



INVESTING IN FORESTS & COMMUNITIES

A PATHWAY TO A SUSTAINABLE SUPPLY OF FOREST HERBS
IN THE EASTERN UNITED STATES

By Holly K. Chittum, MS,^{a,b} Eric P. Burkhart, PhD,^b John F. Munsell, PhD,^c and Steven D. Kruger, PhD^c

^a American Herbal Products Association

^b The Pennsylvania State University

^c Virginia Polytechnic Institute and State University

Above: American ginseng forest farm in Maryland. This is an example of a "woods-cultivated" approach using tillage, raised beds, and near-monocultural production. Photo ©2019 Eric Burkhart

Summary

Forest botanicals are a subset of medicinal herbs that require special considerations in regard to sustainability, based on their unique growth patterns, supply chains and trade history, and the complex and sensitive ecosystems in which they grow. This article introduces sustainability concepts and definitions in the context of the herbal products industry, and forest herbs in particular, and discusses the general trends and issues of forest-derived medicinal products in the eastern United States. Particular focus is given to Appalachia and several herbs native to the region that illustrate important concepts and factors affecting sustainability of the forest herb supply chain. The authors outline key requirements for sustainable production and introduce forest farming as a potential solution to many of the challenges faced within the current forest herb supply chain.

Introduction

Forests are some of the most life-abundant and biodiverse ecosystems on the planet, and humans have a long, rich, and complex relationship with the species that inhabit them. The interactions between humans and forest ecosystems range from reverence and stewardship to large-scale exploitation and degradation. As a growing number of people look toward the future of this relationship, sustainability has become an increasingly essential component of the dialogue. The forests of the eastern United States are home to numerous species that are of great value to people in direct and indirect ways, past and present. These forests have served as a source of botanical medicine for the global market for centuries, and concerns about the sustainability of current production systems coupled with growing consumer demand for traceability in the supply chain create opportunities for intentional forest cultivation and management of important medicinal species within forests.

The US dietary supplement industry netted \$42.6 billion in retail sales in 2018, with herbal products contributing \$8.84 billion to the total.¹ Botanical raw ingredients sourced for herbal products include field herbs (sun-loving plants that can be cultivated in fields or wild-harvested from open spaces like meadows and pastures) and shade plants (herbs that grow in a forest understory). Forest understory medicinal plants have long been wild harvested for commerce, and some of the most widely traded plants are native to the deciduous forests of the eastern United States, with the Appalachian bioregion serving as an epicenter of supply. In Appalachia, as many as 50 medicinal plant species are currently traded, and most have a history of domestic use, first by indigenous peoples, then by settlers, and later by contemporary North Americans and international consumers.²

People depend on these plants and ecosystems economically as well as for health and wellbeing. Not only do forests provide resources such as materials for building, fuel, food, and medicine, but they also contribute to global biodiversity and provide ecosystem services such as carbon sequestration and climate regulation. In the face of growing demand and a complex and international supply chain, how can the relationship between people and forest ecosystems be balanced in a way that guarantees a healthy future for both people and the planet? This is just one of the questions that must be considered when addressing the forest herb supply chain. Others are more nuanced and are deeply rooted in the fiber of the local communities in the regions where these plants are found.

History of the Forest Herb Trade

Communities in forested regions of the eastern United States have depended on the medicinal plants trade for hundreds of years. Recounting what is known of this history of use and commerce is helpful for illustrating the long-standing relationship humans have with forest species.

As many as 20 Native American tribes are known to have used native eastern forest herbs such as black cohosh (*Actaea racemosa*, Ranunculaceae), goldenseal (*Hydrastis canadensis*, Ranunculaceae), and American ginseng (*Panax*



Bloodroot *Sanguinaria canadensis*
Photo ©2019 Priya Jaishanker

quinquefolius, Araliaceae) as medicine. They stewarded stands of these herbs and traded them among each other and later with European settlers. Early settlers first learned of the uses of these plants from indigenous peoples, and, over time, these forest species were used more broadly and commonly and traded both domestically and internationally.³⁻⁷

The deciduous forests of the eastern United States have been a source of medicinal plants in the global trade since the late 17th century, when the exportation of sassafras (*Sassafras albidum*, Lauraceae) to Europe began. Beginning in the early 18th century, American ginseng was exported to Asia after it was discovered to be a relative of and potential analogue for Asian ginseng (*P. ginseng*), which has been in extremely high demand in Asia for centuries and is perhaps the most significant herb in Chinese health culture.^{8,9}

Trade of forest botanicals was substantial even in the early years of modern US history. For instance, after the Civil War, the Wallace Brothers, one of the largest US botanical wholesalers, purchased more than two million pounds of wild-harvested plant materials annually and maintained a catalog of more than 2,000 species. They sourced their materials through a network of smaller buyers and general stores, which in turn bought from or bartered with an estimated 40,000 harvesters in western North Carolina alone.¹⁰ In the 19th and early 20th centuries, the rise of widely prac-

ticed, standardized plant-based medicine, such as the Eclectic medicine movement, created large new markets in the United States and Europe for native North American plant species.

Medicinal plants were part of a diverse, seasonal livelihood strategy for individuals and families.^{11,12} They could be harvested from public or privately owned forestlands and traded for store goods or cash. This trade could help insulate farmers against bad crop years and provide additional income during the “boom and bust” cycles of the timber and coal industries that were beginning to transform the landscape of the Appalachian region.¹³

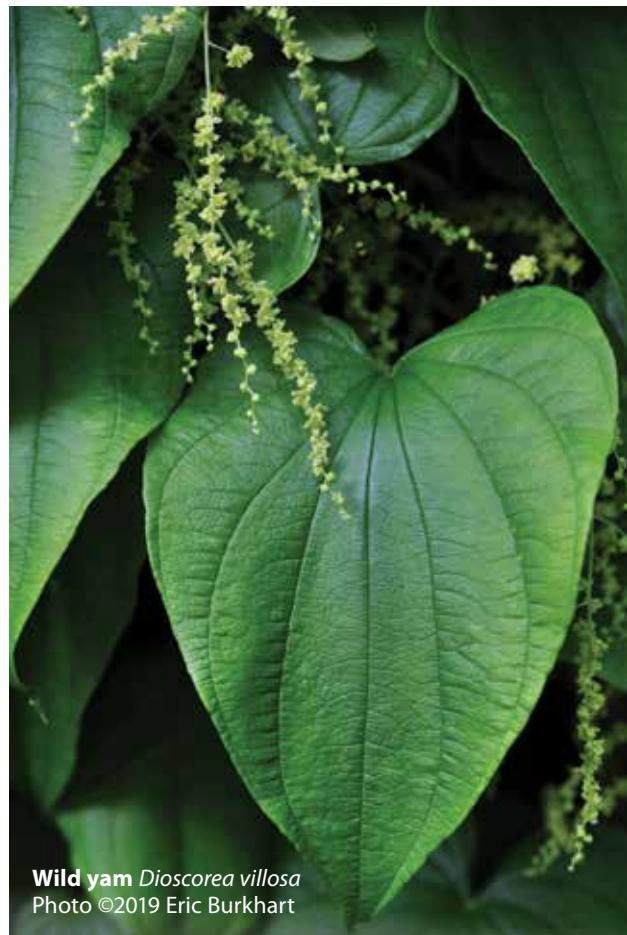
The rise of synthetic drugs in the 20th century resulted in the eventual decline of the medicinal forest plant trade, although some markets remained, particularly in Europe and Asia. Beginning in the 1960s and ’70s, a renewed interest in herbal and integrative therapies caused the market for herbal medicine to rebound. Since then, demand for many native eastern forest species has grown in kind. Today, the trade of forest medicinal plant material in Appalachia and adjacent areas like the Ozarks and Ohio River Valley is substantial. For instance, in 2016, US retail sales of black cohosh root alone totaled an estimated \$40 million.¹⁴ In Florida, Georgia, and South Carolina, saw palmetto (*Serenoa repens*, Arecaceae) berries were harvested and manufactured into products that accounted for almost \$35 million in retail sales across the two major US market channels in 2018,¹ and the southeastern United States provides the sole supply of the herb to the entire global market.

Conservation, Social, and Economic Concerns

Consistent and increasing demand for some of these herbs has sparked concern among forest managers, plant conservationists, and the herbal products industry, because virtually all of the raw materials from plants such as black cohosh, bloodroot (*Sanguinaria canadensis*, Papaveraceae), and false unicorn (*Chamaelirium luteum*, Melanthiaceae) are collected in the wild. In many cases, wild harvesting occurs with little understanding of plant population sustainability and challenges achieving predictable, high-quality supplies of raw herbs for use in herbal products.¹⁵ Additionally, because the majority of the trade volume and value of medicinal plants sourced from eastern deciduous forests pertains to the roots and rhizomes of herbaceous perennial understory plants and the bark of one tree species, slippery elm (*Ulmus rubra*, Ulmaceae),¹⁶ unsustainable harvest practices can and often do result in the complete loss of the plant or tree and may ultimately lead to population declines.

Rising interest in sustainable forest herbs is focused largely on the future of wild plant populations, but supply chain sustainability in relation to social welfare and economic equity is also important. These environmental and social factors form the basis for informed, holistic decision-making among stakeholders and interest groups across the supply chain.

Today’s supply chain for most forest medicinals in the eastern United States is reminiscent of the past. Small, diversified businesses are often the primary buyers of medicinal



forest plants, including gas stations, sporting goods stores, and scrap metal recycling centers that pay cash to their network of harvesters.¹⁷ These primary buyers often sell to a smaller number of aggregators who then provide raw material to manufacturers. This relatively informal chain is another area of concern because it is often difficult for consumers and manufacturers to know from where and under what conditions a particular product originated. Producers and harvesters are often underserved because historical prices paid for raw material have remained extremely low for many species, which contributes to economic disparity in the regions where these plants traditionally have been relied on for income. These low prices do not offer an incentive for harvesters to engage in or initiate proactive practices or attract new producers who are committed to a sustainable future.

Communities in regions like Appalachia, where these plants are found in abundance, are historically underserved economically, which has become more pronounced with the decline of the coal industry and manufacturing. Appalachia lags behind the rest of the country in most socioeconomic indicators. For example, median incomes in central Appalachia are 40% lower than the US average.¹⁸ Harvesting medicinal forest plants on accessible forestland can serve as a source of immediate cash for the impoverished or for people living on a fixed income, requiring little investment other than time and labor.¹⁹

Additionally, many people have deeply personal or cultural attachments to harvesting medicinal plants. Wild harvesting is a traditional activity in Appalachia, with harvesting techniques and locations often passed down from one generation to the next. For people working in the woods, harvesting is a conduit for cultural identity, sense of place, and traditional ecological knowledge. These people already know and use these plants and can be part of a more sustainable trade.

A new population of harvesters has moved to the area and wants to be part of and carry on such traditions.²⁰ Such newcomers may be, for example, millennial city dwellers who feel disconnected from nature and desire to be more engaged with the natural world, or veterans, baby boomers, or retirees looking for wholesome work that connects them with nature. No matter who does it, the work of harvesting woodland botanicals is difficult and strenuous. Locating, digging, washing, and drying plants that often bring only a few dollars per pound mean harvesters often are not fairly compensated for their labor.^{2,18}

Rising rates of substance abuse in the area, in part due to deep economic disparity in the region,^{21,22} contribute to growing rates of theft and illegal harvest of medicinal forest plants on public and private land.^{23,24} This demographic and



American ginseng *Panax quinquefolius*

Photo ©2019 Priya Jaishanker

other “quick cash” harvesters often harvest out of season and are unlikely to observe sustainable harvest practices, which inevitably confounds conservation efforts.

The increased visibility of the forest herb trade in mainstream culture through social media and reality television and increasing use of foraged forest food in upscale cuisine also have had an impact on harvesting demographics and motivations.^{25,26} Along with conservation and wild plant population health concerns, these social factors deserve more attention in order to ensure that informed decisions are made at both ends of the herbal products supply chain. From the purchasing choices of consumers to manufacturer decisions about how they source forest plant materials and how the herbs are produced and/or harvested at their source, the social “fair trade” component of the forest herbal supply chain is a legitimate concern for the future of forest herbs sourcing.

Sustainable Forest Herbs: Toward a Working Definition

Concerns about sustainability are not limited to herbs and herbal products. According to research from New York University’s Stern Center for Sustainable Business on US consumer purchasing trends for packaged goods, products marketed as “sustainable” accounted for 50% of total market growth from 2013 to 2018, even though sustainably marketed packaged goods represented only 17% of the entire category. The number of products marketed as “sustainable” grew almost six times faster than those that were not marketed as sustainable during the study timeframe.²⁷ This indicates rising interest in sustainability and customer willingness to pay for sustainable products.

Customer survey data show that sustainability is becoming more important among herbal supplement users as well. The Natural Marketing Institute reports that a majority of herbal supplement users are more likely to buy a supplement if it uses sustainable or eco-friendly ingredients and packaging, are willing to pay a premium for sustainable supplements, and are loyal to brands that they know are environmentally

Environmental Certification Programs

More than 200 eco-certification and ecolabeling programs are currently available in the United States. These certifications assess, for example:

- How raw materials are grown and/or harvested (e.g., USDA organic, organic regenerative agriculture, Forest Grown Verification, and FairWild certifications);
- The welfare of communities and people at the beginning of the supply chain (e.g., Fair Trade, Rainforest Alliance, and fair labor practices);
- The sustainability of buildings and other places where business operations are carried out (e.g., LEED green building and NSF sustainability certifications);
- Greenhouse gas production across a product's life cycle (e.g., Carbon Neutral or Carbon Care certifications); and
- A company's actions from end to end across all business activities (e.g., certified Benefit or B Corporations that meet comprehensive and transparent social and environmental performance standards designed to expand corporate accountability).

friendly. Most of these consumers also think it is “important that companies are mindful of their impact on the environment and on society.”²⁸ However, a universal definition of sustainability in relation to the herbal supply chain does not currently exist. Reasons for this may include the diversity of production methods for herbs, plant population and growth patterns, trends, and habitats, and the many different stakeholder groups that are involved across the supply chain. In regard to forest herbs, consumers and herbal industry members need to be aware of how they differ from other herbal commodities in order to ensure their sustainability.

The various definitions of sustainability share common themes that encompass people and the planet, both in the present and future. One of the most frequently cited definitions of sustainability comes from the UN World Commission on Environment and Development, which states that sustainability “meets the needs of the present without compromising the ability of future generations to meet their own needs.”²⁹ Specific to botanicals, the International Standard for Sustainable Wild Collection of Medicinal and Aromatic Plants (ISSC-MAP) provides this definition: “to ensure the continued use and long-term survival of MAP species and populations in their habitats, while respecting the traditions, cultures and livelihoods of all stakeholders.”³⁰

Across industries and sectors, definitions of sustainability often are broad and not readily actionable. In some cases, more detailed and specific standards and guidelines have been created using these broader definitions as a foundation, and several widely respected standards and guidelines for collection of wild herbs have been created. Some of these programs are referenced further on and though this article will not delve deeply into the topic, it deserves further consideration.

The terms “regeneration” and “regenerative,” as they relate to

sustainability, design, and agriculture, have also gained attention in recent years. These practices focus foremost on rehabilitation and renewal of ecosystem resources like soil and water in tandem with production, which, when done together, are said to improve ecosystem health and yield over time. Many find regeneration to be a helpful framework, as it brings together important existing ideologies and practices in a way that is accessible and actionable.³¹

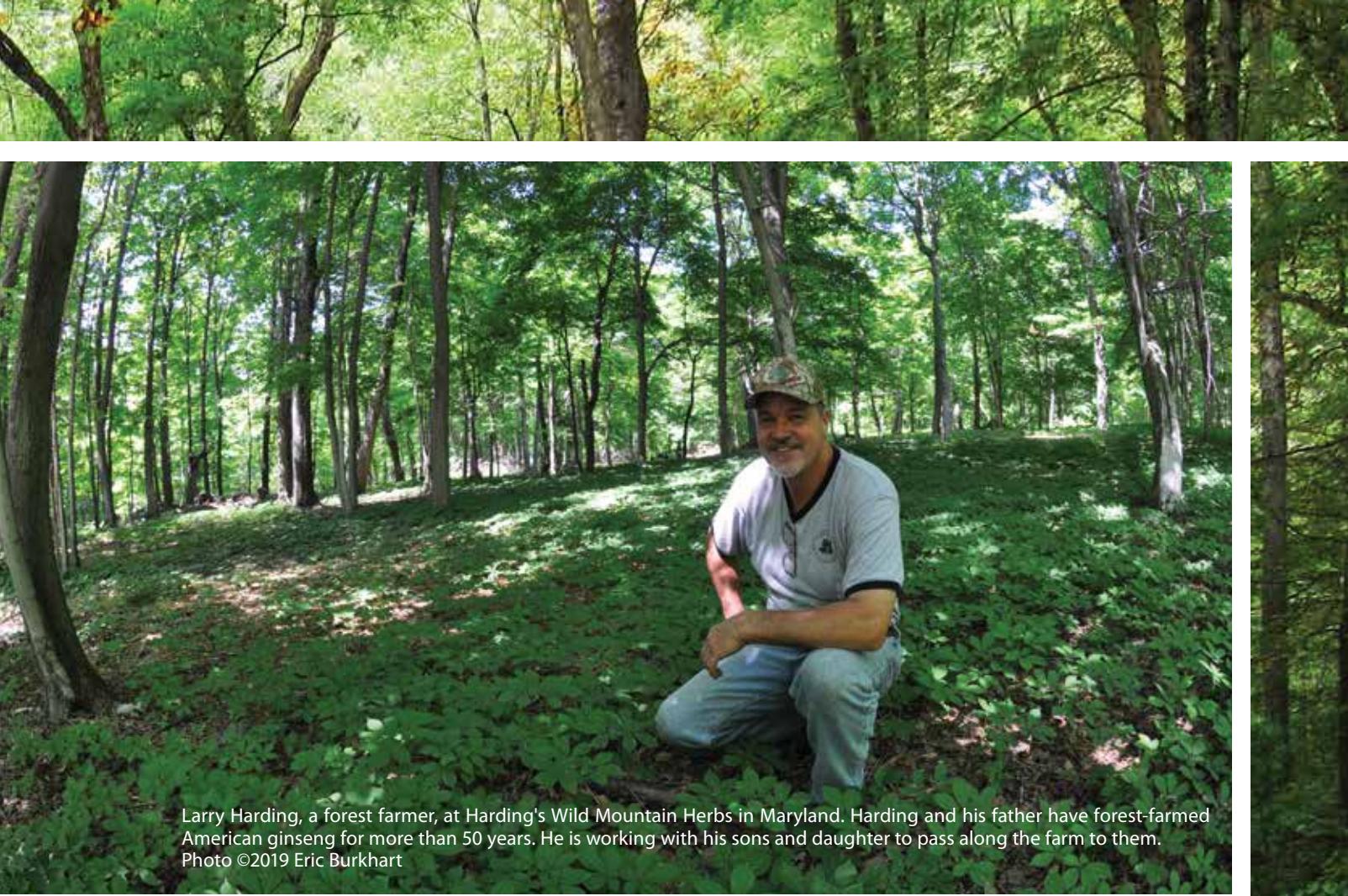
The ‘Triple Bottom Line’ for Forest Herbs

“People, the planet, and profit” are commonly identified as the three key pillars of sustainability. In business, the “triple bottom line” is a three-part accounting framework that examines social, environmental, and financial impacts and concerns related to a company’s business practices.³² Many companies have adopted this framework as part of a commitment to corporate social responsibility and use certification programs and transparent accounting approaches in order to meet the demand of a growing segment of concerned citizens and consumers.³³⁻³⁵ Some companies have developed their own approaches in-house while others use third-party certification programs that offer oversight of certain aspects of business processes or supply chain, and some companies employ both.

In an herbal marketplace that depends on medicinal forest plants, the triple bottom line of sustainability requires these considerations and more. The three pillars in the forest herb supply chain are: (1) the forest ecosystems and plant communities from which raw materials are harvested; (2) the people who act as stewards, farmers, and harvesters of the raw materials, as well as the communities of people who depend on forest ecosystem resources; and (3) the consumers who buy and use the finished products. All



Black cohosh forest farmers Michelle Pridgen and Cynthia Taylor of Windy Hill Farm and Moon Shadow Farm, Virginia. Pridgen, Taylor, and other Virginia landowners have been working with researchers and extension personnel associated with the Appalachian Beginning Forest Farmer Coalition and Appalachian Sustainable Development to help facilitate and transfer forest farming information and technology through collaborative projects and programs.
Photo ©2019 Priya Jaishanker



Larry Harding, a forest farmer, at Harding's Wild Mountain Herbs in Maryland. Harding and his father have forest-farmed American ginseng for more than 50 years. He is working with his sons and daughter to pass along the farm to them.
Photo ©2019 Eric Burkhart



American ginseng *Panax quinquefolius*
Photo ©2019 Eric Burkhart



Black cohosh *Actaea racemosa*
Photo ©2019 Eric Burkhart

of these factors are uniquely and inextricably linked, with each depending on the health and welfare of the others to prosper. These three categories stand to benefit most from an equitable and mutually nourishing relationship. They are also the most vulnerable and stand to lose the most from unsustainable practices or a lack of investment in the future of a just and reciprocal supply chain.

Forest Herb Case Studies: Supply Chain Impacts and Considerations

It is important to recognize that many eastern North American medicinal forest plants grow slowly and can sometimes take up to a decade or more to reach harvestable age and size. Other widely traded medicinal herbs, such as dandelion (*Taraxacum officinale*, Asteraceae), burdock (*Arctium* spp., Asteraceae), nettle (*Urtica dioica*, Urticaceae), and yarrow (*Achillea millefolium*, Asteraceae), for example, are comparatively fast growing and can usually be harvested within one to three years from planting, depending on what part of the plant is harvested. Additionally, many field herbs reproduce within their first year or two and often produce copious fruit and seeds, whereas forest plants may take years to reach reproductive maturity and, once mature, can be limited in reproductive output to only a few fruit and seeds per year or are slow to asexually reproduce.

Three examples of unique forest herbs in trade — black cohosh, goldenseal, and American ginseng — illustrate how supply chains are impacted by issues such as adulteration, quality, predictability, and sustainability, how these issues are interrelated, and how they affect the health and welfare of natural ecosystems and people at both ends of the supply chain. These issues can be addressed through education and engagement about wild plant stewardship and intentional cultivation methods such as forest farming. A lack of consumer awareness concerning the “uniqueness” of this subset of medicinal plants contributes to the undervaluation of their raw materials in the marketplace.

Black Cohosh and Adulteration

The genus *Actaea* contains 28 species from the northern hemisphere, including North America. Black cohosh is the most important *Actaea* species in commerce and is mostly collected from the wild in North America. Black cohosh has a variety of historical uses, but it has emerged in recent decades as a top-selling herbal supplement, most notably as an ingredient in supplements formulated to support women's health. It is highly sought after in domestic and international natural products markets and has been among the 10 top-selling herbal supplements in the US marketplace in the mainstream and natural retail channels for the past several years. Total annual US retail sales of black cohosh supplements reached roughly \$40 million in 2016 and approximately \$35 million in 2017 and 2018.^{1,14,36}

Adulteration of black cohosh is recognized as a problem in the herbal marketplace.³⁷ There are generally two types of adulteration: (1) intentional, economically motivated adulteration, which occurs when a raw material supplier knowingly substitutes or co-mingles one plant species with another, undeclared species; and (2) unintentional, which results from accidental collection of the wrong plant from wild populations and/or unintended mixing with other harvested plant materials. Both forms of adulteration can occur in forest medicinal plant supply chains.

In the eastern United States, several *Actaea* species are widespread, and a few regional taxa are more localized in distribution (and of state-level conservation concern). These taxa are notoriously difficult to differentiate in vegetative developmental stages, even for the well-trained eye. Reproductive structures (e.g., flowers and fruits) must be present for accurate identification, since multiple species can be found growing in the same local environment. However, the gathering of wild plant material without reproductive parts is widely practiced since many wild plants are often not encountered in flowering or fruiting stages and there are no widely adopted guidance or regulations for when plants should be harvested.

Adulteration of black cohosh with lower-cost imported Asian botanical material is also of concern since it is known that *Actaea* species can vary in phytochemistry. *Actaea podocarpa*, for example, contains a constituent (podocarpaside) that has not been found in *A. racemosa*.^{38,39} The health impact of consuming other *Actaea* species is unclear. There have been adverse event reports of liver damage for products

labeled as containing black cohosh, but no causal relationship between authentic black cohosh and liver damage was shown. A lack of authentication of the specific products in question is often cited as a barrier to learning the cause of adverse events. Impurities, adulteration with other *Actaea* species, and problems with quality control have been cited as potential contributing factors.³⁹⁻⁴¹

There is also concern that inadvertent collection of some *Actaea* species may threaten these species in parts of their range. For example, in Pennsylvania, *A. podocarpa* is at the northern edge of its range and is state-listed as a species of conservation concern as a result. Thus, the adulteration of black cohosh is both a human welfare and conservation concern.

Goldenseal and Quality

Goldenseal, an herbaceous perennial plant used medicinally for antimicrobial and digestive purposes, is the only member of the genus *Hydrastis* and is found only in eastern North America.⁴² Since 1999, it has been included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) due to conservation concerns, and, more recently, it also has been listed as vulnerable on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species.⁴³ Currently, only about 30% of goldenseal in the herbal marketplace is from cultivated sources.^{17,18,44}

Medicinal plant product quality often is gauged by the presence or concentration of phytochemical constituents, which can vary according to plant age, growth stage, growing conditions, and genetics. The constituents often associated with goldenseal's medicinal properties are the isoquinoline alkaloids berberine, hydrastine, and canadine, which are found in the roots, rhizomes, and aerial portions of the plant. Research has shown that the alkaloid content of goldenseal root and rhizome peaks at the senescent and dormant stages.^{44,45} This adds to a growing body of literature that demonstrates that harvesting plants without considering when constituents are at a peak or most desirable stage impacts the final quality of the medicinal product.⁴⁶⁻⁵⁰

This scientific evidence confirms what traditional systems have practiced historically in regard to harvest. However, goldenseal collectors frequently harvest wild goldenseal at any time during the growing season at the harvester's convenience and in response to demand. Appalachian root buyers begin advertising prices as early as April, and many collectors begin harvesting goldenseal as soon as plants emerge in the spring. In many cases, buyers offer no guidance to collectors as to when to harvest wild roots and rhizomes.⁴⁴ When it is understood which constituents are important, and when harvesting and cultivation are more organized and proactive, plants can be harvested in a way that maximizes overall efficacy. This, in turn, can help provide consistent and effective usage and dosing. Additionally, if goldenseal is harvested at peak potency at senescent and dormancy stages, the plants would also have an opportunity to produce fruit and seeds, ensuring more sustainable wild collection.

American Ginseng and Sustainability

Indigenous to eastern North American forestlands, American ginseng is used primarily for its adaptogenic and immune-modulating properties.⁵¹ American ginseng is perhaps most well-known for its use and popularity in traditional Chinese medicine (TCM). It is one of the two most commonly used species in the genus *Panax* and the only *Panax* species in commerce that is native to North America. (*Panax trifolius* is also native to North America but is not traded in commerce.) Ginseng trade is profitable because of a strong and lasting niche market in Asia, where consumers are willing to pay more for plants that display wild characteristics, as explained below. This long-standing demand coupled with the high prices paid for ginseng roots with wild-like characteristics have caused concern about wild population decline after almost three centuries of American ginseng wild-harvesting. American ginseng is included in Appendix II of CITES with certain restrictions placed on harvesting and international trade due to sustainability concerns. The whole root has the greatest commercial demand and, therefore, is the item most sought by collectors. This is true even though multiple parts — leaves, fruit, and root — have been shown to contain various ginsenosides, the chemical constituents that are believed to be responsible for some of the medicinal benefits of ginseng.

American ginseng was introduced into horticulture in the late 19th century and has since been cultivated intensively in artificial-shade gardens and plantations. Growing



Goldenseal *Hydrastis canadensis*
Photo ©2019 Catherine Bukowski

ginseng in a monoculture environment in artificially shaded farm plots can decrease growing time from nine or more years in wild forested conditions to three to five years under artificial shade. It also allows for mechanization of planting and harvesting. Most commercially available American ginseng in the United States today originates from cultivation using artificial shade; however, the market for wild ginseng has continued to be strong in large part because of the high premium that Asian consumers are willing to pay for roots that appear “wild,” which they perceive as being of higher quality.⁵² Approximately 90-95% of wild American ginseng root harvested in the United States is destined for Asian markets, where complex visual grading systems have been developed to differentiate and value the roots.^{53,54} The annual wild harvest amount in the United States remains an issue of concern in regard to species conservation.

The higher price of American ginseng grown in the forests of eastern North America results largely from Asian consumers’ preference for plants grown in their native environment under a unique set of soil and climate conditions that cannot be duplicated elsewhere. This has stimulated a new emerging industry based around agroforestry and forest-based cultivation practices and provided livelihood opportunities for landowners in the United States and Canada who have invested in American ginseng production systems in forest-

lands. In fact, many landowners in the eastern United States are growing this plant in forest farming systems using a variety of husbandry practices, from intensive forest cultivation to intentional and diligent seed planting and assisted dispersal from wild plants, a facet of traditional wild stewardship.⁵⁵

In addition to the visual differences of field-cultivated ginseng that make it less valuable to Asian consumers, another difficulty is that commercially grown *Panax* species do not take well to crowded conditions, and many fungal diseases emerge under this type of production, requiring frequent application of fungicides.^{56,57} This also contributes to concerns about quality^{58,59} and affects value for a growing number of consumers who prefer herbal products that are produced using less or no agricultural chemicals.

Some companies have started to implement labeling programs such as Forest Grown Verification, but it has been an ongoing challenge to achieve higher price points for domestic forest-grown products that are fair for the producer. Companies have also started to use ginseng leaf and whole-plant extracts as opposed to just the root. American ginseng phytochemistry studies have supported the use of American ginseng leaf, for example,⁶⁰ and have confirmed chemical differences resulting from product origins and production methods and environments (e.g., forest versus field cultivation).⁴⁸

American ginseng *Panax quinquefolius*

Photo ©2019 Eric Burkhart



Eastern North American Forest Plants as Wild Resources and Crop Candidates

While wildcrafting can serve as a source of supplemental income for rural communities in Appalachia and other areas, the market prices of many forest species, like black cohosh and goldenseal, are too low to fairly compensate for labor, support livelihoods, or encourage long-term investments in managing plant populations or transitioning from wild harvesting to cultivation. In a US botanical dietary supplement industry worth an estimated \$8.8 billion, it may seem odd that people at the beginning of the supply chain rarely earn a living wage. This situation is even more compelling when one also considers that the forests of the eastern United States supply most or all of the national and international market for certain herbs like goldenseal and saw palmetto.^{17,61,62}

The wild supply chain is often unpredictable and lacks traceability. Primary buyers either purchase on speculation or fill orders from an aggregator, and harvest locations often are not tracked. As a result, it is difficult to assess the impact of harvesting on wild populations. Unlike timber or other valuable natural resources, these wild populations are not generally monitored or measured, meaning that the supply, rate of removal, and rate of regeneration are all uncertain. The imperfect market structure increases volatility, hamstrings business planning at all levels of the supply chain, keeps harvesting and primary sales opaque, and is often inefficient and inequitable.⁶³ It also affects product consistency and quality and compromises consumer confidence in the products they buy. Financial incentive and stability are needed to manage populations for the long term and solve various problems.

Cultivation of eastern North American medicinal forest plants is a recognized alternative to the reliance on wild-harvested materials. Cultivation can solve many issues, such as adulteration caused by misidentification of wild plants, since it is possible to trace the material from seed to shelf. It can also enable systematized harvesting that takes place at an optimal time for maximum potency of secondary metabolites and can reduce pressure on wild plant populations. *In situ* cultivation of non-timber woodland crops, also known as forest farming, is especially attractive when considering herb quality and production costs.

Medicinal forest plants, such as black cohosh, goldenseal, and American ginseng, are at least partially shade obligate (they require shade for growth) and therefore generally must be grown under artificial shade when planted in an open field. Significant investment in artificial shade is necessary when forest plants are grown in open field



American ginseng "forest farm" in western Pennsylvania. This farmer manages his overstory to create optimum lighting conditions for his crop. As logs are carefully removed, the tops are spread on the surface of the forest floor to provide organic matter and nutrients to the trees and ginseng, but also to create decomposable barriers to discourage deer and turkey from eating the ginseng plants.

Photo ©2019 Eric Burkhart

settings. Upfront materials and associated labor costs for American ginseng field-based production, for example, average \$30,000-\$50,000 per hectare.⁶⁴

Finally, in keeping with agroforestry's polyculture principles, farming forest plants in their native habitats may eliminate or reduce disease problems and, in turn, reduce or eliminate the need for pesticide use and provide an intuitive pathway for organic production, which offers a product grown without synthetic or genetically modified agricultural chemicals to consumers and gives farmers access to niche, higher-value markets. It also requires improved management of forests, which avoids depreciation costs associated with artificial shade and can lead to healthier, more productive, and regenerative ecosystems.

Forest Farming: Benefits and Challenges

Forest farming is one of five agroforestry practices recognized and promoted by the US Department of Agriculture (USDA) National Agroforestry Center⁶⁵ and defined as "the integration and management or intentional cultivation of high-value non-wood/timber forest crops such as medicinal and edible plants under the canopy of well-managed forest."^{53,66} Agroforestry as a whole comprises practices that combine trees, crops, and/or livestock in the same place.⁶⁷ Perhaps owing to inclusion of the term "farming" in this practice description, forest-based plant husbandry and cultivation often are thought of as row-cropping (e.g., monocultural production practices) in forest understories. While some forest farmers do grow forest crops in such a fashion, forest farming increasingly is being recognized by practitioners, buyers, educators, and regulators as a continuum of production and husbandry practices ranging from

intentional manipulation and stewardship of wild plant populations to more intensive horticultural and agronomic investments that may include technology and inputs such as fertilizers and pesticides. The promotion and adoption of forest farming by practitioners across eastern deciduous forests to date has trended toward the former (i.e., low intensity).⁵⁴ As such, some stakeholders across Appalachia recognize that low-intensity, high-intention forest farms that maximize understory “crop” stewardship and diversity while simultaneously maintaining ecological attributes are perhaps the future of forest “farming” for many indigenous forest herbs. This approach, which uses existing wild plant populations and germplasm, is akin to practices used by indigenous peoples, and as such can derive inspiration from traditional ecological knowledge.⁶⁸

Various forest farming techniques, ranging from intensive woods-grown methods on raised beds, or logs for growing some fungi, to stewarded wild populations, use judicious

harvesting rates and intentional propagation. Regardless of the technique, forest farming generally works with rather than against the environment, allowing the “crop” to grow within the forest and among companion species that are associated with its natural habitat. Forest farming has been in practice for some time; however, farming woodland medicinal botanicals has only recently gained traction as a solution for ensuring predictable, sustainable, and high-quality forest plant supply and for its potential to improve income opportunities in economically distressed forest-dependent communities.

Forest farming is an attractive option that potentially solves many problems within the herbal products supply chain. However, even though demand continues to increase, prices paid to producers do not reflect market value and producer needs. Research conducted in partnership with growers and stewards suggests that farming many native medicinal plants in eastern North American forests would

Table 1. Appalachian Medicinal Forest Plants with Potential as Forest Farming Crops

Common Name	Scientific Name	Part(s) Used	Reported Trade Volumes (lbs dry weight/year) for 1999–2010 ¹⁶	% of Trade Volume from Cultivated Material ^a	Current Industry Prices Per Pound (Wholesale) ^b
American ginseng	<i>Panax quinquefolius</i>	Rhizome, roots, leaves	Wild: 59,000–160,000 ^c (Wild volumes only)	Not applicable ^c	\$150–\$1,300 (Wild prices only) ^c
Bethroot	<i>Trillium erectum</i>	Rhizome, roots	Wild: 402–2,999 Cultivated: 0	0%	\$0.75–\$12.50
Black cohosh	<i>Actaea racemosa</i>	Rhizome, roots	Wild: 117,843–343,771 Cultivated: 149–9,862	< 1–3%	\$2–\$6.75
Bloodroot	<i>Sanguinaria canadensis</i>	Rhizome, roots	Wild: 3,306–48,674 Cultivated: 5–26	< 1%	\$5–\$18.50
Blue cohosh	<i>Caulophyllum thalictroides</i>	Rhizome, roots	Wild: 3,934–8,803 Cultivated: 79–160	2%	\$0.50–\$6.25
Cranesbill	<i>Geranium maculatum</i>	Rhizome, roots	No data	No data	\$1–\$9
False unicorn root	<i>Chamaelirium luteum</i>	Rhizome, roots	Wild: 3,306–6,300 Cultivated: 35–1,400	1–18%	\$20–\$125
Goldenseal	<i>Hydrastis canadensis</i>	Rhizome, roots, leaves	Wild: 31,802–105,099 Cultivated: 11,070–47,559	26–31%	\$8–\$55
Mayapple	<i>Podophyllum peltatum</i>	Rhizome, roots	No data	No data	\$0.50–\$9
Slippery elm	<i>Ulmus rubra</i>	Inner bark	Wild: 78,380–352,727 Cultivated: 1,731–10,200	2–3%	\$1–\$5.75
Solomon's-seal	<i>Polygonatum biflorum</i>	Rhizome, roots	No data	No data	\$0.50–\$15
Stone root	<i>Collinsonia canadensis</i>	Rhizome, roots	No data	No data	\$0.75–\$4.25
Virginia snakeroot	<i>Endodeca serpentaria</i>	Rhizome, roots	Wild: 17–353 Cultivated: 0	0%	\$10–\$125
Wild yam	<i>Dioscorea villosa</i>	Rhizome, roots	Wild: 23,855–59,193 Cultivated: 54–10,055	< 1–15%	\$1–\$9.50

^a Calculated from the preceding column data.

^b Long-term price database maintained by E.P. Burkhart (2019). Prices are compiled from various regional buyers 1973–2018.

^c US Fish and Wildlife Service Division of Scientific Authority. 2018. Data obtained by request of E.P. Burkhart. Only wild data are included in this table since most commercial sources of American ginseng are obtained from cultivation unlike the other plants included in this table. The continued demand for wild ginseng is driven by niche markets in east Asian countries.

not be profitable for producers or even feasible (i.e., producers will not break even) at recent historic prices.² Wholesale market prices are far below production costs for many species, and significant price differences exist between species with approximately the same production requirements and yield potentials (e.g., American ginseng versus black cohosh) (Table 1). While this difference can be attributed to market factors (e.g., differences in consumer demand, scarcity of supply), there is nevertheless little incentive for the adoption of intensive husbandry given such realities.

For example, black cohosh prices per pound have remained low, especially in relation to inflation. Between 2000 and 2018, the price paid per pound of dried black cohosh root averaged \$2-\$3. This price, when examined out of context, does not tell the story of what it means to produce black cohosh and the years of patience, risk, and effort that are necessary for these plants to reach harvestable maturity, which can take four to 10 years. When true costs are included, the price required to break even can be as high as \$50-\$100 per pound.²

In general, commercial medicinal forest plants do not grow fast and vigorously in a range of habitats and are not similar to most agricultural crops like tomatoes (*Solanum lycopersicum*, Solanaceae) and corn (*Zea mays*, Poaceae) that are harvested after one growing season. Many forest herbs

can be challenging to grow. With forestland cultivation or stewardship, production costs are less than field-based farming, but growth rates and yields can be erratic due to habitat or weather events, and plants are subject to browsing by animals or theft by humans if they are not well protected. Climate change is a factor that impacts both wild and farmed forest botanical habitats, and its effects will become increasingly more apparent over time. Additional challenges posed by forest farming include a reduced ability to mechanize many aspects of production, which can increase labor needs.

Access to planting stock is a challenge for many forest farmers, especially seed from local sources that is adapted to local conditions. There is also concern about the introduction of non-local or domesticated genes into natural forest populations through the expansion of forest farming enterprises. Producing and transporting planting stock from outside the region increases its carbon footprint and costs, and also raises the risk of introducing pests and disease into naturally occurring stands. Access to land is another challenge for many new would-be forest farmers, and some stakeholders are working to find widely adoptable land tenure solutions, such as long-term land leasing on corporate or absentee-owned land.⁶⁹ Finally, farmers must know and abide by various state and federal regulations to forest farm certain forest botanicals like American ginseng.

An American ginseng "forest farm" in western Maryland. This farmer spends a lot of resources to prepare the forest understory soil before planting seed, including heavy thinning of the forest understory competition (which in many cases includes non-native exotic invasive shrubs and herbs) along with tillage and mulching with straw. Many companion species are still present when the crop is maturing in this scenario. Photo ©2019 Eric Burkhart



While forest farming offers promise for consumers and farmers, it should not do so at the expense of current wild-harvesters, many of whom live in economically distressed areas where production is currently concentrated. Low-income harvesters are less likely to own land and traditionally operate on large public or corporate-owned land holdings, treated as commons. Though some of these non-landowner harvesters may look to transition to farming via land leasing and other similar strategies, many may not be able to make the long-term investment that forest farming requires.

Wildcrafting has taken place in forests for millennia and deserves a place in the evolution of the industry. Many still practice this art in ways that honor the environment and the relationship humans share with forest ecosystems. While current prices paid are low for wild-harvested materials, often just a few dollars a pound, the flexibility and availability, low risk, and lack of capital needed are assets for some low-income harvesters, and methods must be found to ensure that this practice is both ecologically sustainable and equitable for harvesters.

Forest farming systems offer incentives for some well-placed harvesters and create a new constituency of producers. This does not necessarily mean all current users will benefit from a transition away from wild harvesting. Potential challenges aside, the benefits of forest farming to people and the planet have made it a promising solution to current supply chain predicaments.

Our definition of forest farming includes managing existing stands, and many forest farming practices, such as propagation using root cuttings, have been traditionally performed at the point of harvest in the wild. Having these users, who may not consider themselves farmers, represented with a degree of agency, is part of building equity into management, policy, and industry standards.

One of the primary challenges of including wild stewardship within discussions of sustainability is the question of how to verify or monitor harvests that may occur on land not owned by the harvester or common lands used by multiple harvesters. This is the case in many areas of Appalachia where a high percentage of forest lands are corporate or absentee-owned.⁷⁰

Adoption of adequate, standardized systems for obtaining and demonstrating permis-

sion to harvest will be necessary in these instances. Guaranteeing sustainability of wild harvesting is also essential and could include training programs whereby participants receive certificates of completion, are added to a sustainable harvester registry, or are otherwise established and recognized as sustainable harvesters by companies looking to procure forest herbs.

Some programs already provide wild harvesting guidance and certification services. Programs such as the FairWild Standard, Ethical BioTrade Standard, or USDA National Organic Program (NOP) wild-crop harvesting practice guidance are a few of the existing programs that offer sustainable wild harvesting guidance but are not currently widely adopted in the United States. It could and perhaps should also include a “point-of-harvest” verification initiative through which wild-harvesters receive higher prices because of their participation in harvest education programs and willing transparency at harvesting sites.

Mentorship, training, and professional development is a common component of gainful employment in the United States, and though it may seem unconventional in regard to wildcrafting, it may allow harvesters to receive a fair wage so they can continue their chosen work over the long term, keeping in stride with best practices.

These are just a few examples of ways to integrate wildcrafting into a sustainable model for the future of the herbal industry. A hybrid approach that includes both an intentional shift to forest farming and solid, widely adopted protocols for ensuring sustainability of wild harvesting may

ensure that the largest number of producers are involved in the movement toward sustainable production and procurement of forest herbs.

Some sustainability leaders in the herbal industry are supporting growth in the forest farming sector by spearheading product lines that contain fairly traded and equitably priced forest-farmed herbs and by supporting eco-labeling initiatives designed to verify forest farming and other sustainable sourcing methods for their product ingredients. These spearheading companies can be supported by herbal customers, and many are searchable online or can be found via forest farming resource organizations.

In addition, numerous organizations, individuals, agencies, businesses, and academics have worked to enhance forest farming techniques, provide resources and technical support to farmers, and help connect



Forest-grown American ginseng whole plant extract.

Photo ©2019 Thomas Dick, Creative Director of Mountain Rose Herbs

them to companies that are interested in sourcing their products. In recent years, funding support for such programs have increased. One prominent example is the Appalachian Beginning Forest Farmer Coalition (ABFFC; see sidebar).

Conclusion

With growing demand for accountability, transparency, and sustainability within the herbal marketplace, consumers will continue to have more choices, including forest-farmed and sustainably wildcrafted products. Forest farming is a model for the future of woodland botanical supply and, with the right investments and support from herbal companies and customers, it could be a game changer for the herbal products industry. The forest farming model provides an opportunity for herbal companies that are in the business of health and wellness to demonstrate that their products not only benefit consumers, but that their business philosophy and sourcing strategies also are part of a conscientious balance among communities, the environment, and profit. Some businesses may emphasize economic or social equity, and others may emphasize ecological integrity or regenerative production methods. These priorities will have to be clarified by businesses through marketing and the ways in which they account for and report their

sustainability practices to consumers. Certification standards will also be impactful. The education of consumers about their options, and the refinement and scaling of sustainable production to meet rising demand, are key issues going forward.

Long-term proactive stewardship of wild-harvested plant populations and intentional forest cultivation strategies, rather than short-term “boom and bust” reactive exploitation in response to increased price and/or demand, are obvious solutions to the problems outlined in this article. Ensuring equitable, fair trade prices for farmers and harvesters provides incentive to invest in long-term stewardship and cultivation. What is needed is a “fair price” for producers of forest herbs, along with “fair profit” for additional stakeholders involved at all levels of the supply chain, and a “fair price” that reflects the true value of the product for the consumer at the end of the supply chain.

Consumers must be aware of the circumstances surrounding the offering of forest herbs in the marketplace and, whenever possible, should seek to understand their source, connect with known local or certified sources, and be willing to pay more (when compared with other herbs) in order to support a sustainable supply of raw materials and those who produce them in intentional in situ production systems.

ABFFC and Other Organizations and Programs Support Forest-Grown and Sustainable Herb Production

The Appalachian Beginning Forest Farmer Coalition (ABFFC) is a broad USDA-funded forest farming partnership whose leadership is composed of 16 nongovernmental organizations, governmental agencies, universities, private companies, and supply chain interest groups. The ABFFC began as a community of practice in 2011 and transitioned into a coalition in 2015. The coalition works across the Appalachian region to provide hands-on training and build forest farming networks. The ABFFC has more than 1,600 registered individual coalition members who identify as forest farmers and forest landowners and also as agency personnel or industry stakeholders. The coalition was the first of its kind to receive funding through the USDA's Beginning Farmer and Rancher Development Program to support medicinal plant forest farmers, and recently received a second round of funding to continue its work through 2022. Its website contains hundreds of videos and other media resources for and about forest farming, and includes information and links to all partner organization websites.

A founding ABFFC partner organization is Appalachian Sustainable Development, which manages the Appalachian Harvest Herb Hub in Duffield, Virginia. The Herb Hub is an herb processing facility that offers affordable post-harvest processing to Appalachian forest farmers, works with growers to help plan and organize their forest farming businesses, and connects them to buyers to bring fairly traded forest-farmed herbs to the marketplace. The Herb Hub also maintains USDA certifications, provides farmer training opportunities, and makes it possible for farmers to bring their medicinal crops to market in a cost-efficient manner.

The United Plant Savers (UpS), another founding ABFFC partner organization, administers the Forest Grown Verification (FGV) label, a third-party certification program that originated from a partnership between Penn State and Pennsylvania Certified Organic, with input from NGOs, state and federal agency representatives, and forest farmers. The FGV label certifies that ingredients are produced using forest farming meth-

ods. Together with UpS, another ABFFC founding partner, Rural Action in Ohio, was awarded a National Conservation Innovation Grant from the USDA National Resources Conservation Service to expand the FGV label throughout Appalachia. The US Forest Service and universities such as North Carolina State, Penn State, and Virginia Tech all have scientists who are members of the ABFFC and are researching forest farming techniques and markets and providing outreach to forest communities.

The American Herbal Products Association (AHPA) serves in an advisory capacity to the ABFFC and conducts the Tonnage Survey of North American Botanicals. This survey is considered “a vital index of native U.S. botanical consumption,” according to the US Fish and Wildlife Service, and a key resource supporting sustainable production of native North American botanicals. AHPA also manages a webpage geared toward supporting industry sustainability efforts.

The nonprofit American Botanical Council (ABC) and the Sustainable Herbs Program have partnered to co-manage a website designed to help herbal businesses and consumers learn about the herbal products value chain and efforts to promote sustainability within the herbal industry. ABC also administers the Botanical Adulterants Prevention Program (BAPP), which provides up-to-date information regarding identity and related quality control issues for diverse herbal raw ingredients, including forest herbs.

Readers are encouraged to explore these and other resources such as the National Agroforestry Center's forest farming resources, university extension programs like North Carolina State's Mountain Horticultural Crops Research and Extension Center and the University of Missouri's Center for Agroforestry, or an agroforestry program at a land grant university or rural land use nongovernmental organization. Herbal customers can also aid efforts by supporting fair trade pricing and purchasing herbal products that use sustainably produced ingredients that are certified under the FGV or FairWild labels.



Without an increase in consumer demand for forest-farmed and guaranteed sustainably harvested products, non-guaranteed and uncertified wild-harvested material will likely continue to be most abundant in the marketplace. However, many consumers are looking for product options that are ecologically sustainable, "fair trade," and organic. These customers are willing to pay more for those types of products.⁷¹⁻⁷⁵ Forest farmers and wild harvesters who are appropriately educated and compensated have more impetus to adjust practices to produce sustainable, better quality raw materials for consumers. Consumers and herbal companies benefit from consistently predictable, high-quality herbal ingredients. Herbal product users can feel good and more confident about what they purchase, while companies have an opportunity to be leaders in sustainability and build consumer trust and confidence in their brand.

The bottom line is that herbs are a discretionary consumer product in the first world. People have choices and vote with their wallets. If customers and companies invest in sustainable, traceable value chains such as the forest farming model, these choices will support not only their own health, but also a healthier environment and the wellbeing of the people and communities at the source. What brighter future could be imagined? HG

Holly K. Chittum, MS, is project scientist for the American Herbal Products Association, an herbalist, and a PhD student in the Department of Ecosystem Science and Management at Penn State University. Her research focuses on global supply chain dynamics and sustainability of forest botanicals. She is interested in increasing understanding and awareness of the complex intersection of ecosystem health, human welfare, and responsible commerce in the herbal industry and creating tools for positive social change toward a more resilient and sustainable future. Chittum is a founding partner and previous co-director of the Appalachian Beginning Forest Farmer Coalition. She holds an MS degree from Maryland University of Integrative Health (MUIH), receiving the MUIH President's Award for her research on American ginseng production methods and effects on marketability and buyer preferences/perceptions for the herb in the United States and China.

Eric P. Burkhart, PhD, is a botanist who specializes in ethnobotany, non-timber forest products, and plant conservation in his teaching, research, and educational outreach endeavors. He holds degrees in ethnobotany (BA, Idaho State University), horticulture (MS, Penn State University), and forest resources (PhD, Penn State University) and is currently the program director of the Appalachian Botany



Bethroot *Trillium erectum*
Photo ©2019 Eric Burkhart

and Ethnobotany program for Shaver's Creek Environmental Center and a faculty instructor in the Penn State Department of Ecosystem Science and Management. His research program in Pennsylvania is focused on developing sustainable wild stewardship and agroforestry production systems for specialty forest products, including American ginseng, goldenseal, and ramps.

John F. Munsell, PhD, received his PhD from the State University of New York and is an associate professor at Virginia Tech. He has authored more than 40 peer-reviewed publications and raised more than \$2.5 million to work with communities from Appalachia to Cameroon on agroforestry and sustainable forestry projects. Munsell is a past president of the Association for Temperate Agroforestry, associate editor of the journal Agroforestry Systems, and co-author of The Community Food Forest Handbook (Chelsea Green, 2018). He is also a past winner of the Outreach and Education Award from the Association for Temperate Agroforestry for extraordinary accomplishments in the field of agroforestry engagement.

Steven D. Kruger, PhD, earned a PhD in forestry from Virginia Tech in 2018. He used surveys and qualitative interviews to study Appalachian non-timber forest products, particularly the trade in native medicinal plants. He created RootReport, a program that publishes data on production for a number of Appalachian medicinal plants. He is currently a postdoctoral associate at Virginia Tech, continuing his research and working on agroforestry projects and public engagement at the Catawba Sustainability Center. Prior to coming to Virginia Tech, Kruger he was a public folklorist studying traditional art, music, craft, and occupations, particularly in Appalachia. He is interested in how to include traditional practices and user groups within sustainable agriculture and forestry.

References

1. Smith T, Gillespie M, Eckl V, Knepper J, Reynolds CM. Herbal Supplement Sales in US Increase by 9.4% in 2018. *HerbalGram*. 2019;123:62-73.
2. Burkhart EP, Jacobson MG. Transitioning from wild collection to forest cultivation of indigenous medicinal forest plants in eastern North America is constrained by lack of profitability. *Agroforestry Systems*. 2009;76(2):437-453.
3. Barton BS. *Collection for an Essay towards a Materia Medica of the United States*. Philadelphia, PA: Way & Groff; 1804.
4. Rafinesque CS. *Medical Flora or Manual of the Botany of the United States*. Philadelphia, PA: Atkinson & Alexander; 1828.
5. Persons S. *American Ginseng, Green Gold: A Grower's Guide, Including Ginseng's History and Use*. Asheville, NC: Bright Mountain Books Inc.; 1986.
6. Moerman DE. *Native American Ethnobotany*. Portland, Oregon: Timber Press; 1998.
7. Foster S. Black Cohosh: A Literature Review. *HerbalGram*. 1999;45:35-50. Available at: <http://cms.herbalgram.org/herbalgram/issue45/article2659.html>. Accessed July 29, 2019.
8. Hou J, Jin Y. *The Healing Power of Chinese Herbs and Medicinal Recipes*. Binghamton, NY: The Haworth Integrative Healing Press; 2005.
9. Fulder S. *The Root of Being: Ginseng and the Pharmacology of Harmony*. Essex, UK: The Anchor Press Ltd.; 1980.
10. Manget L. Nature's emporium: The botanical drug trade and the commons tradition in southern Appalachia, 1847-1917. *Environmental History*. 2016;21(4):660-687.



11. Hufford M. Coal River Folklife Project Collection (AFC 1999/008). American Folklife Center, Library of Congress.
12. Newfont K. *Blue Ridge Commons: Environmental Activism and Forest History in Western North Carolina*. Atlanta, GA: University of Georgia Press; 2012.
13. Boettner F, Vanderburg M, Donahue C, et al. 2014. An assessment of natural assets in the Appalachian region: forest resources. A report prepared for the Appalachian Regional Commission. Washington, DC.
14. Smith T, Kawa K, Eckl V, Morton C, Stredney R. Herbal Supplement Sales in US Increase 7.7% in 2016. *HerbalGram*. 2017;115.
15. Vaughan RC, JF Munsell, JL Chamberlain. Opportunities for enhancing non-timber forest products management in the United States. *Journal of Forestry*. 2013;111(1):26-33.
16. American Herbal Products Association. Tonnage surveys of select North American wild-harvested plants, 2006-2010. Silver Spring, MD: American Herbal Products Association; 2010.
17. Kruger SD. Measuring Medicinal Non-timber Forest Product Output in Eastern Deciduous Forests. PhD dissertation. Blacksburg, VA: Virginia Tech; 2019.
18. Pollard K, Jacobsen L. The Appalachian region: a data overview from the 2012-2016 American Community Survey. Report prepared for the Appalachian Regional Commission. March 2018.
19. Bailey B. Social and economic impacts of wild harvested products. PhD dissertation, Forest Resource Science. Morgantown, WV: West Virginia University; 1999.
20. Trozzo K, Munsell J, Niewolny K, Chamberlain J. Forest Food and Medicine in Contemporary Appalachia. *Southeastern Geographer*. 2019;59:52-76. doi: 10.1353/sgo.2019.0005.
21. Jacobs H. Here's why the opioid epidemic is so bad in West Virginia — the state with the highest overdose rate in the US. Business Insider. May 1, 2016. Available at: www.businessinsider.com/why-the-opioid-epidemic-is-so-bad-in-west-virginia-2016-4. Accessed October 17, 2019.
22. Achenback J, Koh J, Bennett D, Mara M. Flooded with opioids, Appalachia is still trying to recover. *The Washington Post*. July 24, 2019. Available at: www.washingtonpost.com/health/flooded-with-opioids-appalachia-is-still-trying-to-recover/2019/07/24/26607328-ad4a-11e9-a0c9-6d2d7818f3da_story.html. Accessed October 17, 2019.
23. Baublitz S. Ginseng season returns to the Mountain State Sept. 1, officials say. WVNews. September 1, 2019. Available at: www.wvnews.com/news/wvnews/ginseng-season-returns-to-the-mountain-state-sept-officials-say/article_8641ab5c-884f-56c6-8b5b-9795edc06993.html. Accessed October 17, 2019.
24. Maher K. Demand for ginseng boosts prices, tempts poachers. *The Wall Street Journal*. September 17, 2014. Available at: www.wsj.com/articles/demand-for-ginseng-boosts-prices-tempts-poachers-1410971637. Accessed October 17, 2019.
25. Tesauro J. One of the world's most famous chefs wants to help you forage for your food. *The Washington Post*. June 29, 2017. Available at: www.washingtonpost.com/lifestyle/food/one-of-the-worlds-most-famous-chefs-wants-to-help-you-forage-for-your-food/2017/06/29/b59a1d34-5ceb-11e7-9fc6-c7ef4bc58d13_story.html. Accessed October 17, 2019.
26. Thomson J. What are ramps, anyway? And why do food lovers freak out over them? HuffPost. December 7, 2017. Available at: www.huffpost.com/entry/what-are-ramps_n_7128438. Accessed October 17, 2019.
27. Kronthal-Sacco R, Whelan S. Actually, Consumers Do Buy Sustainable Products. Sustainable Share Index. 2019. Available at: www.stern.nyu.edu/sites/default/files/assets/documents/NYU%20Stern%20CSB%20Sustainable%20Share%20Index%202019.pdf. Accessed October 17, 2019.
28. Natural Marketing Institute. 2019. Dietary Supplements/OTC/Rx Trends US and Global Databases. Harleysville, PA.
29. United Nations General Assembly. Report of the world commission on environment and development: Our common future. Oslo, Norway: United Nations General Assembly, Development and International Co-operation: Environment; 1987.
30. Medicinal Plant Specialist Group: Species Survival Commission. *International Standard for Sustainable Wild Collection of Medicinal and Aromatic Plants (ISSC-MAP)*. Version 1.0. Bonn, Germany: Bundesamt für Naturschutz; 2007. Available at: www.bfn.de/fileadmin/MDB/documents/service/skript195.pdf. Accessed October 17, 2019.
31. Rodale Institute. Regenerative Organic Agriculture and Climate Change. 2014. Available at: <https://rodaleinstitute.org/assets/WhitePaper.pdf>. Accessed May 22, 2018.
32. Elkington J. Triple bottom-line reporting: Looking for balance. *Australian CPA*. 1999;69(2):18-21.
33. Tschopp DJ. Corporate Social Responsibility: A Comparison Between the United States and the European Union. *Corporate Social Responsibility and Environmental Management*. 2005;12:55-59.
34. Dahl R. Green Washing: Do you know what you're buying? *Environmental Health Perspectives*. 2010;118(6):246-252. doi: 10.1289/ehp.118-a24620515714.
35. Munsell JF, Ares A, Barrett SM, Bond BH, Gagnon JL. Forest certification perspectives in the wood products supply chain in Virginia, USA. *Forests*. 2017;8(10):364.
36. Smith T, Kawa K, Eckl V, Morton C, Stredney R. Herbal Supplement Sales in US Increased 8.5% in 2017, Topping \$8 Billion. *HerbalGram*. 2018;119:62-71.
37. Gafner S. Black Cohosh Botanical Adulterants Bulletin. ABC-AHP-NCNPR Botanical Adulterants Prevention Program website. Available at: http://cms.herbalgram.org/BAP/pdf/BAP-BABs-BlackCohosh-FINAL_copy1.pdf. Accessed October 17, 2019.
38. Ali Z, Khan SI, Farreira D, Khan IA. Podocarpaside, a triterpenoid possessing a new backbone from *Actaea podocarpa*. *Organic Letters*. 2006;8(24):5529-5532.
39. National Center for Complementary and Alternative Medicine, Office of Dietary Supplements. Workshop on the safety of black cohosh in clinical studies. 2004.
40. Gardner Z, McGuffin M, eds. *American Herbal Products Association's Botanical Safety Handbook*. 2nd ed. Boca Raton, FL: CRC Press; 2013.
41. Teschke R, Schwarzenboeck A, Schmidt-Taenzer W, Wolff A, Hennermann KH. Herb induced liver injury presumably caused by black cohosh: a survey of initially purported cases and herbal quality specifications. *Ann Hepatol*. 2011;10:249-59.
42. Braun L, Cohen M. *Herbs and Natural Supplements: An Evidence-based Guide*. 3rd ed. Chatswood, Australia: Elsevier; 2010.
43. Oliver L. *Hydrastis canadensis*. The IUCN Red List of Threatened Species 2017: e.T44340011A44340071. Available at: <http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T44340011A44340071.en>. Accessed October 2, 2019.

44. Zuiderveen GH. Goldenseal (*Hydrastis canadensis* L.) phytochemistry, trade and habitat: implications for conservation and forest-based cultivation. PhD dissertation (Forest Resources). University Park, PA: Pennsylvania State University; 2019.
45. Burkhart EP, Zuiderveen GH. Wild goldenseal (*Hydrastis canadensis* L.) root alkaloid content in relation to colony and harvest stage. *Journal of Herbs, Spices, and Medicinal Plants*. 2019;25(2):128-140.
46. Salmore AK, Hunter MD. Elevational trends in defense chemistry, vegetation, and reproduction in *Sanguinaria canadensis*. *J Chem Ecol*. 2001;27(9):1713-1727.
47. Zheljazkov VD, Jones AM, Avula B, Maddox V, Rowe DE. Lignan and nutrient concentrations in American mayapple (*Podophyllum peltatum* L.) in the eastern United States. *Hort Science*. 2009;44(2):349-353.
48. Bittner M, Schenk R, Springer A, Melzig MF. Profiles of phenolic acids and triterpene glycosides in commercial and cultivated black cohosh. *Planta Medica*. 2019. doi: 10.1055/a-0981-4287.
49. Hongqiang L, Zhu H, Tan J, et al. Non-targeted metabolomic analysis of methanolic extracts of wild-simulated and field-grown American ginseng. *Molecules*. 2019;24(1053).
50. Lim W, Mudge KW, Vermeylen F. Effects of population, age, and cultivation methods on ginsenoside content of wild American ginseng (*Panax quinquefolium*). *J Agr Food Chem*. 2005;53:8498-8505.
51. Upton R. *American Ginseng Root (Panax quinquefolius L.): Standards of Analysis, Quality Control and Therapeutics*. Scotts Valley, CA: American Herbal Pharmacopoeia; 2012.
52. Guo YP, Bailey WG, van Dalzen KB. North American ginseng (*Panax quinquefolium* L.) root grading. In: Bailey WG, Whitehead C, Proctor JTA, Kyle JT, eds. *Proceedings of the International Ginseng Conference - Vancouver 1994*; 1995:380-389.
53. Robbins CS. Comparative analysis of management regimes and medicinal plant trade monitoring mechanisms for American ginseng and goldenseal. *Conservation Biology*. 2000;14:1422-1434.
54. Chamberlain JL, Mitchell D, Brigham T, Hobby T. Forest Farming Practices. In: Garrett HE, ed. *North American Agroforestry: An Integrated Science and Practice*. 2nd ed. Madison, WI: American Society of Agronomy; 2009.
55. Burkhart EP, Zuiderveen GH, Pugh CV, Nilson S. Neither wild nor cultivated: Wild American ginseng (*Panax quinquefolius* L.) trade surveys provide insights into husbandry of an internationally traded non-timber forest product. Manuscript submitted and in peer-review.
56. Davis J, Persons WS. *Growing and Marketing Ginseng, Goldenseal, and Other Woodland Medicinals*. Gabriola Island, BC: New Society Publishers; 2014.
57. Hill S, Hausbeck M. Evaluation of TOM-CAST in timing fungicide sprays for management of *Alternaria* blight on American ginseng. The American Phytopathological Society. 2008;92(12).
58. Wang Z, Linfang H. *Panax quinquefolius*: An overview of the contaminants. *Phytochemistry Letters*. 2015;11:89-94.
59. Durnat J, Heuser J, Andrey D, Perrin C. Quality and safety assessment of ginseng extracts by determination of the contents of pesticides and metals. *Food Additives & Contaminants*. 2005;22(12):1224-1230. doi: 10.1080/02652030500199439.
60. Searels JM, Keen KD, Horton JL, Clarke HD, Ward JR. Comparing ginsenoside production in leaves and roots of wild American ginseng (*Panax quinquefolius*). *American Journal of Plant Sciences*. 2013;4:1252-1259.
61. Gafner S, Baggett S. Adulteration of Saw Palmetto (*Serenoa repens*). Austin, TX: ABC-AHP-NCNPR Botanical Adulterants Prevention Program; 2017. Available at: <http://cms.herb-algram.org/BAP/pdf/BAP-BABs-SawPalmetto-CC-102018-v2.pdf>. Accessed July 29, 2019.
62. Tims M. Adulteration of *Hydrastis canadensis* root and rhizome. Austin, TX: ABC-AHP-NCNPR Botanical Adulterants Prevention Program; 2016. Available at: <http://cms.herb-algram.org/BAP/pdf/BAP-BABs-Goldenseal-v4.pdf>. Accessed July 29, 2019.
63. Vaughan RC, Munsell JF, Chamberlain JL. Opportunities for enhancing non-timber forest products management in the United States. *Journal of Forestry*. 2013;111(1):26-33.
64. OMAFRA. 2018. Cost of Production of Ginseng in Ontario. Ontario Ministry of Agriculture, Food and Rural Affairs website. Available at: www.omafra.gov.on.ca/english/crops/facts/gincop.htm. Accessed July 29, 2019.
65. Forest farming. United States Department of Agriculture National Agroforestry Center website. Available at: www.fs.usda.gov/nac/practices/forest-farming.php. Accessed July 29, 2019.
66. Gold MA, Garrett HE. Agroforestry nomenclature, concepts, and practices. In: Garrett HE, ed. *North American Agroforestry: An Integrated Science and Practice*, 2nd ed. Madison, WI: American Society of Agronomy; 2009:45-55.
67. Garrett HEG. Agroforestry: An integrated land-use management system for production and farmland conservation. US Department of Agriculture Soil Conservation Service Report 68-3A7S-3-1341. Fort Collins, CO: USDA-SCS; 1997.
68. Anderson MK. *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources*. Berkeley, CA: University of California Press; 2005.
69. Hannum, H. (2017) Inspirations for Creating a Long-Term Agricultural Lease for Agroforestry: A Workbook. USDA National Agroforestry Center, Savanna Institute, and Farm Commons collaboration. Available at: www.fs.usda.gov/nac/assets/documents/morepublications/longterm-lease-workbook-book.pdf. Accessed October 17, 2019.
70. Appalachian Land Ownership Task Force. *Who Owns Appalachia? Landownership and its Impact*. Lexington, KY: University of Kentucky Press; 2005.
71. Verteramo Chlu LJ, Liaukonyte J, Gomez MI, Kaiser HM. Socially Responsible Products: what motivates consumers to pay a premium? *Applied Economics*. 2017;49(19).
72. Hainmueller J, Hiscox MJ, Sequeira S. Consumer Demand for the FairTrade Label: Evidence from a Multi-Store Field Experiment. *Review of Economics and Statistics*. 2014;97(2).
73. Konuk F. Consumers' willingness to buy and willingness to pay for fair trade food: The influence of consciousness for fair consumption, environmental concern, trust and innovativeness. *Food Research International*. 2019;120:141-147.
74. Pelssmacker P, Driesen L, Ray G. Do Consumers Care about Ethics? Willingness to Pay for Fair-Trade Coffee. *Journal of Consumer Affairs*. 2005;39(2).
75. Didier T, Lucie S. Measuring consumers' willingness to pay for organic and fair trade products. *International Journal of Consumer Studies*. 2008;32(5).