CHAPTER 6

Economics of Nontimber Forest Products

Gregory E. Frey
Keith A. Blatner
Michael G. Jacobson
C. Meghan Starbuck Downes
Erin O. Sills
D. Evan Mercer
Susan J. Alexander
James L. Chamberlain
Michael A. Gold
Larry D. Godsey
Marla R. Emery
Alisa W. Coffin
Rebecca J. Barlow
Luanne Lohr

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).

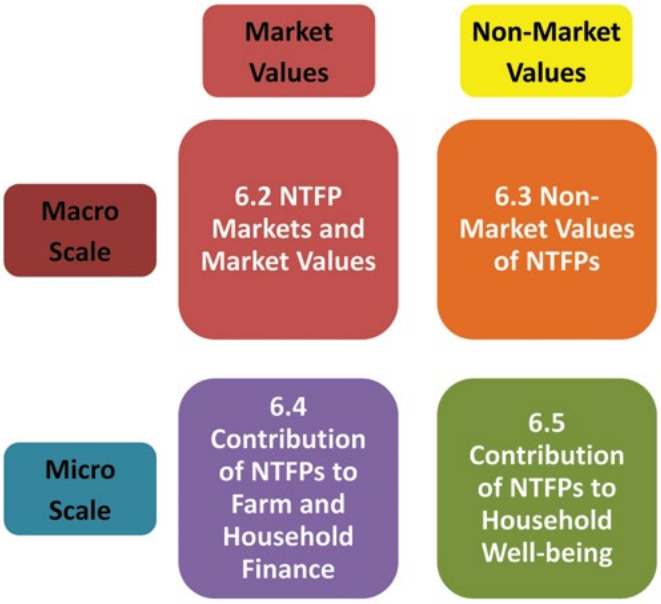


Figure 6.1—Principle sections of Chapter 6: Economics of Nontimber Forest Products. (Source: Greg Frey, U.S. Department of Agriculture, Forest Service, Southern Research Station.)

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. in progress)[1] 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.)

[1] Chamberlain, J.L.; Teets, A. and Kruger, S. [In preparation]. Nontimber forest products in the United States: an update for the 2015 National Sustainable Forest Report for the Montreal Process.

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.

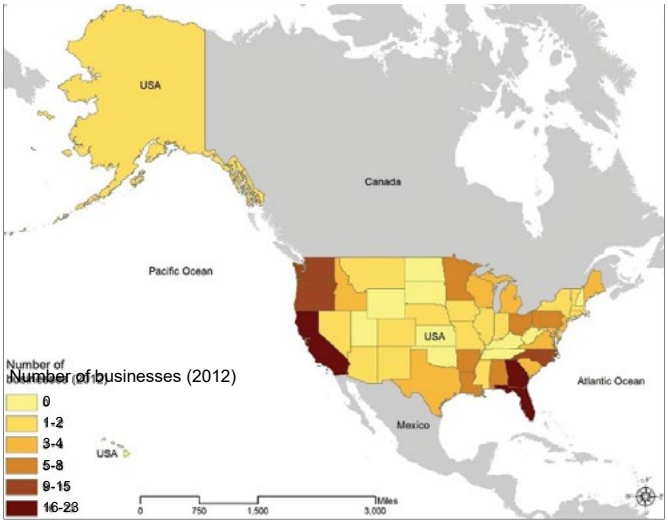
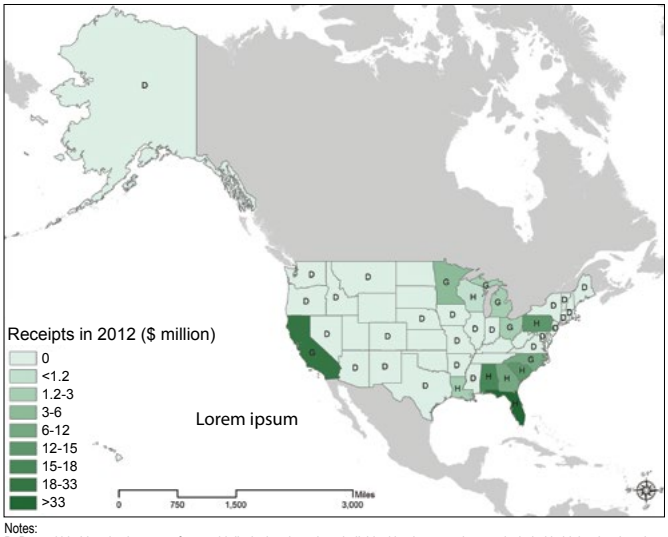


Figure 6.3—Concentration and distribution of firms classified under North American Industrial Classification System (NAICS) 113210: Forest Nurseries and Gathering of Forest Products in 2012. The total number of establishments in the United States was 182 in 2012. (Source: U.S. Census Bureau 2016.)



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 $311.5 million in 2006.

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

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**

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 largest market share for many medicinal NTFPs. Local

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).

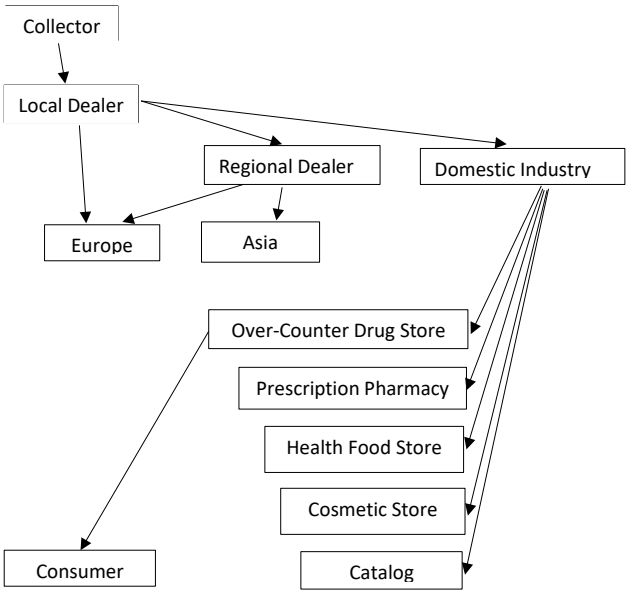


Figure 6.5—Market chain for medicinal and herbal nontimber forest products from southwest Virginia. (Source: Greene et al. 2000.)

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 picked primarily from public forests. The North

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.

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; Maheret et al. 2013; Starbucket 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 forest 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 forested 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:

- Assume that yield risk results 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

Alexander, S.J.; McLain, R.J.; Blatner, K.A. 2001. Socio-economic research on nontimber forest products in the Pacific Northwest. Journal of Sustainable Forestry. 13(3–4): 95–103.

Alexander, S.J.; McLain, R.J.; Jones, E.T.; Oswalt, S.N. 2011a. Challenges and approaches to assessing the market value of wild fungi. In: Cunningham, A.B.; Yang, X., eds. Mushrooms in forests and woodlands: resource management, values and local livelihoods. London: Earthscan: 87–106.

Alexander, S.J.; Oswalt, S.N.; Emery, M.R. 2011b. Nontimber forest products in the United States: Montreal Process indicators as measures of current conditions and sustainability. Gen. Tech. Rep. PNW-GTR-851. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 36 p.

Alexander, S.J.; Pilz, D.; Weber, N.S. [and others]. 2002a. Mushrooms, trees, and money: value estimates of commercial mushrooms and timber in the Pacific Northwest. Environmental Management. 30(1): 129–141.

Alexander, S.J.; Weigand, J.; Blatner, K.A. [and others]. 2002b. Nontimber forest product commerce. In: Jones, E.T.; McLain, R.J.; Weigand, J., eds. Nontimber forest products in the United States: uses and issues. Lawrence, KS: University Press of Kansas: 115–150.

Anderson, J.A.; Blahna, D.J.; Chavez, D.J. 2000. Fern gathering on the San Bernardino National Forest: cultural versus commercial values among Korean and Japanese participants. Society & Natural Resources. 13(8): 747–762.

Bailey, B. 1999. Social and economic impacts of wild harvested products. Morgantown: West Virginia University. Ph.D. dissertation.

Bakkegaard, R.K.; Bosselmann, A.S.; Zheng, Y. [and others]. 2016. National socioeconomic surveys in forestry: guidance and survey modules for measuring the multiple roles of forests in household welfare and livelihoods. FAO Forestry Paper No. 179. Food and Agriculture Organization of the United Nations, Center for International Forestry Research, International Forestry Resources and Institutions Research Network, and World Bank. 188 p.

Barron, E.S.; Emery, M.R. 2012. Implications of variation in social-ecological systems for the development of U.S. fungal management policy. Society & Natural Resources. 25(10): 996–1011.

Baumflek, M.J.; Emery, M.R.; Ginger, C. 2010. Culturally and economically important nontimber forest products of northern Maine. Gen. Tech. Rep. NRS-68. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 74 p.

Blatner, K.A.; Alexander, S.J. 1998. Recent price trends for nontimber forest products in the Pacific Northwest. Forest Products Journal. 48(10): 28–34.

Blatner, K.A.; Cohn, P.J.; Fight, R.D. 2010. Returns from the management of noble fir stands for bough production and sawtimber. Western Journal of Applied Forestry. 25(2): 68–72.

Bowker, J.M.; English, D.; Bergstrom, J.C. [and others]. 2005. Valuing national forest recreation access: using a stratified on-site sample to generate values across activities for a nationally pooled sample. Paper presented at the 2005 annual meeting of the American Agricultural Economics Association, July 24–27, 2005, Providence, RI. Abstract available https://ideas.repec.org/p/ags/aaea05/19506.html. [Date accessed: July 11, 2017].

Bowker, J.M.; Murphy, D.; Cordell, H.K. [and others]. 2006. Wilderness and primitive area recreation participation and consumption: an examination of demographic and spatial factors. Journal of Agricultural and Applied Economics. 38(2): 317.

Bowker, J.M.; Starbuck, C.M.; English, D. [and others]. 2009. Estimating the net economic value of national forest recreation: an application of the National Visitor Use Monitoring database. Athens: University of Georgia, Department of Agricultural and Applied Economics.

Burkhart, E.P. 2011. Conservation through cultivation: economic, socio-political and ecological considerations regarding the adoption of ginseng forest farming in Pennsylvania. State College: Pennsylvania State University. Ph.D. dissertation.

Burkhart, E.P.; Jacobson, M.G. 2009. Transitioning from wild collection to forest cultivation of indigenous medicinal forest plants in eastern North America is constrained by lack of profitability. Agroforestry Systems. 76(2): 437–453.

Butler, B.J. 2008. Family forest owners of the United States, 2006. Gen. Tech. Rep. NRS-27. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 72 p.

Byers, P.L.; Thomas, A.L.; Cernusca, M.M. [and others]. 2012. Growing and marketing elderberries in Missouri. Agroforestry in Action Guide AF1016–2014. Columbia, MO: University of Missouri, Center for Agroforestry. 12 p.

Carroll, M.S.; Blatner, K.A.; Cohn, P.J. 2003. Somewhere between: social embeddedness and the spectrum of wild edible huckleberry harvest and use. Rural Sociology. 68(3): 319–342.

Casanova, V. 2007. Three essays on the pine straw industry in a Georgia community. Auburn AL: Auburn University. Ph.D. dissertation.

Castle, L.M.; Leopold, S.; Craft, R.; Kindscher, K. 2014. Ranking tool created for medicinal plants at risk of being overharvested in the wild. Ethnobiology Letters. 5: 77–88.

Cernusca, M.M.; Gold, M.A.; Godsey. L.D. 2011. Elderberry market research: report based on research performed in 2009. Columbia, MO: University of Missouri Center for Agroforestry. http://www.centerforagroforestry.org/profit/elderberrymarketreport.pdf. [Date accessed: August 9, 2017].

Chamberlain, J.L.; Bush, R.; Hammett, A. 1998. Nontimber forest products: the other forest products. Forest Products Journal. 48(10): 10–19.

Chamberlain, J.L.; Prisley, S.; McGuffin, M. 2013. Understanding the relationships between American ginseng harvest and hardwood forests inventory and timber harvest to improve co-management of the forests of eastern United States. Journal of Sustainable Forestry. 32(6): 605–624.

Chamberlain, J.L.; Teets, A.; Kruger, S. 2018. Nontimber forest products in the United States: an analysis for the 2015 National Sustainable Forest Report. e-Gen. Tech. Rep. SRS-229. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 42 p.

Davis, J.; Persons, W.S. 2014. Growing and marketing ginseng, goldenseal and other woodland medicinals. Gabriola Island, BC: New Society Publishers. 510 p.

Davis, J.M.; Dressler, A. 2012. Bloodroot and black cohosh artificial shade budgets. http://www.ces.ncsu.edu/fletcher/programs/herbs/index.html https://www.ces.ncsu.edu/fletcher/programs/herbs/crops/medicinal/2012%20Black%20Cohosh%20Artificial%20Shade%20Budget%20final.xlsx. https://www.ces.ncsu.edu/fletcher/programs/herbs/crops/medicinal/2012%20Bloodroot%20Artificial%20Shade%20Budget%20final.xlsx. Excel spreadsheets to evaluate costs. [Date accessed: August 15, 2017].

Dickens, E.D.; Moorhead, D.J.; Bargeron, C.T.; McElvany, B.C. 2011. Pine straw yields and economic benefits when added to traditional wood products in loblolly, longleaf and slash pine stands. Athens: University of Georgia, Daniel B. Warnell School of Forestry and Natural Resources. 8 p. http://www.warnell.uga.edu/outreach/pubs/pdf/forestry/Pine_straw_Dickens_et_al_6_July_2011.pdf. [Date accessed: August 9, 2017].

Dyer, J.A.F. 2012. Three essays on pine straw in Alabama: needlefall yields, market demands, and landowner interest in harvesting. Auburn, AL: Auburn University. Ph.D. dissertation.

Dyke, A.J. 2006. The practice, politics and ecology of nontimber forest products in Scotland. Glasgow: University of Glasgow. Ph.D. dissertation.

Eliason, S.L. 2004. Accounts of wildlife law violators: motivations and rationalizations. Human Dimensions of Wildlife. 9(2): 119–131.

Emery, M.R. 1998. Invisible livelihoods: nontimber forest products in Michigan's Upper Peninsula. New Brunswick, NJ: Rutgers University. Ph.D. dissertation.

Emery, M.R. 2001. Nontimber forest products and livelihoods in Michigan's Upper Peninsula. In: Davidson-Hunt, I.; Duchense, L.; Zasada, J., eds. Forest communities in the third millennium: linking research, business, and policy toward a sustainable nontimber forest product sector. Gen. Tech. Rep. NC-217. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station: 23–30.

Emery, M.R.; Ginger, C. 2014. Special forest products on the Green Mountain and Finger Lakes National Forests: a research-based approach to management. Gen. Tech Rep. NRS-131. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 51 p.

Emery, M.R.; Ginger, C.; Chamberlain, J.L. 2006b. Migrants, markets, and the transformation of natural resources management: galax harvesting in western North Carolina. In: Smith, H.A.; Furuseth, O.J., eds. Latinos in the New South: transformations of place: 69–87.

Emery, M.R.; Ginger, C.; Newman, S.; Giammusso, M. 2003. Special forest products in context: gatherers and gathering in the Eastern United States. Gen. Tech. Rep. NE-306. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 59 p.

Emery, M.R.; Martin, S.; Dyke, A. 2006a. Wild harvests from Scottish woodlands: social, cultural and economic values of contemporary nontimber forest products. Edinburgh: Forestry Commission.

Emery, M.R.; Pierce, A.R. 2005. Interrupting the telos: locating subsistence in contemporary U.S. forests. Environment and Planning A. 37(6): 981–993.

Forestry Commission. 2005. GB public opinion of forestry 2005: summary results of the 2005 GB survey of public opinion of forestry. Edinburgh: Forestry Commission. 37 p. http://www.forestry.gov.uk/forestry/infd-5zyl9w. [Date accessed: August 9, 2017].

Freeman, A.M., III. 2003. The measurement of environmental and resource values: theory and methods. 2nd ed. Washington, DC: RFF Press. 490 p.

Frey, G.E. 2014. The basics of hardwood-log shiitake mushroom production and marketing. ANR-102P. Blacksburg, VA: Virginia Cooperative Extension. 9 p. http://www.pubs.ext.vt.edu/ANR/ANR-102/ANR-102.html. [Date accessed: August 9, 2017].

Glenn, J.V. 2012. Economic assessment of landowner incentives: analyses in North Carolina and Malawi. Raleigh: North Carolina State University. Ph.D. dissertation.

Godsey, L.D. 2010. Economic budgeting for agroforestry practices. Agroforestry in Action Guide AF1006-2010. Columbia, MO: University of Missouri Center for Agroforestry. 12 p. http://extension.missouri.edu/explorepdf/agguides/agroforestry/af1006.pdf. [Date accessed: August 9, 2017].

Godsey, L.D.; Mercer, D.E.; Grala, R. [and others]. 2009. Agroforestry economics and policy. In: Garrett, H.E., ed. North American agroforestry: an integrated science and practice. 2nd ed. Madison, WI: American Society of Agronomy: 315–337.

Goodwin, B.K. 2009. Payment limitations and acreage decisions under risk aversion: a simulation approach. American Journal of Agricultural Economics. 91(1): 19–41.

Goodwin, B.K.; Ker, A.P. 2002. Modeling price and yield risk. In: Just, R.E.; Pope, R.D., eds. A comprehensive assessment of the role of risk in U.S. agriculture. Norwell, MA: Kluwer Academic Publishers: 289–323.

Gorman, J.T.; Griffiths, A.D.; Whitehead, P.J. 2006. An analysis of the use of plant products for commerce in remote Aboriginal communities of northern Australia. Economic Botany. 60(4): 362–373.

Greene, S.M.; Hammett, A.; Kant, S. 2000. Nontimber forest products marketing systems and market players in Southwest Virginia: crafts, medicinal and herbal, and specialty wood products. Journal of Sustainable Forestry. 11(3): 19–39.

Greenfield, J.; Davis, J.M. 2003. Collection to commerce: western North Carolina nontimber forest products and their markets. Raleigh: North Carolina State University. 106 p.

Hansis, R. 1998. A political ecology of picking: nontimber forest products in the Pacific Northwest. Human Ecology. 26(1): 67–86.

Hembram, D.; Hoover, W.L. 2008. Nontimber forest products in Daniel Boone National Forest region—economic significance and potential for sustainability. In: Jacobs, D.F.; Michler, C.H., eds. Proceedings of the 16th Central Hardwoods Forest Conference; 2008 April 8–9; West Lafayette, IN. Gen. Tech. Rep. NRS-P-24. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 148–156.

Hill, D.B.; Buck, L.E. 2000. Forest farming practices. In: Garrett, H.; Rietveld, W.; Fisher, R., eds. North American agroforestry: an integrated science and practice. Madison, WI: American Society of Agronomy: 283–320.

Hinrichs, C.C. 1995. Off the treadmill? Technology and tourism in the North American maple syrup industry. Agriculture and Human Values. 12(1): 39–47.

Hinrichs, C.C. 1998. Sideline and lifeline: the cultural economy of maple syrup production. Rural Sociology. 63(4): 507–532.

Hodges, A.W.; Mulkey, W.D.; Alavalapati, J.R.R. [and others]. 2005. Economic impacts of the forest industry in Florida, 2003. Gainesville: University of Florida, Institute of Food & Agricultural Sciences. 47 p. http://fred.ifas.ufl.edu/economic-impact-analysis/pdf/FE53800.pdf. [Date accessed: August 9, 2017].

Huntington, T.G.; Richardson, A.D.; McGuire, K.J.; Hayhoe, K. 2009. Climate and hydrological changes in the northeastern United States: recent trends and implications for forested and aquatic ecosystems. Canadian Journal of Forest Research. 39(2): 199–212.

Hurley, P.T.; Emery, M.R.; McLain, R.J. [and others]. 2015. Whose urban forest? The political ecology of foraging urban nontimber forest products. In: Isenhour, C.; McDonough, G.; Checker, M., eds. Sustainability in the global city: myth and practice. New York: Cambridge University Press: 187–212.

Jones, E.T.; McLain, R.J.; Lynch, K.A. 2004. The relationship between nontimber forest product management and biodiversity in the United States. Washington, DC: National Commission on Science for Sustainable Forestry. 60 p. http://www.ntfpinfo.us/docs/academicdocs/JonesMcLainLynch2005-USNTFPBiodiversity.pdf. [Date accessed: August 9, 2017].

Just, R.E. 2003. Risk research in agricultural economics: opportunities and challenges for the next twenty-five years. Agricultural Systems. 75(2): 123–159.

Just, R.E.; Pope, R.D. 2003. Agricultural risk analysis: adequacy of models, data, and issues. American Journal of Agricultural Economics. 85(5): 1249–1256.

Just, R.E.; Weninger, Q. 1999. Are crop yields normally distributed? American Journal of Agricultural Economics. 81(2): 287–304.

Kassam, K.A.; Karamkhudoeva, M.; Ruelle, M.; Baumflek, M. 2010. Medicinal plant use and health sovereignty: findings from the Tajik and Afghan Pamirs. Human Ecology. 38(6): 817–829.

Ker, A.P.; Goodwin, B.K. 2000. Nonparametric estimation of crop insurance rates revisited. American Journal of Agricultural Economics. 82(2): 463–478.

Kerns, B.K.; Alexander, S.J.; Bailey, J.D. 2004. Huckleberry abundance, stand conditions, and use in Western Oregon: evaluating the role of forest management. Economic Botany. 58(4): 668–678.

Knight, F.H. 1921. Risk, uncertainty and profit. New York: Hart, Schaffner and Marx.

Lal, P.; Alavalapati, J.R.R.; Mercer, D.E. 2011. Socio-economic impacts of climate change on rural United States. Mitigation and Adaptation Strategies for Global Change. 16(7): 819–844.

Landefeld, J.S.; McCulla, S.H. 2000. Accounting for nonmarket household production within a national accounts framework. Review of Income and Wealth. 46(3): 289–307.

Maher, K.; Little, J.; Champ, P.A. 2013. Insights from a harvest trip model for nontimber forest products in the interior of Alaska. Res. Note RMRS-RN-60. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 11 p.

Markstrom, D.C.; Donnelly, D.M. 1988. Christmas tree cutting: demand and value as determined by the travel cost method. Western Journal of Applied Forestry. 3(3): 83–86.

Matthews, S.N.; Iverson, L.R.; Peters, M.P. [and others]. 2014. Assessing and comparing risk to climate changes among forested locations: implications for ecosystem services. Landscape Ecology. 29(2): 213–228.

McLain, R.J. 2008. Constructing a wild mushroom panopticon: the extension of nation-state control over the forest understory in Oregon, USA. Economic Botany. 62(3): 343–355.

McLain, R.J.; Alexander, S.J.; Jones, E.T. 2008. Incorporating understanding of informal economic activity in natural resource and economic development policy. Gen. Tech. Rep. PNW-GTR-755. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 53 p.

McLain, R.J.; Hurley, P.T.; Emery, M.R.; Poe, M.R. 2014. Gathering "wild" food in the city: rethinking the role of foraging in urban ecosystem planning and management. Local Environment. 19(2): 220–240.

McLain, R.J.; Jones, E.T. 2001. Expanding nontimber forest product harvester/buyer participation in Pacific Northwest Forest Policy. Journal of Sustainable Forestry. 13(3–4): 147–161.

McLain, R.J.; Jones, E.T. 2013. Characteristics of non-industrial private forest owners interested in managing their land for nontimber forest products. Journal of Extension. 51(5): 140–150.

McRobert, G. 1985. A walk on the wild side. Oregon Business. October: 105–106.

Mercer, D.E. 2004. Adoption of agroforestry innovations in the tropics: a review. Agroforestry Systems. 61(1–3): 311–328.

Mercer, D.E.; Pattanayak, S.K. 2003. Agroforestry adoption by smallholders. In: Sills, E.O.; Abt, K.L., eds. Forests in a market economy. Dordrecht, the Netherlands: Kluwer Academic Publishers: 283–299.

Mills, R.; Robertson, D. 1991. Production and marketing of Louisiana pine straw. Publ. 2430. Baton Rouge: Louisiana State University Agricultural Center, Louisiana Cooperative Extension Service. 12 p. http://www.sref.info/resources/publications/production-and-marketing-of-louisiana-pine-straw. [Date accessed: August 15, 2017].

Minogue, P.J.; Ober, H.K.; Rosenthal, S. 2007. Overview of pine straw production in North Florida: potential revenues, fertilization practices, and vegetation management recommendations. FOR125. Gainesville: University of Florida, Institute of Food and Agricultural Sciences, School of Forest Resources and Conservation, Florida Cooperative Extension Service. 6 p. http://www.ntfpinfo.us/docs/other/Minogue2007-PineStrawProductionNorthFlorida.pdf. [Date accessed: August 9, 2017].

Mudge, K. 2009. Forest farming. Arnoldia. 67: 26–35.

Muir, P.; Norman, K.; Sikes, K. 2006. Quantity and value of commercial moss harvest from forests of the Pacific Northwest and Appalachian regions of the US. The Bryologist. 109(2): 197–214.

National Tribal Air Association (NTAA). 2009. Impacts of climate change on tribes in the United States. Report submitted December 11, 2009, to Assistant Administrator Gina McCarthy, U.S. EPA, Office of Air and Radiation. Flagstaff, AZ: National Tribal Air Association. 18 p.

Pasalodos-Tato, M.; Mäkinen, A.; Garcia-Gonzalo, J. [and others]. 2013. Review. Assessing uncertainty and risk in forest planning and decision support systems: review of classical methods and introduction of new approaches. Forest Systems. 22(2): 282–303.

Pattanayak, S.K.; Abt, K.L.; Holmes, T.P. 2003. Timber and amenities on nonindustrial private forest land. In: Sills, E.O.; Abt, K.L., eds. Forests in a market economy. Dordrecht, the Netherlands: Kluwer Academic Publishers: 243–258.

Pattanayak, S.K.; Murray, B.C.; Abt, R.C. 2002. How joint is joint forest production? An econometric analysis of timber supply conditional on endogenous amenity values. Forest Science. 48(3): 479–491.

Pattanayak, S.K.; Sills, E.O. 2001. Do tropical forests provide natural insurance? The microeconomics of nontimber forest product collection in the Brazilian Amazon. Land Economics. 77(4): 595–612.

Phillips, K.M.; Pehrsson, P.R.; Agnew, W.W. [and others]. 2014. Nutrient composition of selected traditional United States Northern Plains Native American plant foods. Journal of Food Composition and Analysis. 34(2): 136–152.

Pierce, A.R.; Emery, M.R. 2005. The use of forests in times of crisis: ecological literacy as a safety net. Forests, Trees and Livelihoods. 15(3): 249–252.

Pilz, D.; Molina, R. 2002. Commercial harvests of edible mushrooms from the forests of the Pacific Northwest United States: issues, management, and monitoring for sustainability. Forest Ecology and Management. 155(1): 3–16.

Poe, M.; McLain, R.; Emery, M.; Hurley, P. 2013. Urban forest justice and the rights to wild foods, medicines, and materials in the city. Human Ecology. 41(3): 409–422.

Porter, M.E. 1980. Competitive strategy: techniques for analyzing industries and companies. New York: The Free Press.

Rathke, D.; Baughman, M. 1993. Can shiitake production be profitable. Shiitake News. 10(1): 1–7.

Reid, W.; Coggeshall, M.; Garrett, H.E. [and others]. 2009. Growing black walnut for nut production. AF1011-2009. Columbia, MO: University of Missouri, Center for Agroforestry. 16 p. http://www.centerforagroforestry.org/pubs/walnutNuts.pdf. [Date accessed: August 9, 2017].

Richards, R.T. 1994. Wild mushroom harvesting in the Klamath bioregion: a socioeconomic study. Yreka, CA: U.S. Department of Agriculture, Forest Service, Klamath National Forest, Happy Camp Ranger District.

Robbins, P.; Emery, M.R.; Rice, J.L. 2008. Gathering in Thoreau's backyard: nontimber forest product harvesting as practice. Area. 40(2): 265–277.

Roise, J.P.; Chung, J.; Lancia, R. 1991. Red-cockaded woodpecker habitat management and longleaf pine straw production: an economic analysis. Southern Journal of Applied Forestry. 15(2): 88–92.

Romero-Lankao, P.; Smith, J.; Davidson, D. [and others]. 2014. North America. In: Barros, V.; Field, C.; Dokken, D. [and others], eds. Climate change 2014: impacts, adaptation, and vulnerability. Part B: regional aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate change. Cambridge, UK: Cambridge University Press: 1439–1498.

Rosenberger, R.S.; Loomis, J.B. 1999. The value of ranch open space to tourists: combining observed and contingent behavior data. Growth and Change. 30(3): 366–383.

Rowland, G. 2003. Pine straw market. New Albany, MS: North Central Mississippi Resource Conservation and Development Council. 1 p. http://www.naturalresources.msstate.edu/pdfs/pinestraw.pdf. [Date accessed: August 9, 2017].

Schlosser, W.E.; Blatner, K.A. 1995. The wild edible mushroom industry of Washington, Oregon and Idaho: a 1992 survey. Journal of Forestry. 93(3): 31–36.

Schlosser, W.E.; Blatner, K.A. 1997. Special forest products: an east-side perspective. In: Quigley, T.M., ed. Interior Columbia Basin Ecosystem Management Project: scientific assessment. Gen. Tech. Rep. PNW-GTR-380. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 35 p.

Schlosser, W.E.; Blatner, K.A.; Chapman, R.C. 1991. Economic and marketing implications of special forest products harvest in the coastal Pacific Northwest. Western Journal of Applied Forestry. 6(3): 67–72.

Schulp, C.J.; Thuiller, W.; Verburg, P. 2014. Wild food in Europe: a synthesis of knowledge and data of terrestrial wild food as an ecosystem service. Ecological Economics. 105: 292–305.

Sills, E.O.; Lele, S.; Holmes, T.P.; Pattanayak, S.K. 2003. Nontimber forest products in the rural household economy. In: Sills, E.O.; Abt, K.L., eds. Forests in a market economy. Dordrecht, the Netherlands: Kluwer Academic Publishers: 259–281.

Skinner, C.B.; DeGaetano, A.T.; Chabot, B.F. 2010. Implications of twenty-first century climate change on Northeastern United States maple syrup production: impacts and adaptations. Climatic Change. 100(3–4): 685–702.

Starbuck, C.M.; Alexander, S.J.; Berrens, R.P.; Bohara, A.K. 2004. Valuing special forest products harvesting: a two-step travel cost recreation demand analysis. Journal of Forest Economics. 10(1): 37–53.

Starbuck, C.M.; Berrens, R.P.; McKee, M. 2006. Simulating changes in forest recreation demand and associated economic impacts due to fire and fuels management activities. Forest Policy and Economics. 8(1): 52–66.

Strong, N.; Jacobson, M. 2006. A case for consumer-driven extension programming: agroforestry adoption potential in Pennsylvania. Agroforestry Systems. 68(1): 43–52.

Sumaila, U.R.; Cheung, W.W.; Lam, V.W. [and others]. 2011. Climate change impacts on the biophysics and economics of world fisheries. Nature Climate Change. 1(9): 449–456.

Taylor, E.; Foster, C.D. 2004. Producing pine straw in East Texas forests. B-6145. College Station, TX: Texas A&M System, Texas Cooperative Extension. 12 p. http://hdl.handle.net/1969.1/87207. [Date accessed: August 10, 2017].

Teitelbaum, S.; Beckley, T. 2006. Harvested, hunted and home grown: the prevalence of self-provisioning in rural Canada. Journal of Rural and Community Development. 1: 114–130.

Thornton, J. 1994. Estimating the choice behavior of self-employed business proprietors: an application to dairy farmers. Southern Economic Journal. 579–595.

Trozzo, K.; Munsell, J.F.; Chamberlain, J.L.; Aust, W. 2014. Potential adoption of agroforestry riparian buffers based on landowner and streamside characteristics. Journal of Soil and Water Conservation. 69(2): 140–150.

U.S. Census Bureau. 2016. Statistics of U.S. businesses, 2012. http://www.census.gov/econ/susb/. [Date accessed: September 20, 2016].

Valdivia, C.; Poulos, C. 2009. Factors affecting farm operators' interest in incorporating riparian buffers and forest farming practices in northeast and southeast Missouri. Agroforestry Systems. 75(1): 61–71.

Wolfe, K.; Stubbs, K. 2013. 2012 Georgia farm gate value report. AR-13-01. Athens: University of Georgia, Center for Agribusiness & Economic Development. 180 p. http://www.caes.uga.edu/center/caed/pubs/annual.html. [Date accessed: August 9, 2017].

Workman, S.W.; Bannister, M.E.; Nair, P.K.R. 2003. Agroforestry potential in the southeastern United States: perceptions of landowners and extension professionals. Agroforestry Systems. 59(1): 73–83.

Yin, R.; Newman, D.H. 1996. The effect of catastrophic risk on forest investment decisions. Journal of Environmental Economics and Management. 31(2): 186–197.