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Markets and Market Values of Nontimber Forest Products in the United States: A Review, Synthesis, and Identification of Future Research Needs

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Abstract

Although numerous and varied users harvest, trade, and consume nontimber forest products (NTFPs), relatively little is known about the organization of the markets for these products and the market value or contribution to local and regional economies. In this article, we review and synthesize economic research and information on the markets and market values of NTFPs in the United States. We describe formal and informal markets for NTFPs, and the extent to which and reasons why many of the details of these markets remain unknown to researchers and decisionmakers. We provide examples of the market values of various species and identify information gaps and research needs to improve resource management and increase economic development.

Keywords: informal economy, market chains, price trends, market size, NTFP

Nontimber forest products (NTFPs) are composed of a broad variety of products of plant or fungal origin extracted from forests (Chamberlain et al. 1998). The products have been used and valued by communities across the United States for generations, but many of the products lack systematic research or quantification of the values they provide (Alexander et al. 2001). Controversies over timber harvests on public lands, and other external factors, sparked new interest in research on the markets and market values of NTFPs as an alternative income source from forests, beginning in about the 1990s (Alexander and McLain 2001, Robbins et al. 2008, Frey et al. 2018a). As interest increased, researchers faced challenges of informality and secrecy, which are typical of many NTFP markets (Alexander et al. 2002b, McLain et al. 2008). Harvesters, dealers, and other market players may not trust outside groups and may have an economic interest in keeping harvest locations and methods secret, because of the difficulty in keeping others from

Management and Policy Implications

Nontimber forest products contribute to the broader economy through market and nonmarket channels. There is a basic understanding of the overall nontimber forest products industry, markets, and distribution channels; however, there is limited understanding of market dynamics or influencing factors. In addition, there is a general perception that harvesters, buyers, and companies engaged in the industry are unwilling to share detailed information. No single classification scheme or data source adequately summarizes production of this "sector," and combining data from different sources creates gaps and inconsistencies. The lack of information impedes the ability to provide a comprehensive and dynamic analysis of the economic valuation of forests for the many nontimber products harvested and traded through formal and informal markets.

encroaching (Greenfield and Davis 2003, Burkhart 2011, Frey et al. 2018b). Furthermore, there is no consistent national data tracking by public or private entities of most products, so the studies that have been conducted on NTFP markets and values are generally limited to a small set of products, a single point in time, and/or a narrow geographic location (Chamberlain et al. 2017).

This review synthesizes research related to markets and market values of NTFPs in the United States to provide a fuller understanding of their diversity, characteristics, potential trends, and social and economic drivers. In doing so, we describe and summarize data and information sources that can be used for future research. Based on this knowledge, we identify information and research gaps that, if filled, would help to achieve improved economic development and resource management.

Products and Uses

NTFPs include a variety of products, many of which have been collected and consumed for generations (Chamberlain et al. 1998, Alexander 2001, Alexander et al. 2002b). Specific products are highly valued for cultural or spiritual purposes. This may be particularly true among indigenous peoples in the United States, who have longstanding traditions of NTFP collection and deep connections to the landscapes where they are found (Carroll et al. 2003, Lake et al. 2018). Other non-native communities of people in the United States also have cultural connections to species and products found in the United States, which in some cases have similarities to those found in their countries of origin (Lake et al. 2018). These native and non-native communities can have traditional and local ecological knowledge about NTFP species that can inform production and management (Hummel and Lake 2015, Lake et al. 2018).

Past research has indicated that NTFPs can be integral in subsistence livelihoods (Emery 2001, Pilz et al. 2006), and that commercial sales of NTFPs are valuable sources of income for people, seasonally or during times of economic distress (Schlosser and Blatner 1995, Bailey 1999, Pierce and Emery 2005, Frey et al. 2018b). This manuscript reviews research on markets and market values, and a detailed discussion of culture, history, subsistence, and recreation is beyond the scope of this work.

The diversity of NTFPs makes them difficult to study as a group, or to analyze and synthesize in a universally applicable way (Alexander 2001, Alexander et al. 2001). Table 1 provides a list of a few common NTFPs in the United States[1], demonstrating the diversity of species used and products derived, and the presence of NTFP harvest and use in every region of the country, including Alaska, Hawaii, and Caribbean and Pacific islands. NTFPs are commonly grouped based on their use or "market segment," including: (1) edible or culinary products, (2) medicinal and dietary supplements[2], (3) decorative and floral products, (4) nursery and landscaping products, and (5) fine arts and crafts (Chamberlain et al. 1998, Alexander and McLain 2001, Chamberlain et al. 2017). Sometimes, (6) forage for livestock is also included as a related category (Alexander et al. 2011b, Chamberlain et al. 2018c).

There are differences in how NTFPs are defined, depending on region, country, and institution (Belcher 2003). Literature on NTFPs in the United States generally describes products of plant or fungal origin other than "timber,"[3] including other wood products such as firewood, posts, poles, and wood used for arts and crafts (Alexander et al. 2011b, Chamberlain et al. 2018c). Still, there are differences of opinion about what constitutes a "forest,"[4] and about inclusion of certain other products that are identical or similar to other NTFPs but may not have directly come from a forested area[5], for the purposes of this categorization (Belcher 2003).

Perhaps most revealing is that the NTFP category often is not included in traditional economic

Table 1. Some common nontimber forest products from the United States.

Scientific name	Common name	Harvested organ	Use/market segment	Region*
Abies spp.	Fir	Bough and whole plant	Decorative	GP, MW, NE, NW, SE, SW
Acer saccharum	Sugar maple	Sap	Edible	NE
Actaea racemosa	Black cohosh	Root	Medicinal	NE, SE
Allium tricoccum	Ramp; leek	Whole plant	Edible	NE, SE
Asimina triloba	Pawpaw	Fruit	Edible	NE, SE
Betula papyrifera	Paper birch	Bark	Decorative	MW, NE
Boletus spp.	Bolete	Fruiting body	Edible	NW
Cantharellus spp.	Chanterelle	Fruiting body	Edible	GP, MW, NE, NW, SE, SW
Dioscorea spp.	Wild yam	Tuber	Edible; medicinal	GP, MW, NE, P, SE
Echinacea spp.	Coneflower; echinacea	Root; leaf; stem	Medicinal	GP, MW, NE, SE, SW
Fraxinus spp.	Ash	Wood	Crafts	NE, SE
Galax urceolata	Galax	Leaf	Decorative	SE
Gaultheria shallon	Salal	Leaf	Decorative	NW
Gaylussacia spp.	Huckleberry	Fruit	Edible	NW
Hamamelis virginiana	Witchhazel	Bark	Medicinal	GP, MW, NE, SE
Hydrastis canadensis	Goldenseal	Root and leaf	Medicinal	GP, MW, NE, SE
Juglans nigra	Black walnut	Fruit	Edible; medicinal	GP, MW, NE, SE, SW
Ligusticum porteri	Osha	Root	Medicinal	GP, SW
Matteuccia struthiopteris	Ostrich fern "fiddlehead"	Leaf	Edible	GP, MW, NE
Morchella spp.	Morel	Fruiting body	Edible	C, GP, MW, NE, NW, P, SE, SW
Muhlenbergia spp.	Sweetgrass, deergrass	Leaf	Crafts	SE
Panax quiquefolius	American ginseng	Root	Medicinal	MW, NE, SE
Pinus spp.	Pine	Needle; cone	Landscaping; decorative	MW, NW, SE
Pinus spp.	Pinyon	Seed	Edible	SW
Rubus spp.	Raspberry; blackberry; salmonberry	Fruit	Edible	GP, MW, NE, NW, SE, SW
Sambucus canadensis	American elderberry	Fruit	Medicinal; edible	GP, MW, NE, SE, SW
Sanguinaria canadensis	Bloodroot	Root	Medicinal	NE, SE
Serenoa repens	Saw palmetto	Fruit	Medicinal	SE
Taxus spp.	Yew	Bark	Medicinal	NW
Tricholoma magnivelare	American matsutake	Fruiting body	Edible	NW
Trillium spp.	Trillium	Whole plant	Decorative; landscaping	MW, NE, SE
Vaccinium spp.	Blueberry; cranberry; huckleberry	Fruit	Edible	GP, MW, NE, NW, SE
Xerophyllum tenax	Beargrass	Leaves	Decorative	NW

Note: This list is not comprehensive, but is indicative of the breadth and diversity of the group of products. Source: Adapted from Chamberlain et al. (2018b, appendix 4).

* Regions refer to areas where the products are commonly harvested: C, Caribbean; GP, Great Plains; MW, Midwest; NE, Northeast; NW, Northwest (including Alaska); P, Pacific Islands (including Hawai'i); SE, Southeast; SW, Southwest.

accounting of agricultural, forestry, or other sectors. Most economic accounting systems spread NTFPs across different subaccounts, combined with other non-forest products (Frey et al. 2018a). Conversely, a great variety of extremely diverse NTFPs may be grouped into a single subaccount (Muir et al. 2006, Frey et al. 2018a). Therefore, NTFPs are a loose collection of products, with some unifying characteristics, but somewhat orphaned from traditional economic accounting.

Domestic Markets and Businesses

"Market" refers to a literal or figurative place where suppliers and demanders come together to exchange products or services[6]. Markets may involve a monetary transaction or some other type of exchange such as bartering. There are many types of markets where NTFPs are exchanged, including exchange with known associates, local or portable retail, tourist retail, wholesale or commodity, and Internet markets (Pilz et al. 2006).

NTFP markets often are a mix of informal and formal[7]. Informal markets are those that operate outside nation-state reporting and regulatory systems (Thomas 2001, Hembram and Hoover 2008), and as such are "neither government regulated nor fully taxed" (Levitan and Feldman 1991, p. 151). Consequently, comprehensive studies and data on activities in the informal economy are limited. Employment status and participation in informal and formal markets can change at different layers of the commercial market chain, from harvesting work in the forest to buying, aggregating, processing, shipping, distributing, and retailing. NTFPs move from informal into formal markets if and when the harvester sells the product to a registered dealer (buyer) or processor (Schlosser and Blatner 1997, Greene et al. 2000, Greenfield and Davis 2003). Regardless of the level of formality, market factors such as price and market size (total quantity transacted) are primarily determined by the interaction of supply and demand, as well as policy factors such as taxes, regulation, etc. (Frey et al. 2018b).

Informal Markets

A great deal of economic activity in the NTFP sector takes place outside the formal economy (Emery 1998, 2001). Informal markets in the NTFP sector include exchanges through bartering and self-employment or small businesses with limited record-keeping (McLain et al. 2008). Informal economic activity can be said also to include theft of NTFPs, which is thought to be relatively common in some areas (Greenfield and Davis 2003, Ballard and Huntsinger 2006, Burkhart 2011, Frey and Chamberlain 2016).

Bartering of products is the most basic direct marketing approach and is one example of informal marketing that is relatively common among NTFP producers (Emery 2001, Pilz et al. 2006). Bartering is often linked to subsistence lifestyles and may be common in more remote rural areas, such as Michigan's Upper Peninsula and interior Alaska, where formal markets are not easily available (Emery 2001, Pilz et al. 2006).

Some products, including many medicinal plants, greenery, and mushrooms, are harvested by people working informally part time or in their spare time, as very few harvesters rely on NTFPs for 100 percent of their income (Schlosser and Blatner 1997, Hinrichs 1998, Hembram and Hoover 2008). To access the resource, harvesters often rely on verbal agreements with landowners based on personal relations. Sometimes harvesters use more formal contracts or permits, particularly on public land (Schlosser and Blatner 1997, Hembram and Hoover 2008). Harvesters may market their products through formal or informal channels, depending on the best opportunity available at the time (Teel and Buck 1998) or whether the harvesters prefer to remain unidentified (Carroll et al. 2003).

Many NTFP commercial businesses are small, employing one or only a few people (Emery 1998, Alexander and Emery 2003). NTFP actors may decline to participate in the formal economy for various reasons including very small harvest amounts per harvester, desire not to divulge harvest locations or methods, lack of understanding or complexity of state business or employment/self-employment rules, lack of legal work authorization, avoidance of income reporting to limit taxes or maintain government assistance payments, and others (Carroll et al. 2003, Casanova 2007, Hembram and Hoover 2008, Burkhart 2011).

Formal Markets

Figure 1, adapted from Greene et al. (2000), describes the typical layers of the informal and formal market chain (a k a value chain) for certain medicinal products. The dispersed nature of medicinal plants in a forest may make harvester relations with individual landowners less formal and make a dealer necessary to aggregate product from a relatively large area. Other products with similar characteristics may have similar market structures, such as edible mushrooms in the Pacific Northwest including Alaska (Schlosser and Blatner 1995, Wurtz et al. 2005). Dealer businesses may then

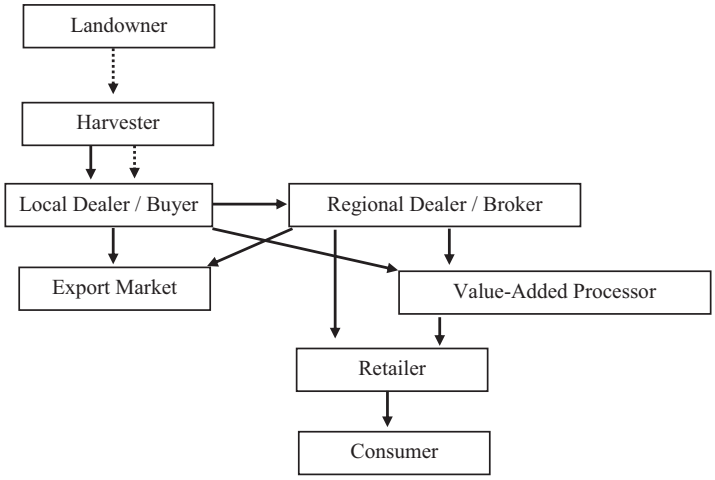

Figure 1. Stylized market chain for medicinal nontimber forest products from southern Appalachia. Not all potential interactions are shown, only some of the more typical ones. Informal economic interactions are shown by dotted lines, whereas more formal interactions are solid. Arrows represent chain of custody of the product. The beginning of the chain may be informal, whereas later stages are more formalized. Source: Adapted from Greene, Hammett, and Kant (2000, p. 31).

ship materials to regional aggregators or wholesalers, who in turn sell to export markets, domestic industrial processors, or retailers. Various degrees of processing may take place throughout this market chain, adding value to the product (Emery 1998, 2001, Greene et al. 2000, Greenfield and Davis 2003).

Other NTFPs may have characteristics that create market chains substantially different from that described in Figure 1, potentially including a more formal harvesting structure. For example, needles (straw) from longleaf (*Pinus palustris*), slash (*P. elliottii*), and loblolly (*P. taeda*) pine are used as a landscaping mulch in the southeastern US (Figure 2). The bulkiness of the product makes it relatively labor-intensive to harvest compared to products that have relatively smaller volumes. Other than raking and bundling into bales, which takes place in the forest, no further processing or value-adding is generally necessary. More formality may be placed on the harvesting relations, potentially involving contracts between dealers and landowners, dealers and labor contractors, and labor contractors and harvest workers (Casanova 2007). Still, the relation between the labor contractor and the laborers themselves may be informal in nature (Casanova 2007) (Figure 2). Other products that involve harvest of a relatively large volume of product per unit area of forest where they are found may have similar market structures, such as saw palmetto (*Serenoa repens*) in Florida (Chamberlain et al. 2017).

Still other market chains may exist, such as those with parallel formal and informal market links (Figure 3).

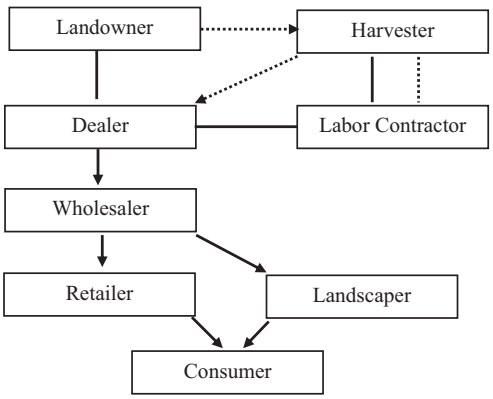

Figure 2. Stylized market chain for pine straw for landscaping from the US Southeast. Not all potential interactions are shown, only some of the more typical ones. Informal economic interactions are shown by dotted lines, whereas more formal interactions are solid. Arrows represent chain of custody of the product; lines without arrowheads represent other related interactions. Unlike with medicinals (Figure 1), it is common to have a formal contract between the landowner and dealer and between the dealer and labor contractor. Labor contractors may or may not use informal labor arrangements with the harvesters. Source: Based on Casanova (2007).

For example, American elderberry (*Sambucus canadensis*) can be either produced by berry growers with a formal business structure or gathered informally from wild[8] populations (Cernusca et al. 2012).

In summary, it is clear that several factors influence the structure of the market chains, and the level of formality of the interactions therein. First, the size and bulkiness of the product and its dispersion throughout

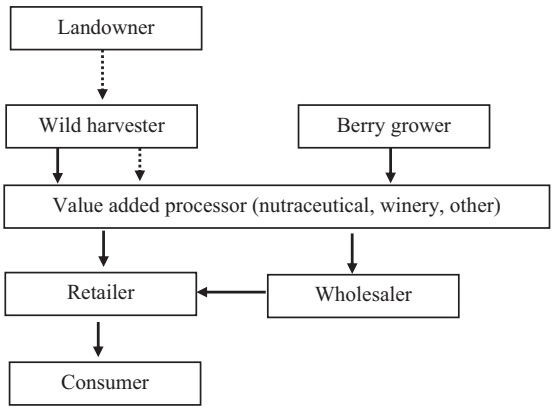

Figure 3. Stylized market chain for American elderberry (*Sambucus canadensis*). Not all potential interactions are shown, only some of the more typical ones. Informal economic interactions are shown by dotted lines, whereas more formal interactions are solid. Arrows represent chain of custody of the product. Berries may enter the market in parallel from wild-harvested and cultivated sources. Source: Adapted from Cernusca, Gold, and Godsey (2012).

the forest affect the landowner–harvester interaction, and the necessity of market aggregators. Second, the degree of processing before final consumption affects the layers of the chain involved in various types of processing and value-adding, and the potential necessity of expensive equipment for processing affects whether product passes through numerous small-scale processors, or a few large-scale operations. Third, perishability and seasonality of the product may influence geographic scale of markets and market players' level of dedication to single or a few products throughout the year. Fourth, similarities to (e.g., wineries processing both grapes and elderberries, or aggregators dealing in various species of medicinal plants) and complementarities with (e.g., galax leaves used in arrangements with flowers) other types of products may affect the way NTFPs are transacted and to whom.

Any accounting of formal economic activity in the NTFP sector will be a vast underestimate of total economic activity because of the prevalence of informality (Alexander et al. 2011a, p. 89) and nonmarket uses. Data on formal businesses are collected by the Statistics of US Businesses (SUSB) program (US Census Bureau 2016). Businesses are classified according to industrial category through the North American Industrial Classification System (NAICS). Many NTFP businesses are incorporated in NAICS code 113210—"Forest Nurseries and Gathering of Forest Products," including: bark, needle, and gum gathering; ginseng, moss, and greens collection; and tree seed extraction and gathering. However, this category also includes activities that are not NTFP-oriented, and some NTFP-oriented activities are included in other categories. The primary non-NTFP groups in NAICS 113210 are related to tree nurseries. Significant NTFP activities that are not included in 113210 include maple (*Acer* spp.) syrup production under 111998—"All Other Miscellaneous Crop Farming," and production of tree nuts or fruits that could be considered NTFPs could be classified under 111335 "Tree Nut Farming," 111336 "Fruit and Tree Nut Combination Farming," or others. Depending on the definition of NTFPs (see discussion under "Products and Uses" above), numerous other production activities could fall within various other agricultural categories. Data on many of these NTFP businesses considered to be "agricultural" are gathered not by SUSB but by the USDA National Agricultural Statistics Service.

These shortcomings notwithstanding, it is possible to use the SUSB data to obtain a basic understanding of formal businesses tied to NTFP production or forest nurseries through NACIS 113210 (Alexander et al. 2011a, Frey et al. 2018a). Formal business establishments tend to be concentrated geographically in the Southeast, Great Lakes region and the Pacific Northwest. The total number of establishments in 113210 in 2016 was 183, spread across 36 states (Figure 4). This was a decrease from 2007, when 231 establishments were located across 41 states (Table 2). The SUSB collects data on receipts every five years, and for this sector, total receipts were US$128 million in 2012, a decline from US$234 million in 2007 (Table 2). With few exceptions, changes in the number of establishments matched the geographic distribution of changes in receipts.

Prices and Price Trends

Information on NTFP prices and price trends can be obtained through periodic interviews or surveys of product dealers (Schlosser and Blatner 1997, Blatner and Alexander 1998, Davis and Persons 2014). Since most products are not tracked by government agencies and few industry associations or for-profit price tracking services exist, estimating average or typical product prices has often fallen to universities or other research institutions. Such research is usually limited in time and thus does not allow long-term trends to be investigated. Furthermore, lack of standardization in product quality/grade, water content, fresh versus dried, cultivated versus wild-harvested, etc., can make it exceedingly difficult to compare and compile price information (Muir et al. 2006).

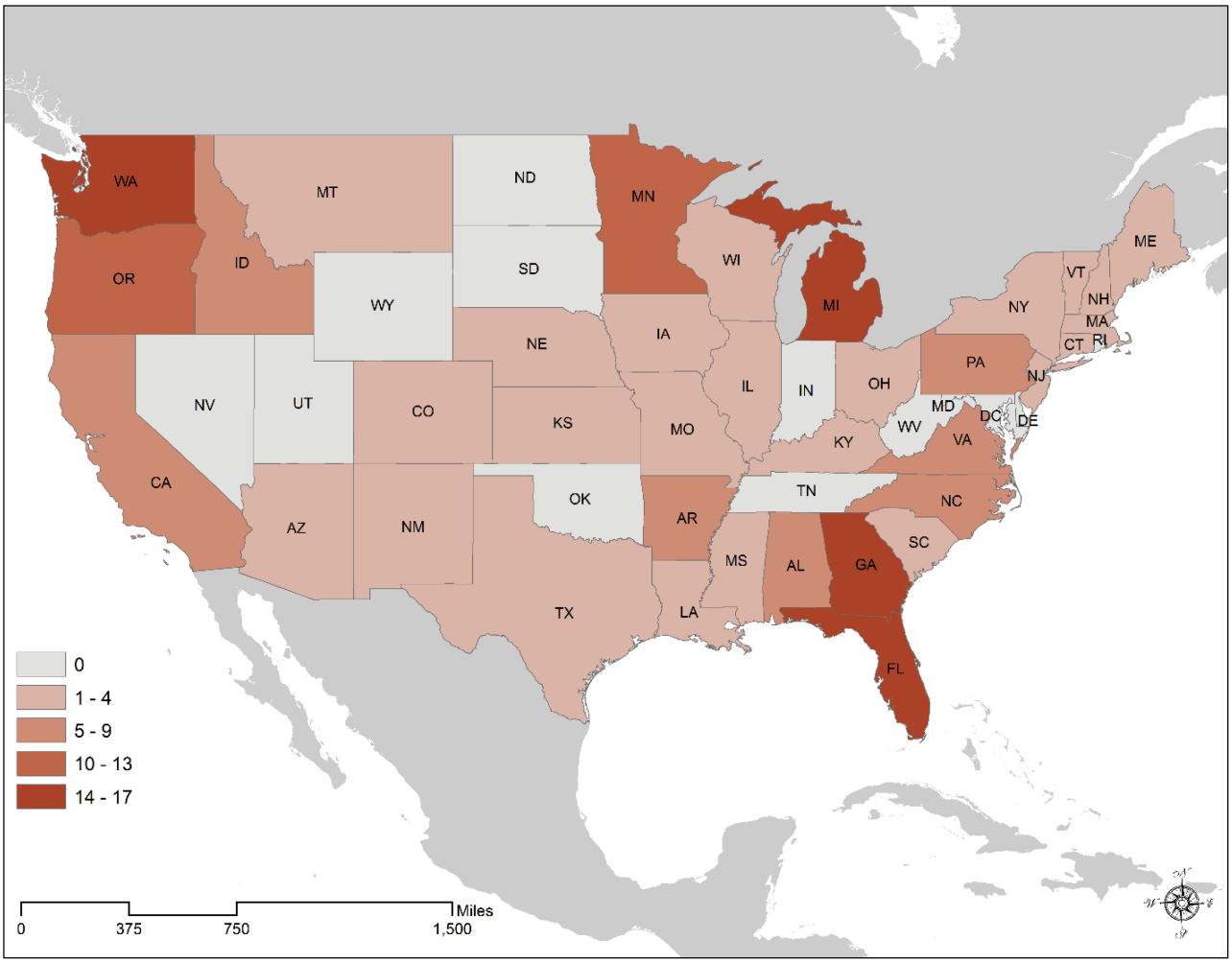

Figure 4. Map on the number of formal business establishments engaged in "Forest Nurseries and Gathering of Forest Products" (North American Industrial Classification System [NAICS] category 113210) reported by the US Census Bureau in the Statistics of US Businesses (SUSB) for 2016. Rendered by Alisa Coffin.

The limited tracking of NTFP prices and quantities sold suggests highly volatile and unpredictable markets (Frey et al. 2018b, Chamberlain et al. 2018c). This reflects changing supply and demand conditions. Supply is affected by ecological and social forces. Because many NTFPs are perishable and/or seasonal, short-term changes in ecological availability or social drivers can have a pronounced effect on market supply. Demand for many products likely responds to changing social perceptions, beliefs, and media reports related to the purported benefits or negative effects of specific products, or in general those labeled "natural," "traditional," and "wild." Further demand shifters may include the availability of complementary and substitute products and economic well-being of potential consumers (Weigand 1997, Frey et al. 2018b).

Some products, such as maple syrup, are tracked by government agencies (in this case, the USDA National Agricultural Statistics Service). US maple syrup prices have increased over the past nearly 100 years at a rate of about 1 percent in real terms (above inflation), with periodic spikes and longer-term changes in prices attributed to environmental (e.g., weather or pests affecting maple production), social (e.g., changes in use of maple by the tobacco industry), and policy (e.g., world war rationing) effects (Hinrichs 1998, Koelling 2006, McConnell and Graham 2016). Other products are of particular interest in some regions and have been tracked by independent researchers and universities for a moderate length of time. Davis and Persons (2014) tracked wild American ginseng (*Panax quinquefolius*) prices over a period of 20 years and found that, similar

Table 2. Number of establishments and receipts (×US$100,000) for businesses classified in "Forest Nurseries and Gathering of Forest Products" (North American Industrial Classification System [NAICS] category 113210) sector, for 2007 and 2012 by region.

	2007		2012		Change 2007–12	
Region	Estab.	Receipts	Estab.	Receipts	Estab.	Receipts
East North Central*	26	19,534	14	6142	–12	–13,392
East South Central†	43	30,748	21	21,628	–22	–9120
Middle Atlantic‡	15	0	11	14,955	–4	14,955
Mountain§	11	1117	9	0	–2	–1117
New England¶	11	0	7	0	–4	0
Pacific‖	41	15,943	45	18,129	4	2186
South Atlantic**	77	143,572	62	68,798	–15	–74,774
West North Central††	6	2224	8	3618	2	1394
West South Central‡‡	27	40,491	16	1238	–11	–39,253
Total	231	234,095	179	128,366	–52	–105,729

Note: Every five years, the US Census Bureau Statistics of US Businesses (SUSB).
*Illinois, Indiana, Michigan, Ohio, Wisconsin.
†Alabama, Kentucky, Mississippi, Tennessee.
‡New Jersey, New York, Pennsylvania.
§Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming.
¶Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont.
‖Alaska, California, Hawaii, Oregon, Washington.
**Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia.
††Iowa, Kansas Minnesota, Missouri, Nebraska, North Dakota, South Dakota.
‡‡Arkansas, Louisiana, Oklahoma, Texas.

to maple syrup, real prices have been increasing over this period (Frey et al. 2018b). This price trend may be due to declining availability of ginseng in the forest, and year-to-year fluctuations in price are due in part to environmental (droughts) and social (unemployment) factors (Bailey 1999, Frey et al. 2018b).

Blatner and Alexander (1998) tracked several Christmas greens, floral greens, edible mushroom, and berry products over an eight-year period in the Pacific Northwest. There were no consistent trends among NTFPs over time, with year-to-year prices for individual or groups of products dependent on numerous factors including yearly weather conditions that lead to changes in availability of individual species, changes in market demand for specific products, and the entrance or exit of new market players (Blatner and Alexander 1998). Edible mushrooms were found to be particularly volatile, perhaps because of the extreme sensitivity of fruiting to weather conditions (Blatner and Alexander 1998).

Similarly, geographic location can play a large role in prices. Various research on pine straw has reported prices paid by harvesters to landowners for the right to access and harvest of US$0.10–0.25 per bale in East Texas (Taylor and Foster 2004) and US$0.50–0.65 per bale in Georgia (Casanova 2007). The reasons for these variations in price are not fully known, but are due at least in part to the lack of an industry standard for the size of a "bale" (which typically may be 3–4 cubic feet [0.08–0.11 cubic meters], but vary significantly), the variable conditions of forests and straw available for harvest, and market demand (Mills and Robertson 1991, Taylor and Foster 2004, Dyer 2012).

Market Size

Market size, though sometimes called market "value," is not a true value in the economic sense (described in more detail below), but relates the average price times the total quantity traded of a particular product. Market size is commonly used to understand the relative contribution or impact of a particular product or sector within the broader economy. Researchers, state agencies, business associations, and others periodically estimate the size of various NTFP markets (e.g., Schlosser et al. 1991, Wolfe and Stubbs 2015); however, in most cases, the estimates are neither frequent nor comprehensive enough to understand trends.

Estimated market sizes of NTFPs may be imprecise and potentially biased. Some estimates of total harvest quantities and market size are reported from the US government to international bodies including the "Montreal Process" Working Group on the Conservation and Sustainable Management of Temperate and Boreal Forests. Although certainly providing valuable information on trends and relative market sizes, these estimates are recognized generally to underreport the market size, since they rely on incomplete data and may not accurately incorporate informal markets or harvests from private lands (Alexander et al. 2011b, Chamberlain et al. 2018c). For example, the estimated first point-of-sale market size of herbal and medicinal products was about US$14.8 million in total for the period 2004–13 (Alexander et al. 2011b, Chamberlain et al. 2018c). This estimate uses assumptions to extrapolate market sizes from receipts of permits to harvest from National Forests and Bureau of Land Management (BLM) forests. Yet, Chamberlain et al. (2013b) used a different data set to estimate the first point of sale market size for American ginseng alone to be approximately US$27 million annually from 2000 to 2007. This difference can be partially attributed to the fact that the method used by Alexander et al. (2011b) and Chamberlain et al. (2018c) employed data from public lands, which are more prominent in the US west, whereas American ginseng is found in the east where public lands are less common (Chamberlain 2015). Estimates based on a nationwide expansion factor from public lands can lead to underestimates of harvest of NTFPs predominant where public lands are less common (Chamberlain 2015). Most NTFPs do not have separate, reliable data sets of harvest quantities from public and private lands.

Wild-harvested NTFPs had an estimated wholesale market size of approximately US$960 million in the US economy in 2013 (Chamberlain et al. 2018c). The total wholesale market size of NTFPs for the period 2004–13 was estimated at about US$9 billion, with annual market size ranging from about US$800 million to US$1 billion (2010) (Table 3). In 2013, fuelwood made up more than half the value, whereas products harvested for food accounted for about 8 percent of the total. Plant materials harvested for crafts and floral decorations accounted for about 18 percent, and the harvest of Christmas trees was 12 percent of the total value (Chamberlain et al. 2018c).

A very general and similarly imprecise understanding of market size can also be gained from the NAICS code 113210 SUSB data described above. Those data showed that receipts to formal businesses listed under 113210 were US$128 million in 2012, which was a large decrease from US$234 million in 2007. This income was concentrated in the US Southeast, as well as a few states in the Midwest and California. A concentration of NTFP harvest and trade is known to exist in the Pacific Northwest, and presumably this activity does not appear large in the SUSB data because of informality.

Pine straw is a product with a relatively large market, which certain states track or make periodic estimates of market size and economic impact. North Carolina, Florida, and Georgia are pine straw industry leaders (Mills and Robertson 1991). The state with the most detailed records regarding pine straw production is Georgia where data are collected for pine straw as an individual commodity. In 2014, pine straw accounted for 11 percent of Georgia's forest products market at US$79.5 million (Wolfe and Stubbs 2015). In Florida, the market size has been estimated at US$79 million in 2003 (Hodges et al. 2005), in North Carolina, US$35 million in 2014 (McConnell et al. 2016), and in South Carolina, US$11 million in 2015 (Hughes 2015).

International Trade

Many NTFPs are exported. For example, wild mushrooms from the US are often exported to Europe or Japan (Alexander and McLain 2001). Further, certain products have a much higher demand overseas than within the US, including some whose market is almost totally international, and some have consolidated most of the international wholesale markets into a single location. For example, the vast majority of ginseng is exported to Hong Kong, where it is auctioned and re-exported to processors in other parts of Asia and the world (Robbins 1998). Similarly, a large portion of floral greens (decorative and floral product market segment) is shipped to the Netherlands for processing and redistribution (Savage 1995, Emery et al. 2006).

In general, data on international trade of most NTFPs are embedded with other products making valuing the industry challenging. However, data on certain exported NTFPs are available because of the use of the Harmonized Tariff Codes (HTC) used by the International Trade Commission (ITC) to track values and quantities of exports from and imports to the US. The level of tracking varies, with some specific products or species having a distinct code, and others grouped together in large classes. Export products individually included in US export data generally have

Table 3. Estimated wholesale value of wild-harvested nontimber forest products in the United States.

Product category	Estimated wholesale value*									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	Million 2013 US$									
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‡	92.8c	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
Nonconvertible	11.9	24.4	30.9	18.1	7.3	2.7	4.7	8.0	0.8	0.8
Total*	900.6	836.6	834.8	986.2	899.7	793.1	1017.1	943.5	901.7	963.3

Note: Source: Chamberlain et al. (2018c).

*Wholesale values assume: (1) that US Forest Service (USFS) and Bureau of Land Management (BLM) sales receipts are 10 percent of first point-of-sales value; (2) that USFS sales represent approximately 20–30 percent, and BLM sales represent approximately 2–15 percent of total supply; and (3) that first point-of-sales value is 40 percent of wholesale price.

†Totals may vary because of rounding.

‡2004–8 have beargrass included as Grass and forage instead of Crafts and floral.

long traditions on international trade, and many are foods, such as blueberries and cranberries (*Vaccinium* spp.), tree nuts, and maple syrup (Alexander et al. 2002b). Many other NTFPs are aggregated with unlike materials, which precludes analyzing the data for specific NTFP species/sectors. One example is fresh foliage and branches (HTC 0604.91.0000), which covers many species and uses. Muir et al. (2006) struggled with another common issue, weights and volumes that can be meaningless because of the range of water content in the various products within the mosses and lichens group.

The export of NTFPs contributes to regional and national US economies. The ITC records imports and exports of 11 specific NTFPs (Table 4), though these products are not explicitly defined by the ITC as such. From 1999 to 2013, the US has exported more than US$4.5 billion (2013 dollars) of these products (Alexander et al. 2011b, Chamberlain et al. 2018c). The average annual value of these exports for the period 2009–13 was approximately US$357 million, representing a 22 percent increase above the years 1999–2003. In this diverse and dynamic industry, there have been major shifts in exports over the 15 years; for example, exports of moss and lichen dropped dramatically, maple syrup exports climbed, and the value of ginseng exports increased (Chamberlain et al. 2018c). The emerging significance in international trade of some native wild-harvested species, such as American matsutake (*Tricholoma magnivelare*), seems to come more from international demand than from concerted marketing efforts in the US (Alexander et al. 2002b).

Imports of NTFPs also contribute to the US economy (Table 5) (Chamberlain et al. 2018c). Total imports of recorded NTFPs from 1999 through 2013 were about US$6.5 billion. Overall, the US experienced a 35 percent increase in the value of NTFP imports over the 15 years. The average annual value of imported truffles increased from US$2.7 million (1999–2003) to over US$10 million (2009–13), which is representative of the increased demand for numerous culinary forest products.

Economic Market Values of NTFPs

In general, economic value is the amount by which the benefit of something outweighs its cost (Freeman 2003). This can include benefits and costs that are based on market and nonmarket uses. We focus here on market-oriented values, while recognizing the importance of nonmarket social, cultural, spiritual, and recreational values in many communities in the United States and worldwide. Economists use various tools to put nonmarket values in monetary terms; however, discussion of these is outside the scope of our work.

Understanding the economic values of an NTFP operation relies on three main types of information: the quantity produced over time, the cost of production,

Table 4. Average annual value of nontimber forest products exported from the United States in thousand US dollars, as reported by the Harmonized Tariff Schedule.

Product	Average 1999–2003	Average 2004–8	Average 2009–13
	Thousand 2013 US$		
Mosses and lichens	11,801	1402	1630
Foliage and branches—fresh, dried, dyed, bleached, impregnated, or otherwise prepared foliage	101,439	129,665	116,962
Mushrooms and truffles, fresh, preserved, dried, sliced, etc.	20,657	11,373	12,957
Fresh fruit of the genus *Vaccinium*; cranberries and others except blueberries	14,396	27,015	22,602
Wild blueberries, fresh, frozen, preserved, dried, canned	44,851	53,474	64,402
Ginseng roots, cultivated, fresh, or dried	19,580	12,396	19,074
Ginseng roots, wild, fresh, or dried	27,065	24,275	42,567
Maple sugar and maple syrup	7690	12,154	20,459
Pine nuts (Pignolia), prepared or preserved NESOI	15	24	922
Gum, wood or sulfate turpentine oils	7560	5392	19,220
Essential oils of cedarwood, clove, and nutmeg	6804	8810	20,355
Pine oil	9491	7968	16,245
Total	271,349	293,948	357,395

Note: Source: US International Trade Commission (2018) reported in Chamberlain et al. (2018c).

Table 5. Average annual value of nontimber forest products imported into the United States in thousand US dollars, as reported by the Harmonized Tariff Schedule.

Product	Average 1999–2003	Average 2004–8	Average 2009–13
	Thousand 2013 $US		
Moss and lichens	4316	4693	4293
Christmas trees	33,620	31,408	25,109
Foliage, branches, and grasses for ornamental purposes, fresh, dried, dyed, or otherwise prepared	77,253	100,399	87,988
Truffles, fresh or dried	2770	6662	10,692
Mushrooms, fresh or dried	35,894	24,268	24,945
Pine nuts (Pignolia), prepared or preserved NESOI	32,989	59,467	24,819
Wild blueberries, fresh, frozen, preserved, dried, or canned	43,479	100,012	76,863
Fruits of the genus *Vaccinium*, fresh other than blueberries	88	467	7625
Ginseng roots, cultivated, fresh or dried, whole, cut, crushed, or powdered	13,889	18,371	23,569
Ginseng roots, wild, fresh or dried, whole, cut, crushed, or powdered	1064	8108	1029
Maple syrup, blended or not	89,128	135,776	158,330
Maple sugar	259	675	721
Essential oils of cedarwood	841	1008	1410
Gum, wood, or sulfate turpentine oils	4679	5266	12,559
Pine oil	1111	989	1570
Total	341,380	497,569	461,522

Note: Source: US International Trade Commission (2018) reported in Chamberlain et al. (2018c).

and the price of the product (Chamberlain et al. 2017). With few exceptions (e.g., maple syrup), these data for NTFPs are not collected or tracked by any organization or body, the way they would be for agricultural or timber commodity crops (Chamberlain et al. 2017). Therefore, social/economic and ecological/biological research is often crucial, yet extremely challenging, given the fact that markets are often informal, harvests are secretive, and permits and contracts are difficult to enforce (McLain et al. 2008, Burkhart 2011, Chamberlain et al. 2017). Complementary to scientific research is understanding traditional and local ecological knowledge, which can have insights pertaining to uses, production, sustainability, and ecological linkages (Hummel and Lake 2015, Lake et al. 2018). Since such work and understanding are necessary preconditions to sound economic modeling, we provide a brief overview with (non-comprehensive) examples.

A first step in understanding the economic value of an NTFP operation includes understanding the amount that may be sustainably harvested over time, which depends, in part, on the amount of the organism present in the forest, as well as biological characteristics and human activity. The inventory of some NTFPs derived from trees, such as bark or boughs, can be estimated using traditional forest inventory data, such as the Forest Inventory and Analysis (FIA) Program of the USDA Forest Service (Shaw et al. 2005, Farrell 2013, Emery et al. 2014, Kauffman et al. 2015). Most forest inventory programs, including FIA, do not specifically track understory species, although NTFPs derived from trees can sometimes be tracked (Kauffman et al. 2015, Chamberlain et al. 2018a). Steps are being taken within FIA to increase the depth of information on understory species, but are not fully developed. Apart from FIA, some protocols and permanent plots have been established to monitor individual species, but are generally limited geographically (Chamberlain et al. 2018a). Finally, for some species, production is ephemeral and subject to extreme variation, and the organism difficult to locate precisely during periods of non-production, so conducting an inventory is particularly challenging and may be unlikely to yield data of value for economic valuation purposes. In the absence of direct information about understory plant populations over large areas, research on preferred habitats of NTFP species has been used in combination with forest inventory data on tree associations and density to identify likely and potential areas of NTFP populations (e.g., Schlosser et al. 1992, Higgins et al. 2004, Chamberlain et al. 2013b, Emery et al. 2014).

Reproduction, growth, and yield models are important to understand future species populations and how those plants translate into merchantable products. Past reproduction models have helped researchers understand how wild-harvesting of natural populations affects reproduction and population levels of understory plants, but typically this research has been limited to species of high value or conservation concern (Mooney and McGraw 2009, Small and Chamberlain 2018). Just as timber volumes are estimated from standing trees using easily measured variables, yields of NTFPs, which may be below ground or otherwise hard to measure directly, may be estimated from simple plant measurements (Blatner et al. 2005, Chamberlain et al. 2013a), but this requires substantial up-front investment in research. Little work exists on the value of NTFP on a per-unit-area basis, or over time, as the biology of most NTFP is not understood well enough to develop yield functions. Susaeta et al. (2012) found that intensive pine straw management significantly exports soil nutrients and hypothesized that this could impair future timber returns, but extensive pine straw management had fewer detrimental effects. Some studies have developed fungi yield functions for individual species and locations (e.g., Pilz et al. 1998, 1999, Alexander et al. 2002a). Studies that are site-specific may be limited in applicability; furthermore, climate change may alter the productivity of species in certain places over time (Frey et al. 2018a).

Private Values

One measure of economic value is net present value (NPV), which compares revenues and other benefits to the financial and opportunity costs of an activity, with future years discounted (Cubbage et al. 2015). NPV provides an understanding of the value of a forest or its product to a private individual, firm, or organization. Burkhart and Jacobson (2009) estimated NPVs for forest farming of medicinal plants in the eastern US, and found these production systems generally to be unprofitable, with the exception of American ginseng. However, simple comparison of values of individual products may not be instructive for making land-management decisions, because often goods and services can be produced jointly, such as managing for timber, whereas medicinal plants grow in the understory (Chamberlain et al. 2013b). In such cases, a better approach is to assess and compare management scenarios that provide for production of both timber and nontimber goods and services, such as recreation, water quality, and NTFPs.

Examples of studies on the private value of joint production of timber and NTFPs include production of pine straw in the Southeast (Roise et al. 1991, Dickens et al. 2012, Susaeta et al. 2012, Mills and Stiff 2013), maple syrup in the Northeast (Farrell 2012), harvest of fir boughs in the Pacific Northwest (Blatner et al. 2010), and collection of mushrooms in the Pacific Northwest (Pilz et al. 1998, 1999, Alexander et al. 2002a). Although optimal management regime depends on market, landowner, and forest stand characteristics (Farrell 2012), studies on NTFP private values indicate that they can provide an economic incentive for forest management, and sometimes are a key component in making certain management regimes competitive and profitable (Blatner et al. 2010, Farrell 2012, Mills and Stiff 2013). Furthermore, NTFP production generates annual or periodic income in the years between timber harvests (Pilz et al. 1998, Blatner et al. 2010, Susaeta et al. 2012), and in certain cases the NTFP component of forest management values rivals the timber component (Pilz et al. 1999, Alexander et al. 2002a, Farrell 2012, Susaeta et al. 2012).

Social Values

The total economic value of a particular forest product to society is the sum of consumer and producer surplus, that is, the amount by which consumers' willingness to pay exceeds the cost of production for each additional unit of product (McConnell and Bockstael 2005). Estimating consumer and producer surplus is challenging because they are not directly revealed by market prices at any given point in time (Chamberlain et al. 2017). The fact that NTFP harvest is usually not tracked and that harvesters are usually reluctant to divulge the type information that would reveal their willingness to pay makes it quite difficult to generate these types of estimates. Although we are not aware of literature that estimates consumer and producer surplus for market-based NTFPs in the US, the willingness-to-pay concept applies equally to nonmarket values, and a few past works have estimated consumer surplus for specific nonmarket NTFPs at specific forest sites by using travel costs as a surrogate for willingness to pay (Markstrom and Donnelly 1988, Starbuck et al. 2004). These studies are quite data-intensive, are usually time- and geography-constrained, and generate values that are not generally transferable to other times or locations.

For a market-based good, focusing on very small (marginal) changes in NTFP production allows some simplifications (Chamberlain et al. 2017). At this

marginal level, the social value of market-oriented NTFP production is the resource quasi-rent, or the residual revenue of the product, after factoring out human costs (McConnell and Bockstael 2005, Smith et al. 2010, Chamberlain et al. 2017).

Key Research and Information Needs and Challenges

Basic and applied economic research is typically undertaken with the general goal of gaining knowledge, which can carry with it the potential societal benefit of better public and private decisionmaking. We propose two long-term strategic goals, or desired impacts, for economic research in NTFPs: (1) improve resource management to ensure the sustainability of the plants and fungi in perpetuity, and (2) increase economic development opportunities for communities and people who benefit from the harvest and sale of these products. To these desired effects, the following discussion is presented.

Land managers must understand the value of the resources to manage them sustainably for maximum long-term benefit to society, and to weigh various possible management objectives. This may involve joint production or tradeoffs between NTFPs, timber, wilderness recreation, and other objectives. This includes the value of existing inventory of NTFPs on private and public lands (stock), and the annual harvests of these species (flow). Likewise, 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.

Data and research needed to improve our knowledge of economic value that would aid land owners and managers and resource-use policymakers, and support rural economic development include the following:

- Time series of prices and quantities of NTFPs traded in markets.
- Cataloging of local and traditional ecological knowledge about uses, production, sustainability, and ecological linkages.
- Characterization of formal and informal harvest and market chains.
- A classification scheme that allows tracking most NTFP businesses while excluding other types of businesses.
- Tracking of NTFP volumes and values from point of harvest through consumer consumption.
- Evaluation of quantities harvested, and numbers and types of harvesters of NTFPs for nonmarket uses (e.g., recreational, cultural, subsistence).
- Including NTFP species in forest inventories to inform managers about the presence and extent of potential products and future harvest, balancing the cost of improved data precision with the value of the species for NTFPs and ecological function.
- Mapping how land-use change affects supply of NTFPs.
- Modeling growth and yield of NTFP species that allow sustainable levels of harvest to be determined and estimates of net present value to be generated.
- Compilation of management actions directed at other goods and services (e.g., timber or recreation management) that may directly or indirectly impact NTFPs.
- Identification and quantification of the costs, and costs trends of potential forest farming systems.
- Survey of management and governance systems for regulating access and use of NTFPs.
- Impact of import and export markets on NTFP prices and quantities harvested.

Attempts to close these information and research gaps will face several challenges (Frey et al. 2018a). Because of their informal nature of many markets, government data do not capture their full extent (McLain et al. 2008). Surveying harvesters is challenging because they are diverse, dispersed, and often secretive. This secrecy is often driven by the fact that forests are relatively easy to access in a practical sense, and many NTFPs are small and easily concealed, so NTFP populations can be accessed legally or illegally by others. Divulging too much information can lead to economic losses from poachers or other harvesters, so harvesters are reluctant to do so (Burkhart 2011). Market players change over time because of social forces like immigration and unemployment (Bailey 1999, Emery et al. 2006, Frey et al. 2018b), and NTFP production varies dramatically with environmental factors over time and space (Pilz and Molina 2002). Most products do not have a systematic method of weights and measures, and some have inconsistencies in species common names and other interpretation issues (Muir et al. 2006). Although these challenges are certainly substantial, collaboration among researchers and institutions can help surmount them.

Conclusions

Market uses including commercial harvest, processing, bartering, and sale of NTFPs, and nonmarket uses including subsistence, recreational, cultural, and spiritual/religious uses of NTFPs are important to the daily lives and livelihoods of people throughout the United States. Recognizing that nonmarket uses and values are important, this article focused on synthesizing past research on markets and market values, and identifying needs and challenges for future research.

Harvest, processing, and sale of NTFPs are not adequately tracked, studied, or recognized, yet they provide income for many people in all regions of the United States. This income can be particularly important

seasonally and in times of economic distress. Information that is known about NTFP markets and values demonstrates that products and markets are as diverse as the plants and fungi from which they originate. Market interactions often begin with informal harvest and first points of sale, which inhibit data needed for economic valuation. Progressing through more formal channels should provide needed data, but the lack of institutional inclusion of these products impedes valuation efforts, as well. Prices, which are often not tracked, are extremely variable over time and space, but the factors driving this variability generally have not been determined. NTFPs often are considered less valuable than timber or other ecosystem services from the same land, but in some rare cases NTFPs can rival timber value. Finally, NTFPs can often be produced jointly with timber and other goods, and the NTFP value can be an important component to making management strategies profitable. Further research is needed on markets to improve resource management and increase economic development; however, the informal and secretive nature of many NTFP markets makes the task particularly challenging.

Markets are only one aspect of NTFP production and use that merit research. Important complementary work is needed in various realms including but not limited to: species' habitat needs and reproduction, impacts of climate change, value of NTFPs in culture and tradition of indigenous and non-native people, management and production, and culturally appropriate methods of resource governance and control of access.

Disclaimer

The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or US Government determination or policy.

Endnote

1. Table 1 is intended not to be comprehensive, but rather to be indicative of the diversity of species and products.
2. "Dietary supplements" are non-food products consumed by mouth to support real or purported health benefits. The US Food and Drug Administration does not test or evaluate dietary supplements before they are sold, unlike medicines (National Institutes of Health 2019).
3. That is, wood for industrial purposes such as pulp and paper, or lumber.
4. That is, there are questions about whether orchards, Christmas tree plantations, etc. should be considered "forests" for the purposes of this categorization
5. That is, products harvested from rangelands, or products historically harvested from forests that are now cultivated in fields.
6. Many valuable uses of NTFPs, such as family subsistence, cultural and religious uses, recreation, etc., are not market-oriented. This manuscript focuses on market uses; however, existing markets developed from nonmarket uses, which in many cases are grounded in the culture and history of indigenous peoples (Lake et al. 2018). Although current NTFP markets are generally dominated by non-native people (Freed and Mason 2011), indigenous traditional ecological knowledge is often critical for sustainable management of NTFPs (Sobrevila 2008), and NTFPs are equally critical to indigenous culture (Lake et al. 2018).
7. Certain NTFP markets today are in many ways similar to historical timber markets in the US after European colonization in terms of informality, lack of regulation, and relative lack of knowledge of management techniques. Initially, timber markets in US were unregulated (Williams 1992). The forest resource was thought to be endless, so as commercial production grew, there were rapid and sometimes wasteful harvesting practices, ignorance of proper forest management, "cut-throat" competition, and unstable markets. Speculators would send "timber cruisers" to scout for the best land that could be purchased at a good price (Williams 1992). Commercial timber production shifted from the Northeast to the Lake States to the Southeast as forests were depleted (Williams 1992, Finkle 2014). It was in the early 1900s when the public and policymakers began to realize that timber-harvesting practices needed to change. There was a push for legislation to preserve forests and require reforestation after timber harvest, which was met with resistance from the industry (Williams 1992).
8. Throughout this manuscript, we use the term "wild" to indicate that the plants are native to the United States and neither domesticated nor actively managed in the present. However, it should be noted that many currently "wild" populations may have been established and/or managed by indigenous peoples in the past (Alexander and McLain 2001, Jones and Lynch 2007).

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