average minimum temperature and changes in precipitation will affect habitats associated with specific NTFPs, with some being more vulnerable to climate change than others (USDA 2015).

Range breadth is frequently used as an indicator of vulnerability to climatic-variability-driven extinction, because a narrow distribution may indicate sensitivity to changing climate as well as habitat specificity (Bellard et al. 2012, Brook and McLachlan 2008, Thomas et al. 2004). At first glance, NTFPs not characterized by a narrow range may appear robust to changing climate. However, specialization to local climate conditions may narrow the thermal niche of a species, thus increasing vulnerability. Relative to trees and weedy species, many NTFP species display limited dispersal distances, which increases the likelihood of local adaptation (Bennington and McGraw 1995, Gregor 1946, McGraw 1985) but also may increase vulnerability (Davis et al. 2005, Etterson 2004). Further, climatic variability may interact with other stressors like harvesting to increase the risk of extirpation or extinction for NTFP populations and species (Brook and McLachlan 2008, Mandle and Ticktin 2012, Souther and McGraw 2014).

Alterations in the phenology of NTFP species are of particular concern for maintenance of their cultural values (see chapter 4) and already are being observed in response to changing climate. Long-term surface data and remote sensing measurements indicate that major events of plant phenology such as leaf-on and leaf-off dates have advanced by 2 to 3 days in spring and delayed by 0.3 to 1.6 days in autumn per decade over the past 30 to 80 years, resulting in a significant extension of the growing season (Badeck et al. 2004, Schwartz et al. 2006). Warmer, shorter winters provide favorable conditions for pest populations as insects and diseases that previously would have been killed by low winter temperatures survive mild winters (Jamieson et al. 2012). In some cases, shorter winters will be characterized by greater fluctuations in temperature, resulting in mortality from extreme cold and/or repeated cycles of freezing and thawing. Earlier spring onset increases frost vulnerability, with consequences for successful fruiting and reproduction of NTFP species. When flowering occurs earlier, blooms are at increased risk of freezing (Inouye 2008, Sherry 2007, Souther and McGraw 2014). Mountain species particularly are experiencing frost damage due to early blooming. Earlier spring dates also may create mismatches, or phenological asynchronies, such as when plants bud earlier and their pollinators have not adapted to this shift in timing. For example, bees may target specific habitats with plant populations they historically pollinate only to find those plants have already bloomed (Fitzpatrick 2010). Such phenological asynchronies adversely impact pollinator and plant alike.

General trends notwithstanding, there is considerable uncertainty in any projection of likely responses to climatic variability by NTFP species. Long-term studies and biotic monitoring projects show that some species have responded to contemporary climatic variability in a manner consistent with expectations (Badeck et al. 2004; Hoffmann and Sgrò 2011; Parmesan 2006; Parmesan et al. 2000, 2013; Parmesan and Yohe 2003; Walther 2010). For instance, many species have shifted distribution northward or upward in elevation and advanced the timing of critical life history events, such as spring emergence in plants or migration in avian species (Badeck et al. 2004; Hoffmann and Sgrò 2011; Parmesan 2006; Parmesan et al. 2000, 2013; Parmesan and Yohe 2003; Pinsky et al. 2013; Walther 2010). However, there have been ecological surprises as well. A significant proportion of species, depending on the datasets analyzed, appear to remain unchanged or respond in a manner opposite to expectations (Tingley et al. 2012, Wolkovich et al. 2012).

8.2 Social, Cultural, and Economic Dimensions of Nontimber Forest Product and Climatic Variability

Shifts in the ecology of NTFPs will condition their availability as social, cultural, and economic resources. Social disruption of climate-induced human displacement, accompanied by economic distress, could also make humans more dependent on NTFPs as sources of food, fuel, and utilitarian materials, as well as social anchors.

As changes associated with altered climate affect landscapes and social systems in which cultural uses of NTFPs occur, they will likely affect cultures throughout the United States and its affiliated territories. Among the contributions to human well-being at risk are the roles of NTFPs in food security (Lynn et al. 2013), health security (Kassam et al. 2010), identity formation, social cohesion, and livelihoods (Cocks and Wiersum 2014, Emery 2002, Lynn et al. 2013, Voggesser et al. 2013). Such alterations could have adverse consequences for diverse communities across rural to urban environments (see chapter 5). Within general parameters, specific effects of climatic variability on NTFP cultural functions will vary by region and cultural group. Each cultural group is vulnerable to the effects of climatic variability depending on their geographic location, species of interest, and capacity to adapt to interacting stressors at multiple scales (Bennett et al. 2014). Such developments may pose new challenges for compliance with laws relevant to cultural values of NTFPs in these regions.

At the same time, culture is dynamic and there are opportunities to mitigate and adapt to climatic variability effects on NTFP cultural values. Indeed, NTFPs frequently provide essential survival resources in times of disruption (e.g., Redzic 2010) and likely will do so during climate-related disturbances. The resilience of cultures and their NTFP-based practices may be a function of the intensity, speed, and duration of events that pose ecological and/or social challenges to them. Indigenous peoples have noted that their cultures are the product of millennia of adaptation to social and ecological change. As a consequence, indigenous peoples may have knowledge and wisdom to offer to adapt to impacts from a changing climate (Voggesser et al. 2013).

NTFPs contribute to microeconomies and macroeconomies, through nonmarket and formal and informal means (see chapter 6). NTFP harvesters and users face many uncertainties in their nonmarket and formal and informal economic activities. Climatic variability adds further risk of (1) changes in biological availability of NTFPs, (2) price pressures for scarce NTFP resources, (3) regulatory barriers in response to reduced production and increased competition, (4) changes in direct and indirect costs of obtaining NTFPs, and (5) disruption of social networks and safety nets due to loss of access to NTFPs. While many social, cultural, and economic consequences of climatic variability effects on NTFPs will unfold over time, others will develop rapidly. Extreme weather events such as hurricanes, tornados, and floods are projected to increase in severity and become more frequent, and produce more acute impacts (short in duration but strong in magnitude) to NTFPs and the people who depend on them. If climatic variability diminishes populations of certain NTFP species, or changes their range, people may lose access to those resources as an economic safety net (see chapter 6).

Risks will be felt more keenly by some individuals than others. Increased food insecurity and decreased nutritional status are likely results for subsistence practitioners and others who rely on wild plants and fungi for significant aspects of their dietary intake. Full-time commercial harvesters also may be hard hit by climatic variability effects on NTFPs, as they tend to rank among the poorest populations in a region (Hembram and Hoover 2008, Schlosser and Blatner 1995). Loss of access to edible plants and mushrooms for personal consumption and/or income from the sale of NTFPs may push more people to rely on assistance programs and make the status of those who already rely on these programs more precarious. Enterprises that rely on wild or forest farmed plants and fungi also may experience differing impacts, with businesses that rely on one or a small number of NTFPs potentially facing greater risks than those whose business is based on a diversity of species and products.

However, climate-related effects on plants and fungi will be complex. Along with potential disruption, NTFP-based opportunities likely will arise. In some cases, disturbance or changing conditions in a location may favor the presence of new NTFP species or increases in the population of previously scarce species. Where this occurs, it could result in increased supplies for subsistence, personal consumption, and sale in value-added or unprocessed forms. Again, adaptive capacity will condition individuals' and communities' abilites to benefit from these new opportunities.

8.3 Nontimber Forest Product Policy, Management, and Climatic Variability

Regulations and policies that address access, management, extraction, trade, and conservation of nontimber forest products exist at multiple governmental levels in the United States (George et al. 1998, McLain and Jones 2002; see chapter 7 for detailed descriptions). At the Federal level, the Endangered Species Act (ESA 1973), the Lacey Act (1900), and the National Environmental Policy Act (NEPA 1969) have particular relevance. Among Federal agencies with jurisdiction over public lands where NTFPs are harvested are the Forest Service, Department of Defense, and three Department of the Interior agencies: Bureau of Land Management, National Park Service, and U.S. Fish and Wildlife Service. In addition to the ESA, Lacey Act, and NEPA, each of these Federal agencies operates under a suite of further laws and regulations that apply to NTFPs. Legal canons applying to Native peoples' access to NTFPs include, but are not confined to, the Federal Indian Trust Responsibility, the Alaska National Interest Lands Conservation Act, and the Hawai'i State constitution. Further laws and regulations are in force at State and local levels.

Maintaining natural diversity through silvicultural practices and other management strategies may be key to mitigating the impact of climate change on NTFPs. High species diversity increases ecological resiliency (Tilman and Downing 1996) and may contribute to functional redundancy (Peterson et al. 1998), protecting ecosystem functions in the face of climate-induced disturbance and change. Conversely, intensive management for one or a few high valued NTFPs may decrease diversity, decreasing resiliency and placing forests and NTFP species in them at greater risk (see chapter 2).

Managed relocation, or assisted migration, may be a viable option for adapting to climate change and its impacts on NTFP-based social, cultural, and economic values. Efforts are underway to see if assisted migration can help tree species that are imperiled by the anticipated impacts of increased drought and higher temperatures on their limited native distributions (McLachlan et al. 2007, Williams and Dumroese 2013). Further, knowledge development may help address challenges with assisted migration of important genetic diversity within the native plant communities by finding seed sources with strong resilience to drought (Vose et al. 2012, p. 287).

Assisted migration may be a promising mitigation approach, but particular consideration must be afforded to potential negative impacts, such as gene-pool degradation, competition with existing native plants, and changes in ecosystem dynamics. The effectiveness of widespread assisted migration is not yet known (Williams and Dumroese 2013), and some have expressed concerns about the risk of introducing invasive species (Mueller and Hellman 2008). The fitness of species that are adapted to other sites may be negatively impacted when associations with key environmental factors are changed. Additionally, the introduction of nonlocal genotypes may cause outbreeding depression or a decline in fitness of subsequent generations due to infiltration of maladapted genotypes (Frankham 1995, Kramer and Havens 2009, Pertoldi et al. 2007). Nevertheless, gene flow from populations adapted to warmer climates may provide genetic variation and traits necessary to adapt to novel climatic conditions (Hampe and Petit 2005).

8.4 Gaps in the State of the Knowledge

There are inherent challenges to managing for NTFPs in a time of changing climate. Forest cover change, invasive species, and increased frequency and severity of extreme weather events all contribute to an environment of intensifying uncertainty. Most forest management is based on historical conditions. Today, we cannot be sure the past is an analog to future forest conditions.

Knowledge is essential to informed planning for and response to the effects of climatic variability on NTFPs. Unfortunately, there are significant gaps in the state-of-the-knowledge about all aspects of NTFP social-ecological systems. The knowledge needed to fill these gaps includes:

- Basic ecology of NTFP species particularly those with high social, cultural, and economic value.
- More detailed information on the abundance and distribution of major NTFPs and impacts of harvesting trends, disturbance, and land-use change.
- Social and ecological dynamics of NTFP management and use.
- Traditional and local ecological knowledge and practices related to NTFPs.
- Forest silviculture and management and harvest practices for NTFP species that addresses responses to climate-induced phenomena.
- Implications for food and health security.
- Climate modeling, projections, and risk-analysis at finer scales for entity-level decisionmaking and reporting on NTFPs.

8.5 Conclusions

Nontimber forest products have supported the peoples and cultures of the United States and its affiliated territories since before the founding of the Nation. Wild and forest farmed plants and fungi continue to sustain humans through personal consumption. They are sources of income for people who have limited options for other earnings and help to smooth chronic and occasional disruptions in household economies. NTFPs supply businesses from cottage industries to multinational corporations.

The plants and fungi from which NTFPs are derived number in the hundreds (appendix 4). Their responses to climate variability and change are proving to be diverse (see chapter 3). As ecological processes proceed, they will have social, cultural, and economic consequences. In some cases, the results may be favorable. It seems likely that in many more cases, short-term to mid-term results will be negative with potentially serious consequences.

Knowledge on the range of NTFP policy and management challenges posed by climatic variability is incomplete. This report identifies many potential outcomes and synthesizes the state of information on the social-ecological systems of wild plants and fungi used for food, medicine, and other purposes. Nevertheless, critical knowledge gaps remain. While there is yet much to learn, traditional, local, and scientific knowledge provide current bases for planning adaption and mitigation of the adverse impacts of climatic variability on NTFPs and the people who depend on them.

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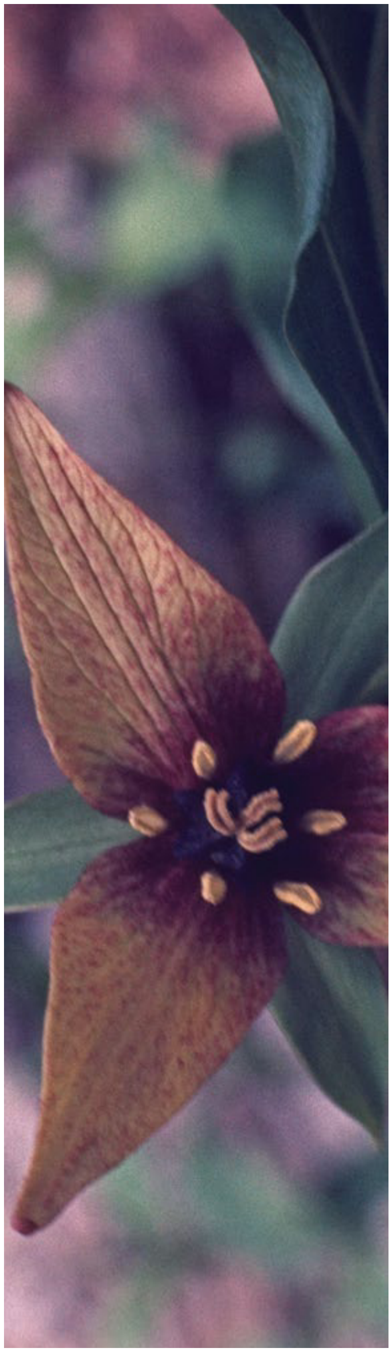

Appendixes

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, Māui, Kaho'olawe, Lāna'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

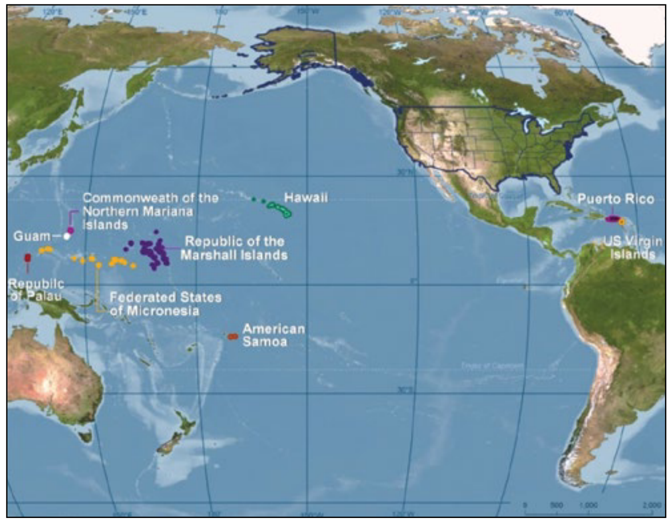

Figure A1.1—Map of Hawai'i and Pacific islands. (Source: Olga Ramos, U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry.)

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.)
State of Hawai'i	4,127,337	n/a	n/a	47%	~0%	44%	9%
Territory of American Samoa	49,280	15,510	35%	≤96%	n/a	≥4%	0%
	44,800	20,000	85	100	0	0	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	~0%	<50%	n/a
Territory of 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 affiliated 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 include 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 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), *lā‘au* (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

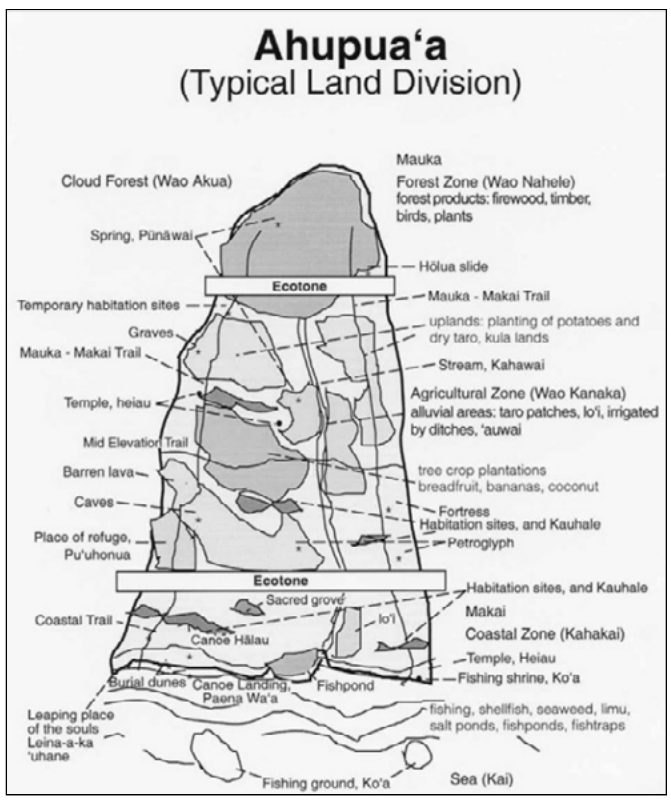

Figure A1.2—An ahupua‘a, a patchwork of nontimber forest products management areas between mauka (mountain) and makai (ocean) resources (Minerbi 1999).

as to the ceremonial adornment of the dancer with ferns (palapalai, *Microlepia strigosa*; and Chinese creeping fern or pala'a, *Sphenomeris chinensis*), flowers ('ōhi'a lehua, *Metrosideros polymorpha*; and 'a'ali'i, *Dodonaea viscosa*), leaves ('ōhi'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

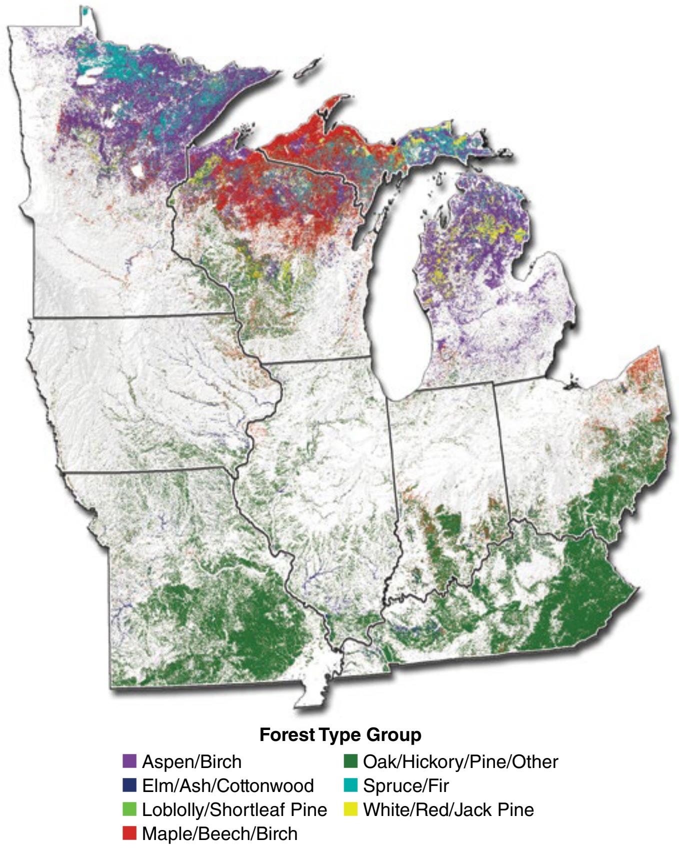

Figure A1.3—Forest type groups of the Midwest. (Source: Handler 2013.)

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

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[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

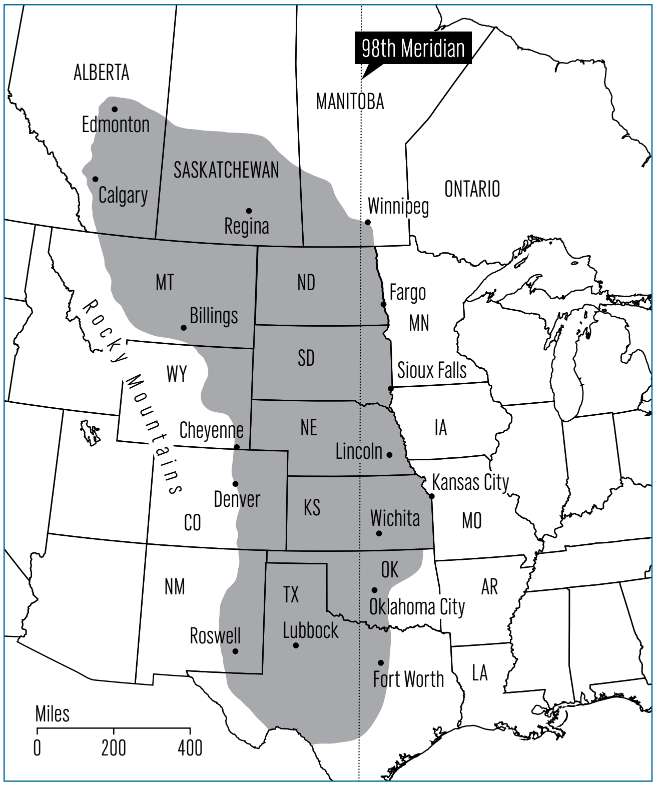

Figure A1.4—The Great Plains region (gray shading). (Source: Wishart 2004.)

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),

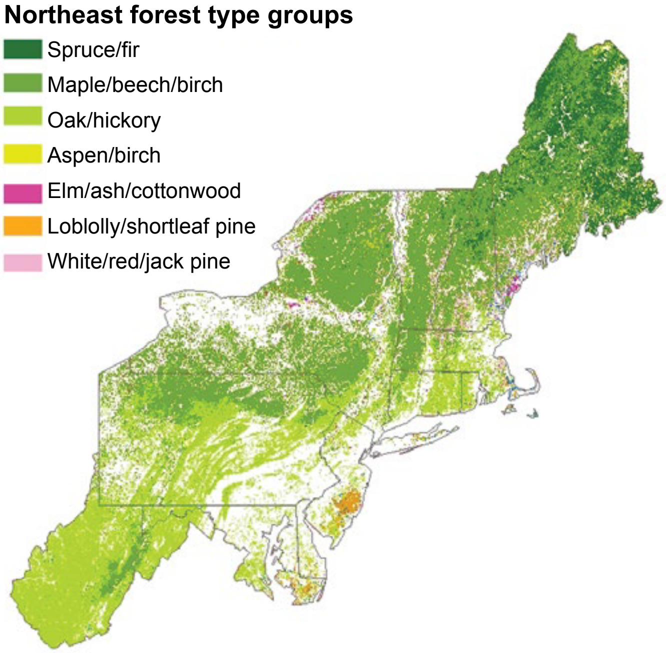

Figure A1.5—Forest type groups of the Northeast. The three dominant forest types of the region from north to south are the spruce-fir group, the maple-beech-birch group, and the oak-hickory group. (Map rendered by Michelle J. Baumflek, U.S. Department of Agriculture, Forest Service.)

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—

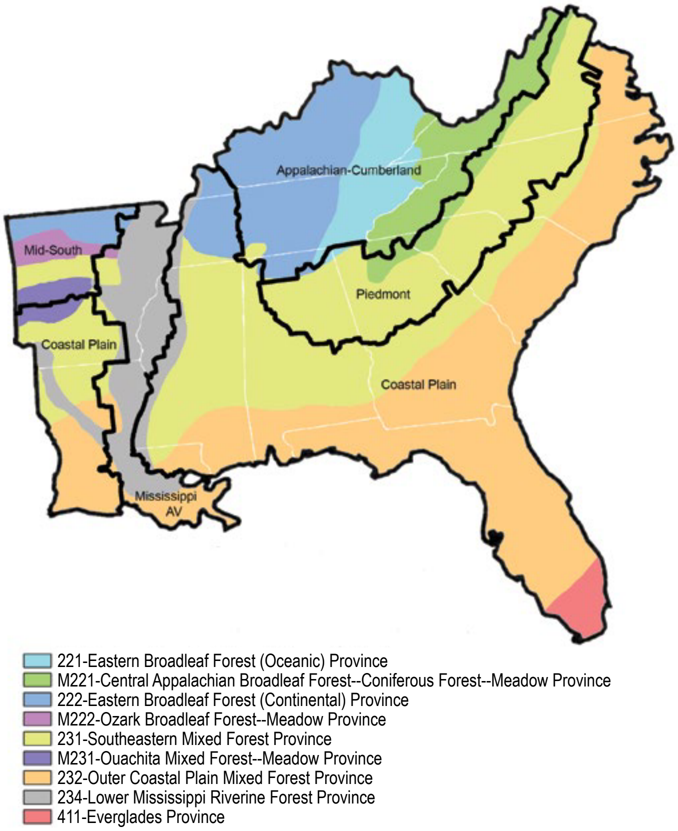

Figure A1.6—Ecoregions of the Southeast. (Source: Adapted from Bailey 1995 and Wear et al. 2009)

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)

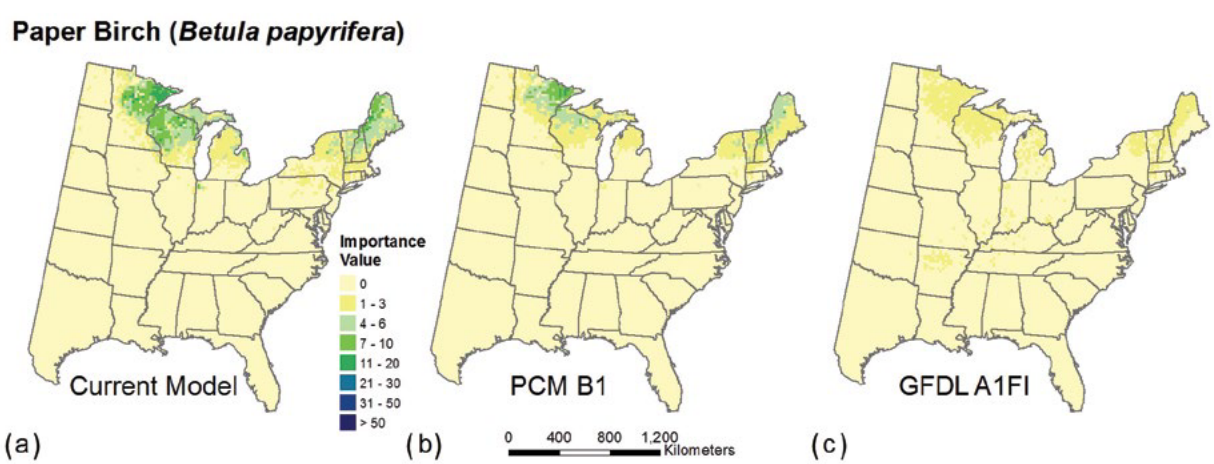

Figure A2.1—Suitable habitat (Iverson and Prasad 2002) for paper birch across the eastern United States according to (a) current USDA Forest Service, Forest Inventory and Analysis data, (b) projected future habitat for the year ~2100 under a mild scenario of climate change (PCM B1), and (c) a harsh scenario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

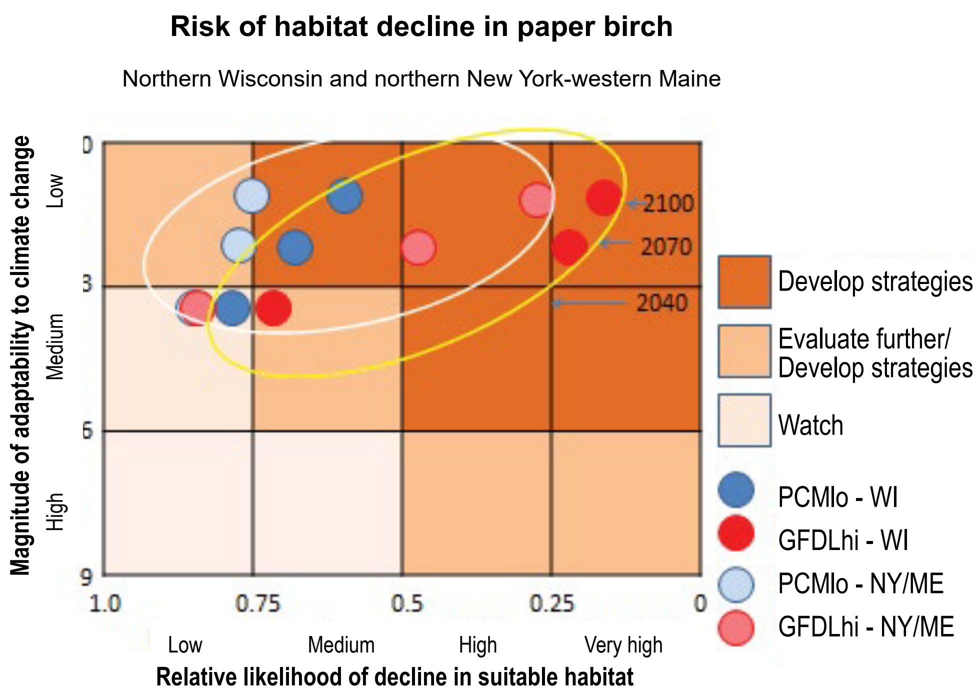

Figure A2.2—Risk of habitat decline in paper birch in northern Wisconsin and northern New York to western Maine. Northern Wisconsin (yellow ellipse) is poised to lose substantially more suitable habitat by 2070 as compared to New England (white ellipse), under either high or low emissions scenarios. 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,

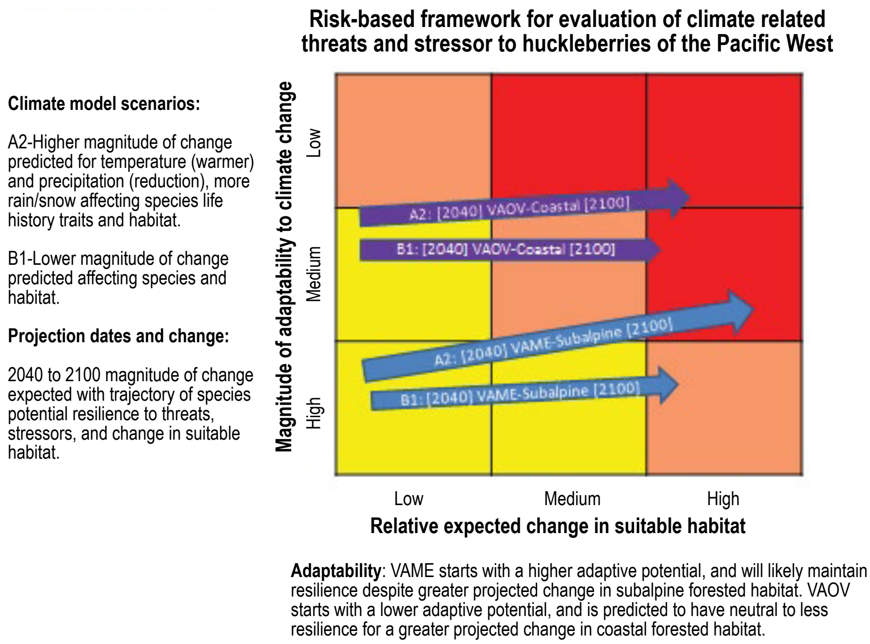

Figure A2.3—Adaptive capacity of thinleaf huckleberry (*Vaccinium membranaceum*) and evergreen huckleberry (*Vaccinium ovatum*) under projected low, medium, and high magnitude changes in their respective habitats.

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.), 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).

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).

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.

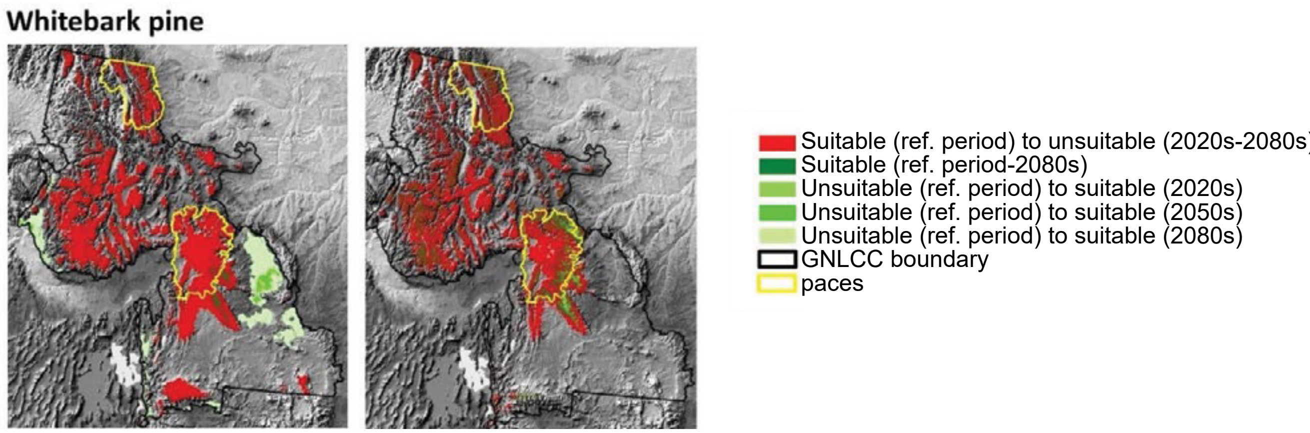


Figure A2.5—Metadata analysis of projected change in modeled spatial distribution of climate suitable areas for whitebark pine (*Pinus albicaulis* Engelm.) in Idaho, Montana, and northwestern Wyoming across the reference and three future time periods (2020, 2050, 2080), under the A2 emission scenario 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.)

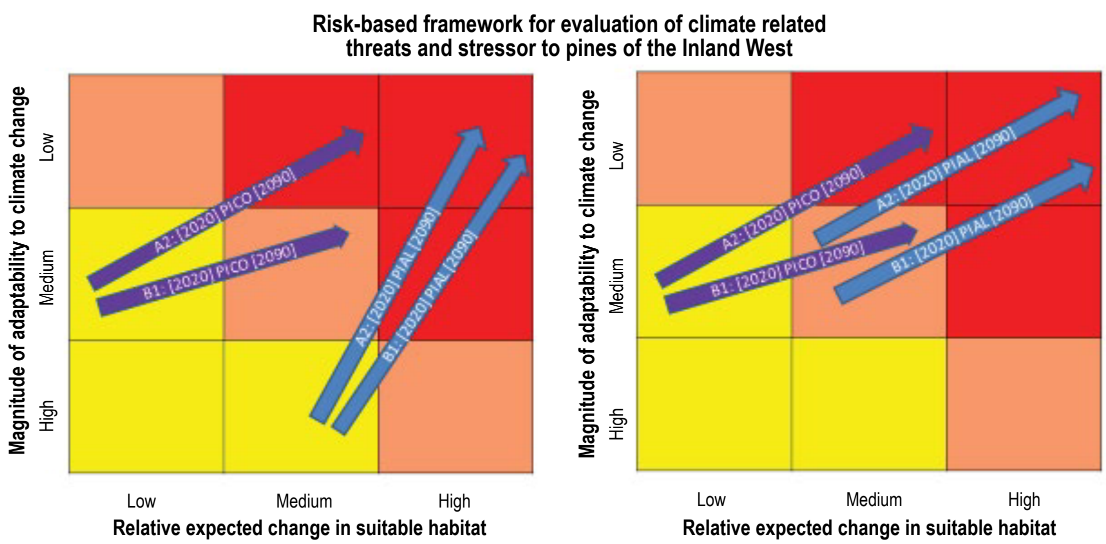
Climate model scenarios:

A2-Higher magnitude of change predicted for temperature (higher) and precipitation (reduction); warmer temperatures and changes in precipitation patterns will impact species life history traits, insect and disease issues, and habitat.

B1-Lower magnitude of change predicted affecting species and habitat; insect and disease issues remain.

Projection dates and change:

2020 to 2090 magnitude of change expected with trajectory of species' potential resilience to threats, stressors, change in suitable habitat, and projected increase in suitable habitat.



Adaptability: PIAL starts with a higher adaptive potential ***with active restoration***, but continued pressure by blister rust, mountain pine beetle, altered fire regimes, and bird-dispersed seed compound its ability to maintain resilience with rapidly shrinking habitat. PICOL starts with a medium adaptive potential, and combined with frequent cone crops and wind-disseminated seed, it is projected to maintain some resilience with fewer threats and a moderate projected change in forested habitat.

Adaptability: PIAL starts with a higher adaptive potential ***without active restoration***, but continued pressure by blister rust, mountain pine beetle, altered fire regimes, and bird-dispersed seed compound its ability to maintain resilience with rapidly shrinking habitat. PICOL starts with a medium adaptive potential, and combined with frequent cone crops and wind-disseminated seed, it is projected to maintain some resilience with fewer threats and a moderate projected change in forested habitat.

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.

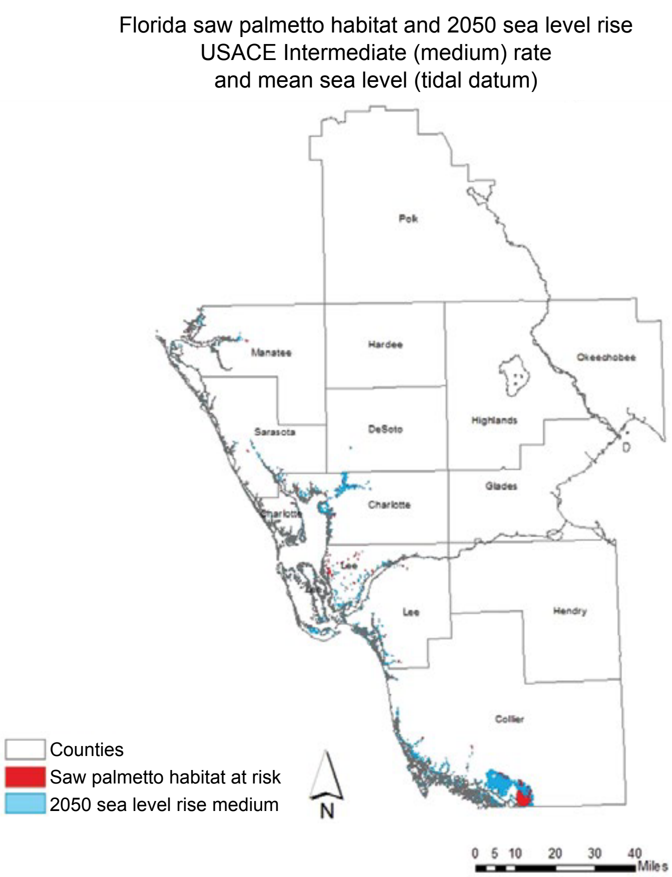

Figure A2.8—Saw palmetto habitat distribution. Results show that almost 60,000 acres of approximately 1.8 million acres of saw palmetto habitat will be lost by sea level rise by 2050. The area in red is habitat at risk. (Map rendered by C.M. Mitchell.)

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

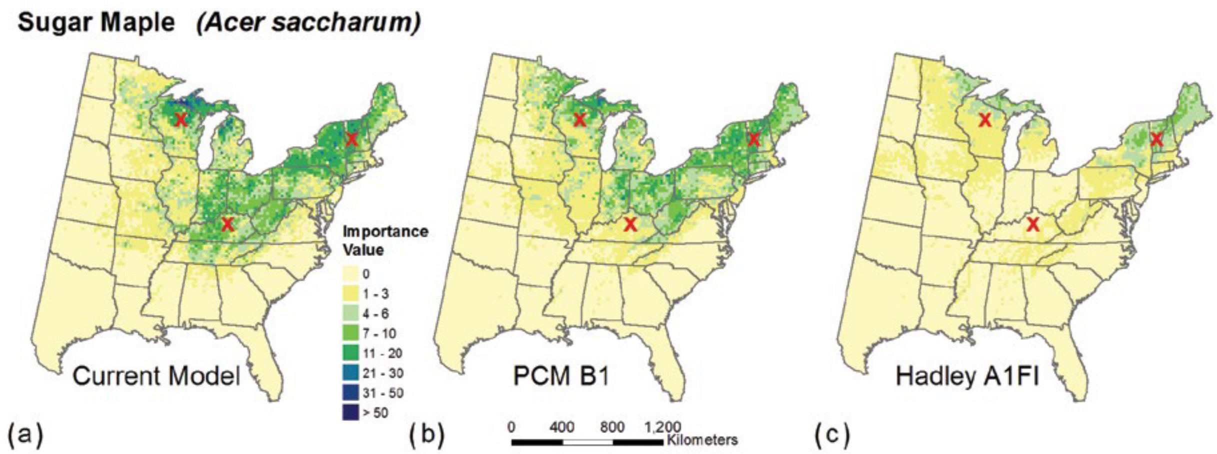

Figure A2.9—Suitable habitat for sugar maple across the eastern United States according to (a) current estimates for 1980 to 2000, (b) projected future habitat for the year ~2100 under a mild scenario of climate change (PCM B1), and (c) a harsh scenario (Hadley A1FI). The Xs mark the northern Wisconsin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

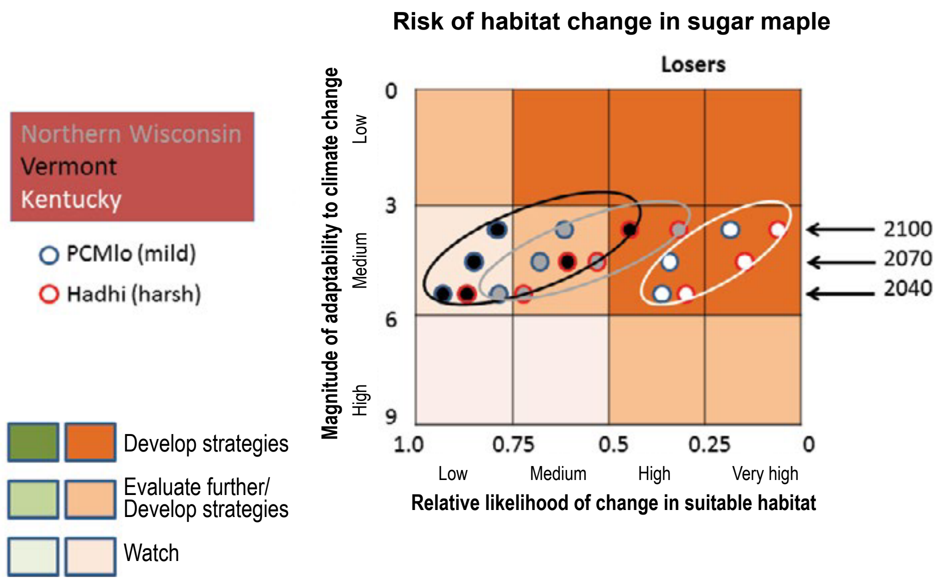

Figure A2.10—Risk matrix for sugar maple in northern Wisconsin, Vermont, and Kentucky. The numbers on the X-axis reflect projected suitable habitat, where 1.0 indicates no change from current values and 0 indicates complete loss of habitat. The numbers on the Y-axis are based on modifying factors, with 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.