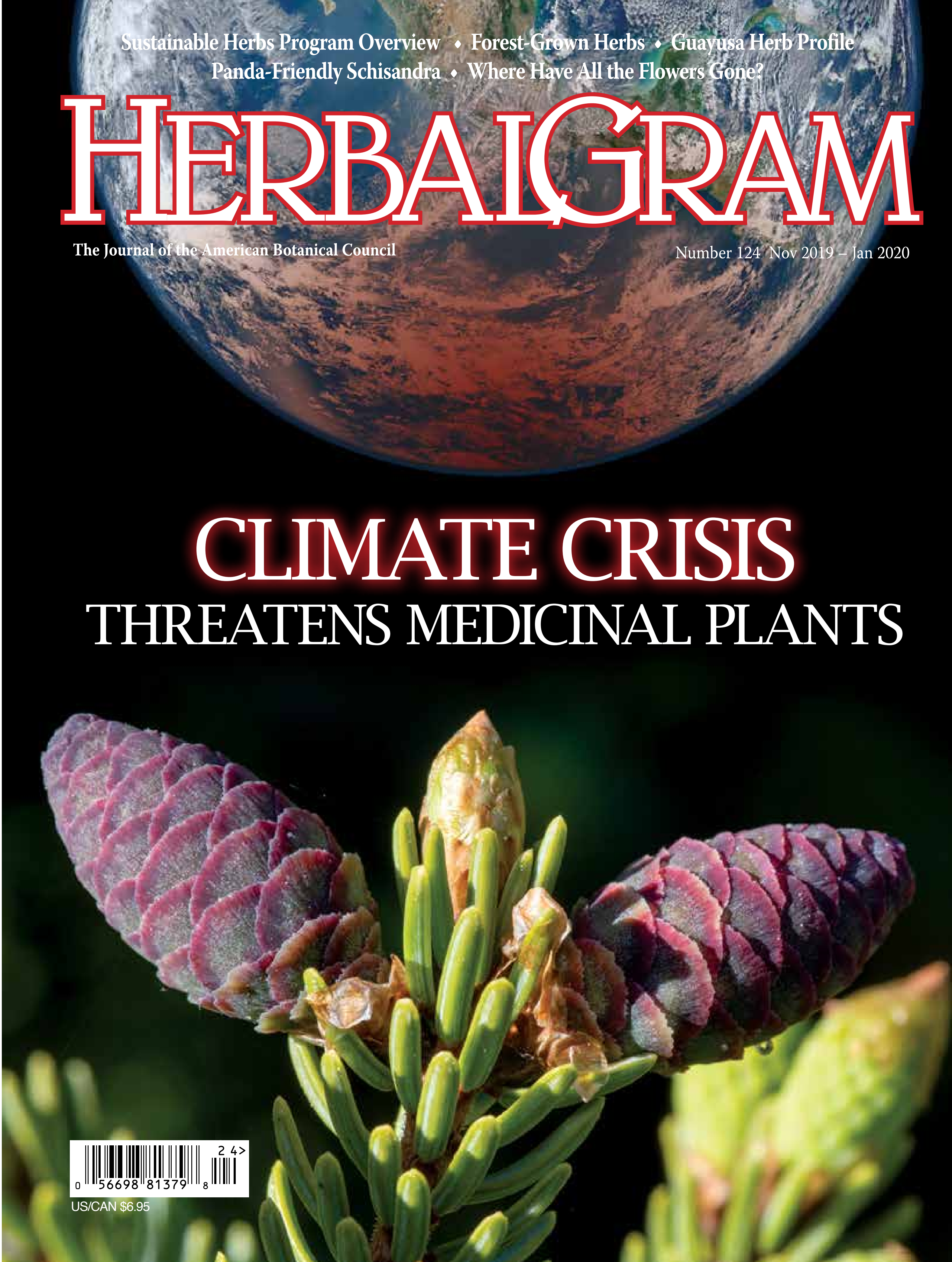
HerbalGram 124 • Nov 2019 – Jan 2020 Climate Crisis Threatens Medicinal Plants • Forest-Grown Herbs • Guayusa Herb Profile • Panda-Friendly Schisandra • Sustainable Herbs Program Overview • Where Have All the Flowers Gone? www.herbalgram.org

Sustainable Herbs Program Overview • Forest-Grown Herbs • Guayusa Herb Profile
Panda-Friendly Schisandra • Where Have All the Flowers Gone?

HerbalGram

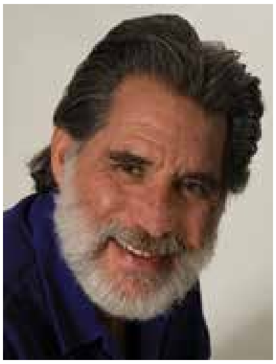
The Journal of the American Botanical Council

Number 124 Nov 2019 – Jan 2020



CLIMATE CRISIS THREATENS MEDICINAL PLANTS

US/CAN $6.95



dear *reader*

This is a special issue on the impacts of climate change — what many are now referring to as the "climate crisis" — on medicinal and aromatic plants (MAPs). Like many concerned citizens, including scientists, policy makers, and others, we are alarmed by the evidence of increasingly overwhelming changes in the Earth's climate, much of which is attributable to human activity. These changes include, but are not limited to, increasing temperatures, the melting of polar ice caps and glaciers, rising sea levels, changes in weather patterns, and much more. We are now facing an existential threat to not only plants and animals, but much, or perhaps almost all, of the biosphere itself.

This is not the first time we have addressed these concerns. In 2009, in *HerbalGram* issue 81, we published a cover article by then-Managing Editor Courtney Cavaliere on the impact of climate change on medicinal plants. To our knowledge, that was the first comprehensive, peer-reviewed article on this subject. Now, 10 years later, *HerbalGram* Assistant Editor Connor Yearsley, Associate Editor Hannah Bauman, and Managing Editor Tyler Smith have written an in-depth update that highlights new evidence of the impacts of a changing climate on MAPs. Significant effects on plants, including phenological changes, shifting ranges, and reduced populations, have been documented in regions around the world, from the Arctic and alpine areas to tropical forests and islands. This extensive article is one of the key features in this thematic issue.

In fact, we have dedicated almost the entire issue to this theme, including matters of conservation, sustainability, and regeneration. We have reduced or eliminated some of our usual departments in order to make more room for our coverage of these important topics.

This issue's other feature article deals with the theme of wild North American medicinal forest plants. Holly Chittum, MS, an expert on this subject, and co-authors Eric Burkhart, PhD, John Munsell, PhD, and Steven Kruger, PhD, provide an in-depth view of the benefits and challenges related to forest-grown medicinal botanicals. North American forest herbs have been a part of global trade since the 17th century, and their increased popularity in recent years has led to sustainability concerns. Responsible forest farming may help ensure a sustainable supply of these botanicals.

In November 2018, we announced that ABC had partnered with Ann Armbrecht, PhD, to form the Sustainable Herbs Program (SHP), a new educational initiative under ABC's aegis. Ann, who has a doctorate in anthropology from Harvard, created the Sustainable Herbs Project before joining with ABC. (For various reasons, we believed that "Program" was a more apt name for this new venture.) In the ensuing year, Ann, along with ABC trustee and acclaimed medicinal plant author and photographer Steven Foster, members of the ABC staff, and others, helped produce new videos and articles for the SHP website, newsletter, and blog.

SHP's mission deals not only with ecological issues related to the climate crisis and the need for medicinal plant conservation and sustainable/regenerative practices, but also the lives and welfare of the people involved in all aspects of botanical value networks (supply chains), including harvesting, cultivation, processing, and production of medicinal plants and their value-added finished products. SHP is deeply anthropocentric, with the hope that increased industry and consumer attention to these issues will result in enhanced revenues and quality of life for people in the value network.

Part of the input for SHP comes from a group of 17 highly experienced individuals who form what we are calling the SHP Advisory Group. This issue presents brief biographies of the inaugural members, each of whom has considerable expertise in sourcing, conservation, and/or sustainability of medicinal plants. A tip of the hat as well to the SHP Inaugural Underwriters: herb industry members that were the first to provide financial resources to allow ABC to take on and steward SHP and its compelling agenda.

One of the initial members of the SHP Advisory Group is our good friend and collaborator Josef Brinckmann, also a longtime member of the ABC Advisory Board, who has written a guest editorial titled "Where Have All the Flowers Gone?," after folksinger Pete Seeger's classic song, on the climate crisis and its relevance to MAPs and our lives in general. We are profoundly grateful to Josef for his many contributions to this issue, also including the herb profile on guayusa that he and collaborator Thomas Brendler provided. HG

ABC Advisory Board

Each issue of *HerbalGram* is peer reviewed by members of the ABC Advisory Board and other qualified experts before publication.

HerbalGram The Journal of the American Botanical Council

Bloodroot *Sanguinaria canadensis*
Photo ©2019 Eric Burkhart

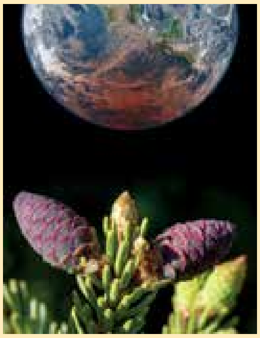
By Hannah Bauman, Tyler Smith, and Connor Yearsley

Increasing atmospheric carbon dioxide levels, warming Arctic temperatures, and earlier springs: The signs of a climate crisis continue to grow, and the projected effects on medicinal and aromatic plants could be severe. This article, a 10-year update of the cover story of *HerbalGram* issue 81, explores findings from the past decade of research on climate change and its effects on global plant life. The future is uncertain, but since climate change has been labeled the third-biggest driver of "change in nature," its effects could be significantly detrimental to people who rely on these plants. Now, more than ever, reversing the warming trend around the world and identifying conservation priorities are vital for the protection of plants and people.

By Holly K. Chittum, MS, Eric P. Burkhart, PhD, John F. Munsell, PhD, and Steven D. Kruger, PhD

Plants grown in forest understories in the eastern United States have been a part of global trade since the late 17th century, and they have been a vital source of food, medicine, and income for inhabitants of this region for generations. Medicinal forest plants remain an important part of the modern herbal supplement industry. As many as 50 forest herbs grown in Appalachia are traded currently, and the global supply of many of these botanicals comes entirely from wild harvesting. Increased demand coupled with unsustainable harvesting practices and limited traceability in the informal forest herb supply chain have necessitated responsible, intentional cultivation and management methods. Forest farming, the authors propose, is one potential solution that can help increase traceability and ensure fair labor compensation and a sustainable, high-quality supply for consumers.

departments



On the Cover
Spruce pine *Picea mariana*
Photo ©2019 Steven Foster

Contributors

Ann Armbrecht, PhD
Thomas Brendler
Josef Brinckmann
Eric P. Burkhart, PhD
Holly K. Chittum, MS
Mariann Garner-Wizard
Shari Henson
Steven D. Kruger, PhD
John F. Munsell, PhD
Heather S. Oliff, PhD
Samaara Robbins

Published by the American Botanical Council, P.O. Box 144345, Austin, TX 78714-4345.

Subscriptions to *HerbalGram* are a benefit of ABC membership at every level. One-year memberships: Individual $50; Academic $100; Professional $150; Organization $300; Retailer $250; HerbClip Service $690; Small Business; Sponsor. Add $20 for memberships outside of the U.S. Student and Senior discounts are available. For information about Small Business or Sponsor Memberships, contact Denise Meikel at denise@herbalgram.org or 512-926-4900.

***HerbalGram*® is printed on recycled paper at Craftsman Printers, Inc. Lubbock, Texas**

Guayusa

Ilex guayusa

Family: Aquifoliaceae

By Josef Brinckmann and Thomas Brendler

INTRODUCTION

Ilex guayusa is one of the 500 to 600 *Ilex* species[1] and belongs to the holly family (Aquifoliaceae) of shrubs and trees, which includes only two genera (*Ilex* and *Nemopanthus*).[2] While the taxonomic status of *Nemopanthus* species remains accepted by some authors, others now consider *Nemopanthus* species to be members of the genus *Ilex*.[3] *Ilex* species are distributed in tropical and subtropical to temperate regions, mainly in tropical Central and South America but also Asia.[2] The perennial *I. guayusa* tree, native to Bolivia, Colombia, Ecuador, Peru, and Venezuela,[4] is dioecious (male and female flowers occur on separate plants) and reaches about 10 m (32.8 ft) when cultivated and up to 25 m (82 ft) when unmanaged or wild.[5] Other authors give a range of 6-30 m (19.7-98.4 ft). Guayusa is fast-growing, and commercial harvesting of the leaves may commence about one year after planting, with increasing annual yields until leveling off with tree maturity at around five years.[6]

Domesticated in the pre-Columbian era, guayusa is now grown in traditional agroforestry systems by indigenous farmers of the western Amazon region. In recent years, scaled-up production of certified organic and fair trade guayusa leaf has linked some indigenous farmers in the Ecuadorian Amazon to a global market for sustainable herbs, helping to conserve biodiversity (prevent forest clearing) and improve traditional economies in rural and remote indigenous communities.[6] Emerging evidence suggests that traditional agroforestry systems support climate change adaptation because they enable measurably higher levels of carbon sequestration and tree diversity compared to other forms of cultivation.[7]

HISTORY AND CULTURAL SIGNIFICANCE

Ilex guayusa is known as *waysa*[7] or *guayusa* in Kichwa, a dialect of the Quechua language group, the latter also used by Spanish speakers,[8] and as *waís* in the Shuar language in Ecuador.[9] A standard common name for this species is not provided in the American Herbal Products Association's *Herbs of Commerce*, 2nd edition.[10] In his 1737 work *Genera Plantarum*, Swedish botanist Carl Linnaeus (1707-1778) assigned the genus name *Ilex*,[11] which was already the Latin name for the Mediterranean holly oak (*Quercus ilex*, Fagaceae), probably due to the similar glossy leaves.[12] German botanist Ludwig Eduard Theodor Loesener (1865-1941) assigned the Kichwa name guayusa as the species name, forming the Latin binomial *Ilex guayusa*, in his 1901 publication *Monographia Aquifoliacearum*.[13]

Archaeobotanical evidence suggests that guayusa has been used medicinally and traded since at least 500 BCE in the greater Andes-Amazon region.[5] The contents of a tomb dated to that time, found at Niño Korin in the Bautista Saavedra Province of Bolivia, included pouches of guayusa leaves as well as *Anadenanthera colubrina* (Fabaceae) along with specialized medical equipment (e.g., enema syringes and snuff trays) believed to have belonged to a medicine person of the pre-Incan Kallawaya society of traditional healers, descendants of the Tiwanaku culture.[14] Although cultivation may have begun earlier, evidence suggests that guayusa was grown extensively and processed by at least 350 CE.[15] In 1972, American renowned Harvard University ethnobotanist Richard Evans Schultes, PhD, (1915-2001) reported discovering the vestiges of an ancient guayusa plantation in Putumayo Department of southwestern Colombia, with tall trees that were hundreds of years old.[16]

A 1683 letter from Jesuit priest Juan Lorenzo Lucero to the Viceroy of Peru, Don Melchor de Navarra y Rocafull,

Guayusa *Ilex guayusa*
Photo ©2019 Applied Food Sciences

described the drinking of a decoction of guayusa throughout the day by the indigenous Jivaroan peoples of Ecuador and Peru for the purpose of remaining awake for many nights at times when an enemy invasion was feared.[17] Seventeenth-century Jesuit missionaries planted guayusa in mission gardens and established commercial trade to highland Andean markets, including Quito.[18] According to Schultes, the Jesuits also established a market for guayusa leaf in Europe as a cure for syphilis, among other diseases.[19] With the expulsion of the Jesuits from the Spanish colonies in the 1760s, small-scale cultivation and regional trade were taken over by indigenous peoples, and guayusa is still found today in Ecuadorian village markets.[18] In 1894, anthropologist Charles Dolby Tyler wrote that guayusa, also known as "Napo tea," was the favorite beverage of the Záparo people, who lived along the Napo River in Ecuador. The Záparo drank the tea in the morning as an emetic to rid the stomach of undigested food. Tyler also noted their use of coca (*Erythroxylum coca*, Erythroxylaceae) leaf, which was chewed and mainly taken before long journeys.[20]

Shamans of the indigenous Shuar people in Amazonian Ecuador and Peru include guayusa in hallucinogenic herbal formulations, although it is a stimulant rather than a hallucinogen. For example, guayusa is combined with *Banisteriopsis caapi* (known by the local common name *ayahuasca*) and *Diplopterys cabrerana* (both in the family Malpighiaceae) and prepared as an aqueous decoction.[9] Guayusa tea is also reportedly used by Canelos-Kichwa people before and after drinking ayahuasca tea (i.e., the blend of *Banisteriopsis caapi* and other plants), as it is believed to mitigate the bitter taste of the ayahuasca, prevent hangover, and strengthen the ability to cope with the hallucinogenic effects.[21] As a daily ritual, men of the Jivaroan Achuar community in Ecuador and Peru drink aqueous decoctions of guayusa leaf, called *wayus*, before sunrise, and then vomit, for stimulating effects. Boys are taught how to vomit using a feather or finger, and they join the men in the daily ritual after puberty.[22,23]* A study looking at obstetrical practices of Canelos-Kichwa women living in communities along the Bobonaza River in the Pastaza Province of Ecuador, near the Peruvian border, found that guayusa tea is drunk for the purpose of reducing blood loss during menstruation, with concomitant avoidance of both salt and chili (*Capsicum* spp., Solanaceae) for one to three days. Postpartum, women are also given guayusa tea to drink in order to "prevent blood drying up inside her and thus cause other complications."[24]

In a study of traditional plant usage among the indigenous Kichwa people of Canton Loreto in Ecuador, guayusa was found to be the most used, harvested, and significant plant in daily life.[25] In another recent study that surveyed indigenous Shuar and *mestizos* about traditional ecological knowledge and medicinal plant diversity in Ecuadorian Amazon home gardens, guayusa ranked among the highest in importance. The study asserts that guayusa and other medicinal plants grown in these home gardens are ecosystem service providers that support human well-being, biodiversity conservation, and traditional knowledge in agroecosystems.[26]

CURRENT AUTHORIZED USES IN COSMETICS, FOODS, AND MEDICINES

In the United States, guayusa is marketed as a beverage tea for energy, similar to caffeine-containing leaves of other *Ilex* species such as yerba maté (*I. paraguariensis*) and yaupon (*I. vomitoria*).[27] It may also be used as a component of dietary supplement products, which require notification with the US Food and Drug Administration within 30 days of marketing if a structure-function claim is made.[28] In Canada, guayusa is regulated as a medicinal ingredient of licensed natural health products (NHPs), which require pre-marketing authorization from the Natural and Nonprescription Health Products Directorate (NNHPD).[29] At the time of this writing, two licensed NHPs in Canada list *I. guayusa* as an active ingredient.[30] In the EU, use of

* Although English botanist William Townsend Aiton (1766-1849) assigned the Latin binomial *Ilex vomitoria* to the related North American yaupon,[66] and both guayusa and yaupon have been used traditionally in indigenous vomiting rituals,[67] constituents that could be responsible for emetic action have not been identified in either species.[68]

an extract of the leaves in cosmetic products is authorized specifically for skin-protecting function.[31] However, for oral ingestion, *I. guayusa* is presently classified as an unauthorized novel food in the EU. According to EU regulatory authorities, *I. guayusa* was not used as a food or food ingredient in the EU before May 15, 1997, and, therefore, a premarketing safety assessment under the Novel Food Regulation is required.[32]

MODERN RESEARCH

Largely seen as a stimulant traditional beverage among indigenous communities,[9,16,17,22] with some medicinal uses therein (e.g., to avoid postpartum complications; as a tonic, diuretic, flu remedy, mouth wash, and insect repellent; for dysmenorrhea, diabetes, venereal diseases, and weight loss[5,24,26,33-35]), guayusa only recently attracted interest from the research community for its health benefits. Published research on its actions and effects remains limited. Many recent academic theses investigating medicinal and cosmetic applications of guayusa[36-42] indicate new interest, likely also stimulated by international commercialization and regulatory requirements.[35,43,44] There are no known human clinical trial publications to date.

Plants in the genus *Ilex* are known to contain a significant number of secondary metabolites, such as xanthines, chlorogenic acid derivatives, flavonoids, and triterpenoids.[33,34,45,46] Wise and Santander (2018) provide a comprehensive summary of the composition of dried guayusa leaves, including total and free amino acids, chemical elements, nutritional values, and caffeine content.[47] Earlier research addressing the composition of guayusa focused on its high caffeine content (e.g., Lewis et al., 1991).[22] More recently, triterpenoids in guayusa leaf, specifically ursolic acid, have gained attention due to their antihyperglycemic, antibacterial, and antiparasitic effects.[33-35]

Ursolic acid is a known activator of the G protein-coupled bile acid receptor 1 (GPBAR1), which is involved in energy homeostasis, bile acid homeostasis, glucose metabolism, inflammatory response, cancer progression, and liver regeneration, giving guayusa a potential role in the management of diabetes and metabolic syndrome. Swanston-Flatt et al. (1989, 1991)[48,49] showed that guayusa had a hypoglycemic effect in normal mice and in mice with streptozotocin-induced diabetes. In addition, guayusa reduced hyperphagia (increased appetite), polydipsia (excessive thirst), body weight loss, and glycated hemoglobin. These results were confirmed by Stoyell-Conti et al. (2018),[50] who showed positive effects on metabolic, cardiovascular, and oxidative stress in mice with streptozotocin-induced diabetes. Espinosa Soto et al. (2015)[51] reported the presence of ursolic acid, which was confirmed by Chianese et al. (2019),[52] who determined a similar triterpenoid profile for *I. guayusa* and *I. paraguariensis*, as well as the presence of amyrin esters. They characterized amyrin palmitate, palmitoleate, and corresponding isomers as the primary constituents of the amyrin complex from both plants.

García-Ruiz et al. (2017)[53] identified a total of 14 phenolic compounds and five carotenoids in guayusa leaf, and further showed high antioxidant capacity for blanched and untreated leaves. This antioxidant capacity was much reduced during fermentation. Pardau et al. (2017)[54] demonstrated protection from oxidative stress in the Caco-2 cellular antioxidant assay and anti-inflammatory activity in lipopolysaccharide-stimulated RAW 264.7 cells, and these effects were attributed to the phenolic mono- and dicaffeoylquinic acid derivatives in guayusa leaves. Cadena-Carrera et al. (2019)[55] studied the biological activities of guayusa leaf extracts using supercritical CO_2 as the solvent and ethanol as the co-solvent and showed antifungal activity against *Trichophyton rubrum*, *T. mentagrophytes*, *Microsporum gypseum*, and *M. canis*. Caffeine, squalene, and α-amyrin were the main compounds found; antioxidant activity varied with extraction technique, solvent, and conditions (e.g., pressure, temperature). Gamboa et al. (2018)[56] demonstrated an antimicrobial effect for an ethanolic extract of guayusa leaves, inhibiting *Porphyromonas gingivalis*, *Prevotella intermedia*, and *Fusobacterium nucleatum*, bacteria implicated in chronic periodontitis. Both Tuquinga Usca (2013)[57] and Contero et al. (2015)[58] reported an estrogenic effect of guayusa in albino rats, both in terms of significantly increased estradiol levels and weight of reproductive organs.

Sequeda-Castañeda et al. (2016)[33] summarized a number of investigations of the safety of guayusa preparations and attest an excellent safety profile. No signs of hepatotoxicity were found in an in vivo hepatotoxicity model using Wistar rats. No acute toxicity was shown at 1,000, 500, 250, and 125 mg/kg ethanol extract in animals. Repeat doses were also found to be safe. Due to the high caffeine content, however, large quantities can affect the nervous system. Bussmann et al. (2011)[59] demonstrated a LC_{50} > 10,000 µg/mL for an aqueous extract and 300 µg/mL for an ethanol extract of guayusa leaves in the brine shrimp lethality assay. Kapp et al. (2016)[60] found guayusa concentrate to be negative in in vitro genotoxicity tests, including the Ames test and a chromosome aberration study in human lymphocytes. This confirmed previous results finding an LD_{50} > 5,000 mg/kg for female rats. A 90-day sub-chronic study at 1,200, 2,500, and 5,000 mg/kg/d of guayusa concentrate administered to male and female rats found effects comparable to those of caffeine, including weight loss, reductions in food efficiency and triglycerides values, increases in serum alanine aminotransferase, serum aspartate aminotransferase, and cholesterol, as well as adaptive salivary gland hypertrophy. Overall, no harmful effects specific to guayusa or its components were observed in any of the tested models.


Tea being made from guayusa (*Ilex guayusa*)
Photo ©2019 Applied Food Sciences

ADULTERATION

Although adulteration with other related plants, such as yerba maté, is conceivable, adulteration of guaysa products is, so far, not known to occur. While there is a *European Pharmacopoeia* monograph for testing of yerba maté (Mate Folium PhEur 10.0),[61] which provides macroscopic, microscopic, thin-layer-chromatography (TLC), and high-performance-liquid-chromatography (HPLC) tests for confirming composition, identity, quality, and strength, no known monographs are available for guayusa or yaupon that provide identification methods for differentiating or ruling out admixing among the three related species.

SUSTAINABILITY AND FUTURE OUTLOOK

The International Union for Conservation of Nature (IUCN) assigns wild *I. guayusa* to the conservation category of least concern (LC), meaning that the species is not considered to be threatened. According to the 2019 IUCN report, "this species has a very wide distribution, large population, is not currently experiencing any major threats, and no significant future threats have been identified."[4]

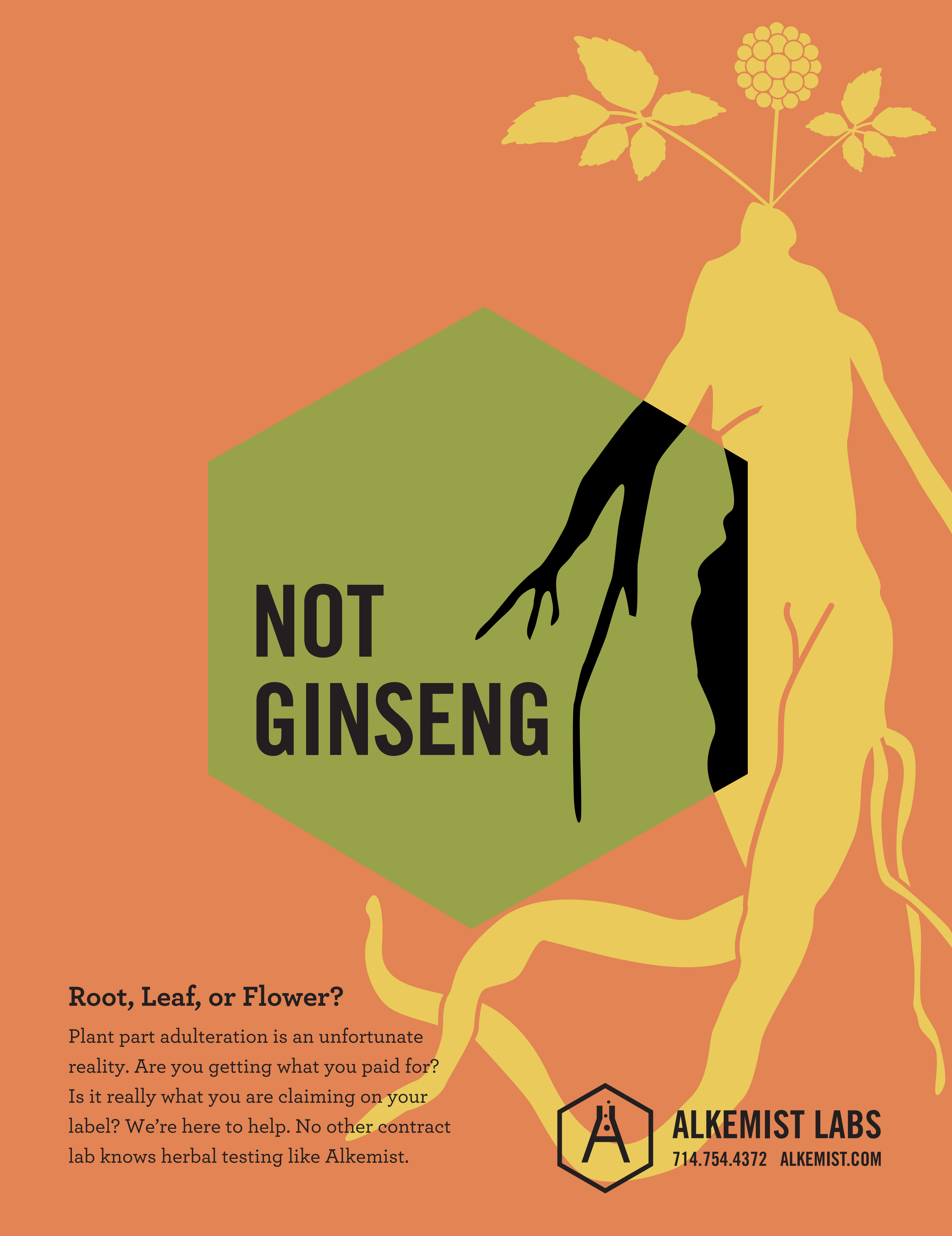
In 2009, the company RUNA (Brooklyn, New York) began to commercialize guayusa in Ecuador and, by 2017, had 477 hectares of cultivation area under US Department of Agriculture (USDA) National Organic Program (NOP) certification.[6] Today, NOP-certified guayusa operations in Ecuador include Asociación de Caficultores el Pangui, Fundación Chankuap "Recursos Para el Futuro," Greenmattersecuador CIA LTDA, Jumandipro S.A., Productos SKS Farms CIA LTDA, Rareeats S.A., Runatarpuna Exportadora S.A., and Tryskelwork Soluciones S.A.[62] One of these organic guayusa operations has also achieved economic and social sustainability certification through implementation of the Fair Trade USA standards: Runatarpuna Exportadora S.A. (Quito, Pichincha, Ecuador), which exports organic- and fair trade-certified guayusa to their North American counterpart, RUNA. Runatarpuna's guayusa farmers are situated primarily in Napo Province in the Ecuadorian Amazonian rainforest, and cultivate it within a multi-crop traditional agroforestry system along with cacao (*Theobroma cacao*, Malvaceae), coffee (*Coffea arabica*, Rubiaceae), and yuca (*Manihot esculenta*, Euphorbiaceae).[63] As opposed to mono-cropping, these traditional agroforestry practices are believed to mitigate some of the local effects of climate change and increase food security for smallholder farmers.[6]

RUNA is also a Certified B Corporation, audited under a certification standard that measures a company's social and environmental performance, public transparency, and legal accountability.[64] In 2018, RUNA's nonprofit arm, Runa Foundation, merged with PlanJunto Ltda to form a new organization called Aliados, whose mission is "to build resilient community business based on biodiversity in the Andes and the Amazon — and connect them to markets across the globe." A current Aliados venture involves a partnership with Ally Guayusa, an indigenous-owned guayusa export association composed of 140 farming families operating 40 hectares of organic guayusa production.[65]

Before RUNA was founded in 2009, the use of guayusa leaf was relatively unknown outside of the Amazon. The socially conscious and responsible manner in which RUNA has sought to bring guayusa to the world is admirable. In collaboration with the local farming communities, RUNA has invested in building the foundation for a guayusa market that is ecologically, economically, and socially sustainable. However, Krause and Ness (2017) caution that guayusa production is still a niche agroforestry experiment and that the sustainability initiatives, such as fair trade and organic standards and certifications, so far "only provide partial solutions for protecting ecosystem services in the Ecuadorian Amazon." Growing popularity and success of guayusa in the global market may present the risk of its becoming a new monoculture cash crop that could displace diverse agroforestry systems.[6] HG

Declaration of Interest

The authors declare that they have no conflict of interest and no affiliation with the Runa organizations.


NOT
GINSENG
Root, Leaf, or Flower?
Plant part adulteration is an unfortunate reality. Are you getting what you paid for? Is it really what you are claiming on your label? We're here to help. No other contract lab knows herbal testing like Alkemist.
ALKEMIST LABS
714.754.4372 ALKEMIST.COM

References

1. Cuénoud P, Del Pero Martinez MA, Loizeau P-A, Spichiger R, Andrews S, Manen J-F. Molecular phylogeny and biogeography of the genus *Ilex* L. (Aquifoliaceae). *Ann Bot.* 2000;85(1):111-122.
2. Chen S, Ma H, Feng Y, Barriera G, Loizeau PA. Aquifoliaceae. 冬青科 dong qing ke. In: *Flora of China.* Vol 11. St. Louis, MO: Missouri Botanical Garden Press; 2008:359-438.
3. NatureServe. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. Arlington, VA: NatureServe; 2019.
4. Botanic Gardens Conservation International (BGCI) & IUCN SSC Global Tree Specialist Group. *Ilex guayusa*. The IUCN Red List of Threatened Species 2019: eT145566259A145678088 http://dxdoiorg/102305/IUCNUK2019-2RLTS-T145566259A145678088en. 2019.
5. Dueñas JF, Jarrett C, Cummins I, Logan–Hines E. Amazonian guayusa (*Ilex guayusa* Loes.): A historical and ethnobotanical overview. *Econ Bot.* 2016;70(1):85-91.
6. Krause T, Ness B. Energizing agroforestry: *Ilex guayusa* as an additional commodity to diversify Amazonian agroforestry systems. *Int J Biodivers Sci Ecosyst Serv Manag.* 2017;13(1):191-203.
7. Torres B, Maza OJ, Aguirre P, Hinojosa L, Günter S. The Contribution of Traditional Agroforestry to Climate Change Adaptation in the Ecuadorian Amazon: The Chakra System. In: Leal Filho W, ed. *Handbook of Climate Change Adaptation.* Berlin, Heidelberg, Germany: Springer Berlin Heidelberg; 2015:1973-1994.
8. Edwards AL, Bennett BC. Diversity of methylxanthine content in *Ilex cassine* L. and *Ilex vomitoria* Ait.: Assessing sources of the North American stimulant cassina. *Econ Bot.* 2005;59(3):275-285.
9. Bennett BC. Hallucinogenic plants of the Shuar and related indigenous groups in Amazonian Ecuador and Peru. *Brittonia.* 1992;44(4):483-493.
10. McGuffin M, Kartesz JT, Leung AY, Tucker AO. *American Herbal Products Association's Herbs of Commerce.* 2nd ed. Silver Spring, MD: American Herbal Products Association; 2000.
11. Linné Cv. *Caroli Linnæi ... Genera plantarum eorumque characteres naturales secundum numerum, figuram, situm, & proportionem omnium fructificationis partium.* Lugduni Batavorum :: apud C. Wishoff; 1737.
12. Marzell H. *Wörterbuch der deutschen Pflanzennamen. 2. Band.* Stuttgart/Wiesbaden: S. Hirzel Verlag/Franz Steiner Verlag; 1977.
13. Loesener T. Monographia Aquifoliacearum. Pt. I. In: *Abhandlungen der Kaiserlichen Leopoldinisch-Carolinischen Deutschen Akademie der Naturforscher.* Vol 78. Leipzig, Preußen: W. Engelmann; 1901:311.
14. Wassén H. *A Medicine-Man's Implements and Plants in a Tiahuanacoid Tomb in Highland Bolivia. Etnologisca studier, Vol. 32.* Göteborg, Sweden: Göteborgs Etnografiska Museum; 1972.
15. Lathrap DW. The antiquity and importance of long-distance trade relationships in the moist tropics of pre-Columbian South America. *World Archaeology.* 1973;5(2):170-186.
16. Schultes RE. Discovery of an ancient guayusa plantation in Colombia. *Botanical Museum Leaflets, Harvard University.* 1979;27(5/6):143-153.
17. Patiño VM. Guayusa, a neglected stimulant from the eastern Andean foothills. *Econ Bot.* 1968;22(4):310-316.
18. Jamieson RW. The essence of commodification: Caffeine dependencies in the Early Modern World. *J Soc Hist.* 2001;35(2):269-294.
19. Schultes RE. Antiquity of the use of new world hallucinogens. *The Heffter Review of Psychedelic Research.* 1998;1:1-7.
20. Tyler CD. The River Napo. *The Geographical Journal.* 1894;3(6):476-484.
21. Shemluck M. The flowers of *Ilex guayusa*. *Botanical Museum Leaflets, Harvard University.* 1979;27(5/6):155-160.
22. Lewis WH, Kennelly EJ, Bass GN, Wedner HJ, Elvin-Lewis MP, W DF. Ritualistic use of the holly *Ilex guayusa* by Amazonian Jivaro Indians. *J Ethnopharmacol.* 1991;33(1):25-30.
23. Lewis WH, Elvin-Lewis MP. Medicinal plants as sources of new therapeutics. *Ann Miss Bot Gard.* 1995;82(1):16-24.
24. Baruffati V. The reproductive cycle of Ecuadorian rain forest women. *Bull Lat Am Res.* 1984;3(1):99-109.
25. Innerhofer S, Bernhardt K-G. Ethnobotanic garden design in the Ecuadorian Amazon. *Biodivers Conserv.* 2011;20(2):429-439.
26. Caballero-Serrano V, McLaren B, Carrasco JC, et al. Traditional ecological knowledge and medicinal plant diversity in Ecuadorian Amazon home gardens. *Glob Ecol Cons.* 2019;17:e00524.
27. Runa. Clean energy® drink. Available at: https://runa.com/our-story. Accessed August 11, 2019.
28. US Food and Drug Administration. Regulations on Statements Made for Dietary Supplements Concerning the Effect of the Product on the Structure or Function of the Body; Final Rule. *Federal Register.* 2000;65(4):1000-1050.
29. Natural and Non-prescription Health Products Directorate. *Natural Health Products Ingredients Database.* Ottawa, Ontario: Health Canada; 2019.
30. Natural and Non-prescription Health Products Directorate. *Licensed Natural Health Products Database (LNHPD).* Ottawa, Ontario: Health Canada; 2019.
31. European Commission. *Cosmetic ingredient (CosIng) database.* Brussels, Belgium: DG Internal Market, Industry, Entrepreneurship and SMEs; 2019.
32. European Commission. *Novel Food Catalogue.* Brussels, Belgium: European Commission; 2019.
33. Sequeda-Castañeda L, Costa G, Celis C, Gamboa F, Gutierrez S, Luengas P. *Ilex guayusa* (Aquifoliaceae): Amazon and Andean native plant. *Pharmacologyonline.* 2016;3:93-202.
34. Radice M, Scalvenzi L, Sablón Cossío N. *Ilex guayusa*: A systematic review of its traditional uses, chemical constituents, biological activities and biotrade opportunities. In: *Proceedings of MOL2NET 2016, International Conference on Multidisciplinary Sciences*. 2nd ed. Basel, Switzerland: MDPI; 2017:3868.
35. Wise G, Negrin A. A critical review of the composition and history of safe use of guayusa: a stimulant and antioxidant novel food. *Crit Rev Food Sci Nutr.* 2019:1-12.
36. Calderón Borja EA. *Investigación y desarrollo de un protector solar empleando como ingrediente activo los agentes antioxidantes en extractos de guayusa (Ilex guayusa Loes)*. Quito, Ecuador: Universidad San Francisco de Quito, Colegio de Ciencias e Ingenierías; 2017.
37. Espinosa Caiza EP. *Actividad anti-biofilm de los extractos de plantas Urtica dioica L., Ilex guayusa y Uncaria tomentosa en Staphylococcus aureus.* Universidad Técnica de Ambato - Facultad de Ciencias de la Salud - Carrera de Laboratorio Clínico. 2019.
38. Carpintero Salvador N, Salazar Enríquez ME. *Evaluación del efecto anticelulítico de una formulación cosmética a base de extracto alcohólico foliar de Guayusa, Ilex guayusa Loes (Aquifoliaceae)*. Quito, Ecuador: Universidad Politécnica Salesiana; 2014.
39. Hernández Dávila CA. *Elaboración y caracterización de Microcápsulas mediante Gelificación Iónica externa, de la fracción alcaloidea de ILEX GUAYUSA con ALGINATO SÓDICO, y su utilización en la formulación de una forma de dosificación sólida*. Escuela Superior Politécnica de Chimborazo; 2015.
40. Silva Escobar ME. *Valoración de las especies Ilex guayusa (GUAYUSA) y Plukenetia volubilis L. (SACHA INCHI), como una materia prima cosmética antioxidante*. Quito, Ecuador: Universidad Politécnica Salesiana; 2018.
41. Pardau MD. *Antioxidant content activity and nitric oxide scavenging ability of Ilex guayusa compared with Camellia sinensis and Aspalathus linearis tea.* MSc Dissertation, University of Pretoria, Pretoria, South Africa; 2016.
42. Palchizaca Pinguil MN. *Evaluación del efecto antiinflamatorio de Ilex guayusa (Loes), Vernonanthura patens (Kunth) y Theobroma cacao (Linneo) en el modelo Animal Rata (Rattus norvegicus) de laboratorio*. Escuela Superior Politécnica de Chimborazo. Riobamba; 2019.
43. Wise G. *Substantial Equivalence Application for the Approval of Guayusa Leaf Tea (Ilex guayusa Loes.) for Use as a Dry Leaf Infusion.* Tena, Ecuador: IKIAM EP; 2017. Available at: https://acnfp.food.gov.uk/sites/default/files/guayusaapp.pdf. Accessed September 9, 2019.

44. Runa LCC. Substantial Equivalence of Aqueous Extracts of the Dried Leaves of *Ilex guayusa*. As cited in Food Safety Authority of Ireland Substantial Equivalence Opinion *Ilex guayusa*. 2017. Available at: www.fsai.ie/uploadedFiles/Science_and_Health/Novel_Foods/Notifications/2017%20SE%20opinion%20Ilex%20Guayusa.pdf. Accessed September 9, 2019.
45. Yi F, Zhao X-l, Peng Y, Xiao P-g. Genus *llex* L.: Phytochemistry, ethnopharmacology, and pharmacology. *Chin Herb Med.* 2016;8(3):209-230.
46. Gan R-Y, Zhang D, Wang M, Corke H. Health benefits of bioactive compounds from the genus *Ilex*, a source of traditional caffeinated beverages. *Nutrients.* 2018;10(11):1682.
47. Wise G, Santander DE. Comparative composition analysis of the dried leaves of *Ilex guayusa* (Loes.). *J Food Nutr Res.* 2018;6(10):638-644.
48. Swanston-Flatt SK, Day C, Flatt PR, Gould BJ, Bailey CJ. Glycaemic effects of traditional European plant treatments for diabetes. Studies in normal and streptozotocin diabetic mice. *Diabetes Res.* 1989;10(2):69-73.
49. Swanston-Flatt SK, Flatt PR, Day C, Bailey CJ. Traditional dietary adjuncts for the treatment of diabetes mellitus. *Proc Nutr Soc.* 1991;50(3):641-651.
50. Stoyell-Conti FF, Mello TC, Dias DS, et al. Effects of *Ilex guayusa* tea on glycaemia, cardiovascular autonomic modulation and oxidative stress in streptozotocin-diabetic rats. *The FASEB Journal.* 2018;32(1_supplement):906-912.
51. Espinosa Soto I, Valle ME, Menestrina B, Rosella MA. PS029: Ursolic acid in *Ilex guayusa* Loes. (Aquifoliaceae). In: *XXIV SILAE Congress. II International Congress on Integrative Medicine. Congress Abstract Book.* Salerno, Italy: Società Italo-Latino Americana di Etnomedicina (SILAE); 2015:97.
52. Chianese G, Golin-Pacheco SD, Taglialatela-Scafati O, et al. Bioactive triterpenoids from the caffeine-rich plants guayusa and maté. *Food Res Int.* 2019;115:504-510.
53. García-Ruiz A, Baenas N, Benítez-González AM, et al. Guayusa (*Ilex guayusa* L.) new tea: Phenolic and carotenoid composition and antioxidant capacity. *J Sci Food Agric.* 2017;97(12):3929-3936.
54. Pardau MD, Pereira ASP, Apostolides Z, Serem JC, Bester MJ. Antioxidant and anti-inflammatory properties of *Ilex guayusa* tea preparations: A comparison to *Camellia sinensis* teas. *Food Funct.* 2017;8(12):4601-4610.
55. Cadena-Carrera S, Tramontin DP, Bella Cruz A, Bella Cruz RC, Müller JM, Hense H. Biological activity of extracts from guayusa leaves (*Ilex guayusa* Loes.) obtained by supercritical CO2 and ethanol as cosolvent. *J Supercrit Fluid.* 2019;152:104543.
56. Gamboa F, Muñoz C-C, Numpaque G, Sequeda-Castañeda LG, Gutierrez SJ, Tellez N. Antimicrobial activity of *Piper marginatum* Jacq and *Ilex guayusa* Loes on microorganisms associated with periodontal disease. *Int J Microbiol.* 2018;2018(Article ID 4147383):9.
57. Tuquinga Usca MR. *Efecto Estrogénico del Extracto de las Hojas de Guayusa (Ilex guayusa Loes) en Ratas (Ratus novergicus).* Escuela Superior Politécnica de Chimborazo; 2013.
58. Contero F, Abdo S, Vinueza D, Moreno J, Tuquinga M, Paca N. Estrogenic activity of ethanolic extracts from leaves of *Ilex guayusa* Loes. and *Medicago sativa* in *Rattus norvegicus*. *Pharmacologyonline.* 2015;2:95-99.
59. Bussmann RW, Malca G, Glenn A, et al. Toxicity of medicinal plants used in traditional medicine in Northern Peru. *J Ethnopharmacol.* 2011;137(1):121-140.
60. Kapp RW, Mendes O, Roy S, McQuate RS, Kraska R. General and genetic toxicology of guayusa concentrate (*Ilex guayusa*). *Int J Toxicol.* 2016;35(2):222-242.
61. European Pharmacopoeia Commission. *European Pharmacopoeia*. 10th ed. (PhEur 10.0). Strasbourg, France: European Directorate for the Quality of Medicines; 2019.
62. United States Department of Agriculture. *Organic INTEGRITY Database.* Washington, D.C.: USDA Agricultural Marketing Service; 2019.
63. Nealis K. Trip report: Fair trade impact in Ecuador. Fair Trade Campaigns Blog. 2017. Available at: https://fairtradecampaigns.org/2017/08/trip-report-fair-trade-impact-in-ecuador/. Accessed August 11, 2019.
64. B Lab. Certified B Corporation. B Impact Report: Runa. Available at: https://bcorporation.net/directory/runa. Accessed August 17, 2019.
65. Aliados. Ally Guayusa: Organic guayusa tea. Available at: www.losaliados.org/ally-guayusa. Accessed August 17, 2019.
66. Alston AHG, Schultes RE. Studies of early specimens and reports of *Ilex vomitoria*. *Rhodora*. 1951;53(636):273-279.
67. Samorini G. The oldest archeological data evidencing the relationship of *Homo sapiens* with psychoactive plants: A worldwide overview. *J Psyched Stud*. 2019;3:1-18.
68. McClatchey WC, Mahady GB, Bennett BC, Shiels L, Savo V. Ethnobotany as a pharmacological research tool and recent developments in CNS-active natural products from ethnobotanical sources. *Pharmacol Ther*. 2009;123(2):239-254.

ADOPT-AN-HERB

HerbMedPro™ PROGRAM

The American Botanical Council's Adopt-an-Herb Program provides a mutually beneficial opportunity to support ABC's nonprofit educational efforts and promote a company's most important herbs.

One of the benefits of supporting the Adopt-an-Herb Program is that it ensures that the most current information on the adopted herb is available through ABC's powerful HerbMedPro™ database.

HerbMedPro provides online access to abstracts of scientific and clinical publications on more than 250 commonly used medicinal herbs. A free version, HerbMed®, is available to the general public and includes access to adopted herbs. HerbMedPro is available as a member benefit to all ABC members at the Academic Membership level and up.

In addition to ensuring that recently published information on an adopted herb is up to date on HerbMedPro, another benefit adopters enjoy is being included among their peers in each issue of ABC's acclaimed quarterly, peer-reviewed scientific journal, *HerbalGram*, on the ABC website, and at scientific, medical, and other educational conferences. Press releases also are issued on new adoptions, bringing attention to the program, the adopted herb, and the adopting company. Each adopted herb is featured on its own page on the ABC website.

Parties interested in taking part in the Adopt-an-Herb Program are invited to contact ABC Development Director Denise Meikel at 512-926-4900, extension 120, or by email at denise@herbalgram.org.

AMERICAN BOTANICAL COUNCIL
SINCE 1988

Herbal Adopters

EUROMED	Milk Thistle	*Silybum marianum*
EUROMED	Fig	*Ficus carica*
CENTROFLORA NUTRA (Now part of Givaudan)	Yerba Maté	*Ilex paraguariensis*
Nature's Gift	Helichrysum	*Helichrysum italicum*
PHARMACTIVE BIOTECH PRODUCTS	Saffron	*Crocus sativus*
NATURE'S SUNSHINE	Cayenne	*Capsicum annuum*
EMBRIA Health Sciences	EpiCor® Fermentate	*Saccharomyces cerevisiae*
JIAHERB essentials of nature	Rhodiola	*Rhodiola rosea*
neem BIOTECH A ZALUVIDA COMPANY.	Garlic	*Allium sativum*
neem BIOTECH A ZALUVIDA COMPANY.	Artichoke	*Cynara cardunculus* Scolymus Group
DMH ingredients Inc	Baobab	*Adansonia digitata*
DMH ingredients Inc	Rooibos	*Aspalathus linearis*
Friends of the Honey Bee	Propolis	
YOUR LOGO	Plant name	Scientific name

KP Authentic Botanical Extracts	Senna	*Senna alexandrina*
Soladox BOTANICALS	Black Chokeberry	*Aronia melanocarpa*
Soladox BOTANICALS	Elderberry	*Sambucus nigra*
Soladox BOTANICALS	Stinging Nettle	*Urtica dioica*
natural Factors	Echinacea	*Echinacea* spp.
ARTEMIS INTERNATIONAL	Purple Corn	*Zea mays*
FOUR ELEMENTS	Lemon Balm	*Melissa officinalis*
afrigetics BOTANICALS	Bulbine	*Bulbine natalensis*
BRASSICA PROTECTION PRODUCTS	Broccoli	*Brassica oleracea* Broccoli Group
DownUnder enterprises	Tea Tree	*Melaleuca alternifolia*
Aromatics INCORPORATED	Peppermint	*Mentha x piperita*
HERBALIFE.	Aloe Vera	*Aloe vera*
Natural Health International Conscious | Leading | Empowering	Maca	*Lepidium meyenii*
YOUR LOGO	Plant name	Scientific name

Visit us at www.herbalgram.org/adopt

Contact Denise Meikel at 512-926-4900 x120
or by email at denise@herbalgram.org

Herbal Adopters

NEW ADOPTER! Loomis® Enzymes	Dog Rose Hip	*Rosa canina*
Ginseng Plus®	Notoginseng	*Panax notoginseng*
Far Long®	Lifeflower	*Erigeron breviscapus*
Botalys – Better plants for a better Life	Asian Ginseng	*Panax ginseng*
NAHA	Lavender	*Lavandula angustifolia*
Verdure Sciences®	Pomegranate	*Punica granatum*
KSM-66®	Ashwagandha	*Withania somnifera*
RFI – From Field to Formula	Hibiscus	*Hibiscus sabdariffa*
SFI™	Bacopa	*Bacopa monnieri*
Nature's Way®	Ginkgo	*Ginkgo biloba*
biotropics Malaysia	Kesum	*Persicaria minor*
biotropics Malaysia	Tongkat Ali	*Eurycoma longifolia*
layn USA	Monk Fruit	*Siraitia grosvenorii*
travel medic – travelmedic.net	Kratom	*Mitragyna speciosa*
Diana – Performance from nature – Food	Acerola	*Malpighia* spp.
Contains Zembrin	Sceletium	*Sceletium tortuosum*
NEW ADOPTER! iff Health	Oat	*Avena sativa*
Brauer natural medicine	Chamomile	*Matricaria chamomilla*
grownetwork™	Rough Horsetail	*Equisetum hyemale*
natural™ remedies	Licorice	*Glycyrrhiza* spp.
valensa	Saw Palmetto	*Serenoa repens*
Naturopathica® Holistic Health	Arnica	*Arnica montana*
Future Ceuticals	Coffee Fruit	*Coffea* spp.
Teawolf – Natural Extract Solutions	Guayusa	*Ilex guayusa*
Gaia Trading Company, Inc.	Hops	*Humulus lupulus*
The Actives Factory	Birch	*Betula* spp.
Natac – Science to Market	Olive	*Olea europaea*
Natac – Science to Market	Grape	*Vitis vinifera*
Pharmatoka	Cranberry	*Vaccinium macrocarpon*
Ecoso Dynamics	Devil's Claw	*Harpagophytum* spp.
Terry Naturally – EuroPharma	Turmeric	*Curcuma longa*
YOUR LOGO	Plant name	*Scientific name*

Become an adopter today!

Farlong Pharmaceutical Adopts Notoginseng and Lifeflower through ABC's Adopt-an-Herb Program

By ABC Staff

The American Botanical Council (ABC) announces the adoptions of notoginseng (*Panax notoginseng,* Araliaceae) and lifeflower (*Erigeron breviscapus*, Asteraceae) by Farlong Pharmaceutical, an herbal ingredient and supplement company based in Walnut, California, through ABC's Adopt-an-Herb Program. With its adoption, Farlong Pharmaceutical helps ABC expand its nonprofit research and educational mission and keep its unique HerbMedPro database updated with the latest scientific and clinical research on these botanical ingredients.

HerbMedPro is a comprehensive, intearactive online database that provides access to important scientific and clinical research data on the uses and health effects of more than 265 herbs, spices, medicinal plants, and medicinal fungi.

"We really like the fact that ABC is putting all the clinical, scientific studies and research together to help educate the public, so more people can be aware of and better understand the medicinal value and wide range of uses of these plants and extracts," said Jing Struve, CEO and executive director of Farlong Pharmaceutical. "We hope that ABC will leverage its own resources and professional networks to help spread awareness and assist more people in reaping the benefits of using notoginseng and lifeflower."

ABC Founder and Executive Director Mark Blumenthal said: "ABC is doubly grateful to Farlong Pharmaceutical for its adoptions of notoginseng and lifeflower on ABC's unique and robust HerbMedPro database. These adoptions will not only help ABC keep up to date on the scientific and clinical research on these two herbs, but it will also increase the public's awareness of their potential health benefits, especially as the emerging modern research supports some of the traditional uses."

About Notoginseng

Panax notoginseng is known by multiple common names, including notoginseng, sanchi ginseng, sanqi ginseng, and tienchi ginseng, among others. A member of the Araliaceae family, notoginseng is a slow-growing perennial that is native to parts of China, Japan, Myanmar, and Nepal. Notoginseng has been used for centuries in traditional Chinese medicine (TCM) to improve circulation, for cardiovascular conditions, and to stop bleeding.

Researchers have identified more than 200 chemical compounds in notoginseng, including polysaccharides, flavonoids, phytosterols, volatile oils, and saponins (e.g., ginsenosides and notoginsenosides), which are considered to be the primary active components. Pharmacological studies suggest that notoginseng has antioxidant, anti-inflammatory, hypoglycemic, neuroprotective, and anticoagulation properties. Human clinical trials have examined notoginseng's effects on unstable angina pectoris, diabetic retinopathy, acute ischemic stroke, blood hyperviscosity, and other cardiovascular-related conditions.

About Lifeflower

Erigeron breviscapus is an herbaceous perennial in the daisy family. It is found in alpine regions, forests, and grasslands in the Chinese provinces of Guizhou, Hunan, Sichuan, and Yunnan and the autonomous regions of

ADOPT-AN-HERB
HerbMedPro™ PROGRAM

Notoginseng *Panax notoginseng*
Photo ©2019 Steven Foster

Guangxi and Xizang. Known as *deng zhan hua* in pinyin, lifeflower is used in TCM primarily for cardiovascular diseases, cerebral blood flow, and digestive disorders. The dried whole plant has been used traditionally to treat a variety of conditions, including paralysis, gastritis, fever, and toothache.

Human clinical trials have largely focused on the effects of breviscapine, which is a combination of several flavonoids found in lifeflower, including scutellarin. In vitro studies have demonstrated that breviscapine has vasodilation, anti-thrombotic, anti-coagulation, and anti-platelet-aggregation actions. Results from human clinical trials suggest that breviscapine may have potential benefits for cerebral infarction (stroke), diabetic nephropathy, and angina pectoris.

About Farlong Pharmaceutical

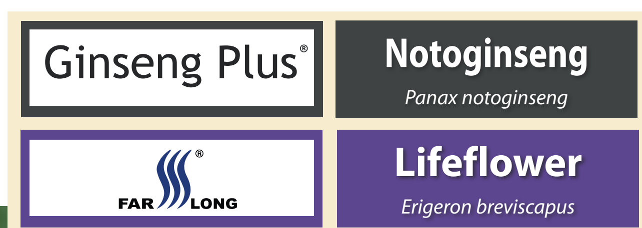
According to the company, Farlong Pharmaceutical has created products using natural and herbal ingredients to promote a healthy and natural life, focusing on quality ingredients with ancient Chinese roots, for more than 20 years. Farlong is a vertically integrated company and is responsible for ingredients from seed to shelf, beginning at its 6,000-acre farm in the Wenshan mountainous area of Yunnan province in China. The company states that the soil acidity, sunlight, temperature, rainfall, pressure, and altitude of the farm enable *Erigeron breviscapus* and *Panax notoginseng* to yield the most optimal active components. Farlong combines traditional processing methods with modern technology to help ensure that ingredients achieve high levels of stability and activity.

About Adopt-an-Herb and HerbMedPro

Farlong Pharmaceutical is one of 64 companies that have supported ABC's educational efforts to collect, organize, and disseminate reliable, traditional, science-based, and clinical information on herbs, medicinal plants, medicinal fungi, and other botanical- and fungi-based ingredients through the Adopt-an-Herb program. This program encourages companies, organizations, and individuals to "adopt" one or more specific herbs for inclusion and ongoing maintenance in the HerbMedPro database. To date, 71 herbs have been adopted.

Each adopted herb is continuously researched for new articles and scientific and clinical studies, ensuring that its HerbMedPro record stays current and robust. The result is an unparalleled resource not only for researchers, health professionals, industry, and consumers, but for all members of the herbal and dietary supplements community.

HerbMedPro is available to ABC members at the Academic level and higher. Its "sister" site, HerbMed, is free and available to the general public. In keeping with the ABC's position as an independent research and education organization, herb adopters do not influence the scientific information that is compiled for their respective adopted herbs. HG



Lifeflower *Erigeron breviscapus*
Photo ©2019 Farlong Pharmaceutical

Botanical Adulterants Prevention Program Publishes Saw Palmetto Berry Extract Laboratory Guidance Document

By ABC Staff

The ABC-AHP-NCNPR Botanical Adulterants Prevention Program (BAPP) recently published a new Laboratory Guidance Document (LGD) on saw palmetto (*Serenoa repens*, Arecaceae) fruit extract.[1]

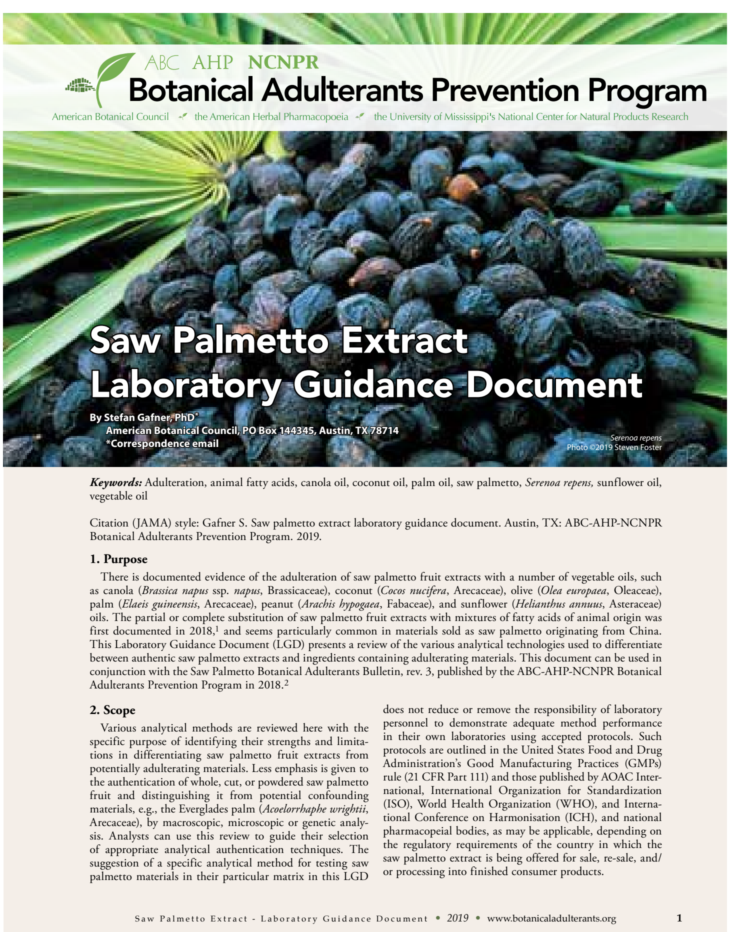
In human clinical trials, saw palmetto extracts have been shown to improve symptoms related to benign prostatic hyperplasia (BPH). Products containing saw palmetto are among the top-selling botanical dietary supplements in the United States — ranking 11th in the mainstream market (supermarkets, drug stores, mass-market retailers, etc.) and 14th in the natural channel in 2018, with a combined $34.7 million in sales for both channels, according to *HerbalGram's* 2018 Herb Market Report.[2]

Poor harvests from 2016 to 2018, and possibly the introduction of new permit requirements by the Florida Department of Agriculture and Consumer Services, have led to a situation in which the saw palmetto berry supply cannot keep up with demand. Consequently, prices for saw palmetto berries, which grow only in the southeastern United States, mainly in Florida, increased substantially in 2018.

While admixture or substitution with berries of related species in the palm family appears to be infrequent, the substitution or dilution of saw palmetto extracts with vegetable oils or "designer" fatty acid blends from plant or animal sources to attempt to mimic saw palmetto's fatty acid composition is more commonplace. Routine analytical methods using gas chromatography (GC) for fatty acids are not suitable to detect adulteration if the method measures only the total fatty acid content. A combination of various analytical methods including an organoleptic (color, taste, etc.) inspection of the liquid, determination of the acid value (pH), and GC for measuring fatty acid, fatty alcohol, and phytosterol profiles provides a more robust approach to ensure saw palmetto extract authenticity.

The new LGD was written by Stefan Gafner, PhD, chief science officer of the American Botanical Council (ABC) and technical director of BAPP. The LGD evaluates the usefulness of 34 published analytical methods to detect saw palmetto berry and berry extract adulteration, and it summarizes the main advantages and disadvantages of each method regarding suitability for use in a quality control laboratory. In addition, the document details the chemical composition of saw palmetto and many of its known adulterants. The LGD was reviewed by 25 experts from third-party contract analytical laboratories, nonprofit scientific organizations, and the herbal industry, and follows the publication of the third version of the Saw Palmetto Botanical Adulterants Prevention Bulletin in October 2018.[3]

Gafner explained: "Complete substitution of saw palmetto with vegetable oils is readily detected by organoleptic and chemical assays. However, fraudulent suppliers have become increasingly sophisticated in producing low-cost materials that are chemically similar to authentic saw palmetto. Therefore, a set of methods is now needed to determine if an extract labeled to be saw palmetto is actually authentic."



Keywords: Adulteration, animal fatty acids, canola oil, coconut oil, palm oil, saw palmetto, *Serenoa repens,* sunflower oil, vegetable oil

Citation (JAMA) style: Gafner S. Saw palmetto extract laboratory guidance document. Austin, TX: ABC-AHP-NCNPR Botanical Adulterants Prevention Program. 2019.

1. Purpose

There is documented evidence of the adulteration of saw palmetto fruit extracts with a number of vegetable oils, such as canola (*Brassica napus* ssp. *napus*, Brassicaceae), coconut (*Cocos nucifera*, Arecaceae), olive (*Olea europaea*, Oleaceae), palm (*Elaeis guineensis*, Arecaceae), peanut (*Arachis hypogaea*, Fabaceae), and sunflower (*Helianthus annuus*, Asteraceae) oils. The partial or complete substitution of saw palmetto fruit extracts with mixtures of fatty acids of animal origin was first documented in 2018,[1] and seems particularly common in materials sold as saw palmetto originating from China. This Laboratory Guidance Document (LGD) presents a review of the various analytical technologies used to differentiate between authentic saw palmetto extracts and ingredients containing adulterating materials. This document can be used in conjunction with the Saw Palmetto Botanical Adulterants Bulletin, rev. 3, published by the ABC-AHP-NCNPR Botanical Adulterants Prevention Program in 2018.[2]

2. Scope

Various analytical methods are reviewed here with the specific purpose of identifying their strengths and limitations in differentiating saw palmetto fruit extracts from potentially adulterating materials. Less emphasis is given to the authentication of whole, cut, or powdered saw palmetto fruit and distinguishing it from potential confounding materials, e.g., the Everglades palm (*Acoelorrhaphe wrightii*, Arecaceae), by macroscopic, microscopic or genetic analysis. Analysts can use this review to guide their selection of appropriate analytical authentication techniques. The suggestion of a specific analytical method for testing saw palmetto materials in their particular matrix in this LGD does not reduce or remove the responsibility of laboratory personnel to demonstrate adequate method performance in their own laboratories using accepted protocols. Such protocols are outlined in the United States Food and Drug Administration's Good Manufacturing Practices (GMPs) rule (21 CFR Part 111) and those published by AOAC International, International Organization for Standardization (ISO), World Health Organization (WHO), and International Conference on Harmonisation (ICH), and national pharmacopeial bodies, as may be applicable, depending on the regulatory requirements of the country in which the saw palmetto extract is being offered for sale, re-sale, and/or processing into finished consumer products.

Saw Palmetto Extract - Laboratory Guidance Document • 2019 • www.botanicaladulterants.org 1

Mark Blumenthal, ABC founder and executive director and BAPP founder and director, said: "For years, we've known that some unethical ingredient suppliers have been selling fraudulent 'saw palmetto' extracts containing lower-cost oils from other plants. Recently, reports have been published in reputable journals that fraudsters have begun to add fatty acids from animal fats to so-called 'saw palmetto' extracts. This is not only unfair to consumers but also to the reputable companies that produce and market authentic, reliable saw palmetto ingredients and products made from them."

The saw palmetto LGD is the ninth publication in the series of LGDs and the 53rd peer-reviewed publication published by BAPP. As with all publications of the program, LGDs are freely accessible to all ABC members, registered users of the ABC website, and all members of the public on the BAPP website (registration required).

About the ABC-AHP-NCNPR Botanical Adulterants Prevention Program

The ABC-AHP (American Herbal Pharmacopoeia)-NCNPR (National Center for Natural Products Research) Botanical Adulterants Prevention Program is an international consortium of nonprofit professional organizations, analytical laboratories, research centers, industry trade associations, industry members, and other parties with interest in herbs and medicinal plants. The program advises industry, researchers, health professionals, government agencies, the media, and the public about various issues related to adulterated botanical ingredients sold in commerce. To date, more than 200 US and international parties have financially supported or otherwise endorsed the program. HG

References

1. Gafner S. Saw Palmetto Extract Laboratory Guidance Document. Austin, TX: ABC-AHP-NCNPR Botanical Adulterants Prevention Program; 2019. Available at: http://cms.herbalgram.org/BAP/LGD/SawPalmettoExtractLabGuidanceDoc.html. Accessed September 25, 2019.
2. Smith T, Gillespie M, Eckl V, Knepper J, Morton Reynolds C. Herbal Supplement Sales in US Increase by 9.4% in 2018. *HerbalGram*. 2019;123:62-73. Available at: http://cms.herbalgram.org/herbalgram/issue123/files/HG123-HMR.pdf. Accessed September 25, 2019.
3. Gafner S, Baggett S. Botanical Adulterants Prevention Bulletin: Adulteration of Saw Palmetto (*Serenoa repens*). Version 3. Austin, TX: ABC-AHP-NCNPR Botanical Adulterants Prevention Program; 2018. Available at: http://cms.herbalgram.org/BAP/pdf/BAP-BABs-SawPalmetto-CC-102018-v2.pdf. Accessed September 25, 2019.


Saw palmetto *Serenoa repens*
Photo ©2019 Steven Foster

Sustainable Herbs Program Announces Inaugural Members of Advisory Group

By ABC Staff

The Sustainable Herbs Program (SHP) and the American Botanical Council (ABC) welcome 17 inaugural members to the new Advisory Group. These highly regarded professionals bring many years of experience working in a wide range of relevant disciplines, including botanical raw material sourcing and sustainability, regenerative and sustainable agriculture, botany, ethnobotany, ethnobiology, horticulture, pharmacognosy, wild harvesting, and herbal medicine.

SHP Director Ann Armbrecht, PhD, said: "I am so grateful to have the support and guidance of these individuals, all of whom are leaders in creating conversations about sustainable practices for the botanical industry. We are greatly honored to have them join us to help guide the development of new programming and educational content for the botanical community. We very much look forward to working with them to help us forward our educational and inspirational mission."

Mark Blumenthal, founder and executive director of ABC, added: "We see SHP as a collaborative effort, and these SHP Advisory Group members represent a wide field of expertise and organizations in the botanical medicine and conservation communities."

More detailed biographies are available in the Advisory Group section of the SHP website.

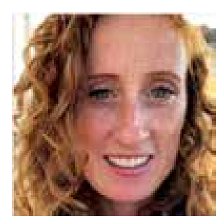
Josef Brinckmann

Brinckmann has worked with medicinal plants since 1979 and serves as the Medicinal Plants and Botanical Supply Chain Research Fellow of Traditional Medicinals, Inc. (Sebastopol, California), a manufacturer of herbal medicinal products. He is also an ABC Advisory Board member and a contributing editor of *HerbalGram*. Brinckmann is a member of the Medicinal Plant Specialist Group of the International Union for Conservation of Nature's (IUCN's) Species Survival Commission and serves as vice chair of the Board of Trustees of the FairWild Foundation, a Switzerland-based nonprofit standards-setting organization for the sustainable wild collection of medicinal and aromatic plants. He received the 2013 American Herbal Products Association (AHPA) Herbal Insight Award, the 2016 ABC Champion Award, and in 2016 was conferred an honorary degree of Doctor of Humane Letters in Healing and Sustainability honoris causa from the California Institute of Integral Studies and American College of Traditional Chinese Medicine.

Bill Chioffi

Chioffi has more than 21 years of experience with the production of herbal supplements, including vertically integrated manufacturing of botanical liquid extracts and concentrates. He also has experience in international and domestic regulatory and good agricultural and collection practices (GACPs) auditing, social responsibility/sustainability management and program development, agroforestry and supply chain development planning, political advocacy, clinical research guidance, and education. He is the director of Botanical Consulting International and has served on various boards, including the AHPA Executive Committee as vice chair and the AHPA Board of Directors for two terms. He is also a founding board member of the Appalachian Beginning Forest Farmer Coalition and a current advisor to United Plant Savers (UpS), reflecting his commitment to conservation.

Bethany Davis



Davis is the director of advocacy and government affairs of FoodState/MegaFood. She is the president of the Coalition for Supplement Sustainability, a group of supplement and ingredient companies that united to support a non-GMO (genetically modified organism) and sustainable supply chain. She serves on the Board of Trustees of ABC and AHPA. Davis is deeply engaged with regenerative agricultural practices, sustainability, and transparency as they relate to the supplement industry. She holds a MS in Regulatory Affairs and Health Policy from Massachusetts College of Pharmacy and Health Sciences in Boston and is a certified coach with the Conscious Leadership Group.

Trish Flaster

Flaster, an ethnobotanist and botanical ingredients sourcing and sustainability expert, serves as executive director of Botanical Liaisons, LLC, an ethnobotanical consulting firm that focuses on new products based on traditional knowledge and development of authenticated botanical reference specimens. Flaster also conducts field studies on sustainable supplies. For more than 30 years, she has been the editor of "Plants and People," the newsletter of the Society for Economic Botany. With extensive herb industry experience, including formerly working in the research department of Celestial Seasonings, Flaster is the cofounder of IDDI, IngredientID.com. She holds a master's degree in ethnobotany from the University of Colorado at Boulder and serves on the ABC Advisory Board.

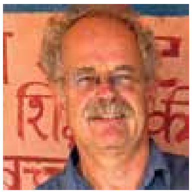
Edward Fletcher

Fletcher has worked in the horticultural industry for more than 35 years, starting with propagating and growing native American wildflowers for his family's ornamental nursery business in North Carolina. He has extensive experience working with farmers, growers, and herb producers around the world and offers consulting services via his company Native Botanicals, Inc. Fletcher has been the chairperson and is a current member of the AHPA Board of Trustees and chair of the AHPA Botanical Raw Materials Committee. He has worked with the United States Agency for International Development as a medicinal plant expert on the Island of Dominica to develop a line of medicinal teas based on the traditional knowledge of the Kalinago people. Fletcher continues to work to improve the quality of botanical raw materials, focusing on cultivation and post-harvest handling techniques.

Jackie Greenfield

Greenfield is a plant biologist and global sourcing specialist. For more than 18 years, she owned and operated an organic herb and flower farm in Pennsylvania, and later worked for North Carolina State University developing cultivation systems for native botanicals and assisting farmers with medicinal herb and organic production practices. Greenfield then served as a sourcing and sustainability specialist for manufacturing companies in the herbal extract, tea, food, and beverage industries, and helped companies develop long-term sustainability programs to protect and preserve their supply chains. She has traveled worldwide, collaborating with organic farmers, grower co-ops, and strategic business partners, to promote plant conservation through cultivation. She currently serves on the Board of Directors of the AHPA Foundation for Education and Research on Botanicals (ERB Foundation).

David Hircock



Hircock is the executive director of corporate affairs of Estée Lauder Companies, having started with its subsidiary, Aveda. He has worked extensively around the globe on issues related to human rights and biodiversity conservation. He also has worked with indigenous peoples, particularly in regard to the supply chains of raw materials and services for essential oils. A passionate advocate for human rights, Hircock has worked since 2005 with Nobel Peace Prize Laureate Kailash Satyarthi's teams that are committed to the eradication of child labor and slavery in India.

Holly Johnson, PhD

Johnson is the chief science officer of AHPA. She previously served as laboratory director of Alkemist Labs, an accredited natural product testing laboratory that specializes in botanicals. Johnson has a PhD in pharmacognosy and was awarded a US National Institutes of Health (NIH) fellowship for training at the University of Illinois at Chicago/NIH Center for Botanical Dietary Supplements Research. She did extensive ethnobotany fieldwork and botanical collecting and completed a postdoctoral research fellowship at the Institute for Ethnomedicine in Jackson Hole, Wyoming. Johnson is active in sustainability initiatives at AHPA and in standards-setting activities with AOAC International and the United States Pharmacopeia (USP) for foods and dietary supplements. She is a member of USP's Medical Cannabis Expert Panel, the Editorial Board of the *Journal of AOAC International*, and the Advisory Boards of ABC and the American Herbal Pharmacopoeia (AHP). Johnson has more than 20 years of experience in the lab and in the field with natural products and botanicals and has spent many years conducting research and teaching at the University of Hawaii.

Sarah Laird

A forester and ethnobiologist by training, Laird has diverse interests, including forest-based traditional knowledge, livelihoods, conservation, governance, and the commercial use of biodiversity. Since the mid-1990s, Laird has collaborated with local communities around Mt. Cameroon in southwestern Cameroon on ethnobiological research and knowledge exchange programs to support and conserve threatened traditional management practices and cultural forests. Laird also works on the international trade of medicinal plants and other non-timber forest products, including their governance, certification, markets, and sustainability, and, since 1990, on the ethical and conservation implications of the commercial use of biological and genetic resources, including through the Convention on Biological Diversity. Laird is the co-director of People and Plants International, a bioeconomy research associate at the University of Cape Town, South Africa, and the co-director of the Voices for BioJustice program.

Danna J. Leaman, PhD

Leaman, a conservation biologist/ethnobotanist, is an independent consultant and is affiliated with the Canadian Museum of Nature as a research associate. Leaman received her PhD in biology from the University of Ottawa, Canada, in 1996 based on ethnobotanical research in East Kalimantan, Indonesian Borneo. A member of the IUCN's Species Survival Commission, she is co-chair of the Medicinal Plant Specialist Group and the Red List authority for medicinal plants. She is a founding member of the Board of Trustees of the FairWild Foundation. Among her many affiliations, Leaman is a member of the ABC Advisory Board.

Susan Leopold, PhD

Leopold is an ethnobotanist and passionate defender of biodiversity. She is the executive director of United Plant Savers. She currently serves on the boards of directors of Botanical Dimensions and the Center for Sustainable Economy and is a board member of the AHPA ERB Foundation, an Advisory Board member of ABC, and a member of the IUCN's Medicinal Plant Specialist Group. She is a proud member of the Patawomeck Native American tribe of Virginia and the author of the children's book *Isabella's Peppermint Flowers*, which teaches about Virginia's botanical history. She lives on and manages a productive farm, the Indian Pipe Botanical Sanctuary, with her three children in Virginia, where she raises goats, peacocks, and herbs. She is an avid recreational tree climber, in love with the canopy just as much as the herbs of the forest floor.

Sebastian Pole

Pole encountered the world of traditional herbal medicine in 1991, when he met an Ayurvedic doctor in India. Pole and Tim Westwell started Pukka Herbs in 2001 to connect people with herbs and do as much good as possible. Pukka Herbs is now one of the most successful organic herbal tea companies in the world. As well as formulating all of Pukka Herbs' organic herbal teas and supplements, Pole has run his own herbal practice since 1998. He is a registered member of the Ayurvedic Practitioners Association, the Register of Chinese Herbal Medicine, and the Unified Register of Herbal Practitioners. Fluent in Hindi, a registered yoga therapist, an obsessive gardener, and passionate about running a business that benefits everyone it connects with, Pole wants to bring the power of plants into peoples' lives. He is also an advisor to the FairWild Foundation and AHP.

Anant Darshan Shankar

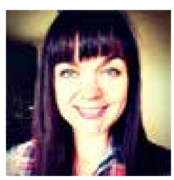
Shankar is the managing trustee of the Foundation for Revitalization of Local Health Traditions (FRLHT) and vice chancellor of the University of Trans-Disciplinary Health Sciences and Technology (TDU) in Bengaluru, India. Since 1991, FRLHT has overseen the creation of the largest in situ conservation program in India consisting of 110 medicinal plant conservation areas (MPCAs) for conserving wild gene pools of threatened medicinal botanicals. TDU also leads translational research in the field of Ayurveda-biology, a new transdisciplinary domain that combines systemic perspectives of Ayurveda with the molecular approaches of biology. Shankar's work has received several national and international awards, including the Norman Borlaug Award for Field Research and Application from the Rockefeller Foundation (1998), Colum-

bia University's Center for Complementary and Alternative Medicine's International Award (2003) for revitalization of traditional systems of health care in India, and the Padma Shri by the Government of India (2011).

Erin Smith

Smith is a clinical herbalist and ethnobotanist who has been working with medicinal plants for more than 30 years. She has worked internationally with indigenous communities on traditional medicine, natural resource management, community-based conservation, and traditional knowledge preservation, including with the Food and Agriculture Organization of the United Nations and as the former managing director of Global Diversity Foundation – North America. She has taught internationally on herbal medicine, ethnobotany, and the human/nature relationship for more than 15 years. Passionate about botanical sourcing, social impact, and sustainability issues in the natural product industry, Smith is co-chair of AHPA's Sustainability Subcommittee and currently oversees education and sustainability at WishGarden Herbs in Colorado.

Anastasiya Timoshyna



Timoshyna is TRAFFIC's senior program coordinator for sustainable trade. She is based in Cambridge, UK, and has more than ten years of experience working on issues of wildlife trade, with a focus on implementing best practices in sustainability of harvesting and trade in wild-collected plants in the source and consumer countries. This involves engagement with companies from around the world and relevant policy work, including in the contexts of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on Biological Diversity (CBD). Timoshyna has experience with standards and certification mechanisms, particularly the FairWild Standard. She is a co-chair of the IUCN's Species Survival Commission, Medicinal Plant Specialist Group, and a member of IUCN's Sustainable Use and Livelihoods Specialist Group.

Anne Wedel-Klein

Wedel-Klein grew up with a passion for botanicals as a fourth-generation member of the Martin Bauer family. Founded in 1930, the Martin Bauer Group sources more than 200 cultivated and wild-collected botanicals from more than 80 countries, supplying ingredients to provide solutions for the food, beverage, and dietary supplement industries. More than a decade ago, the Martin Bauer Group developed its own sustainable sourcing standard and has implemented it with like-minded customers and partners. Many of the company's projects are designed to help improve the living standards of local peoples and maintain biodiversity. Wedel-Klein holds an MBA and heads the sustainability strategy of the Martin Bauer Group.

Steven Yeager

Yeager is trained as a field botanist and wild harvester. He is the director of quality at Mountain Rose Herbs where he oversees laboratory operations, including the company's identity program as well as assuring good manufacturing practices (GMPs) and Food Safety Modernization Act compliance. He serves on multiple organizations' boards of directors, including AHPA, AHPA's ERB Foundation, UpS, and the Native Plant Society of Oregon. Yeager is co-owner of the Columbines School of Botanical Studies in Eugene, Oregon, and has been an instructor with the school since 1997. HG

The ABC Sustainable Herbs Program: An Overview

By Ann Armbrecht, PhD

The Sustainable Herbs Program (SHP) began with a simple mandate: to re-connect consumers and companies with an understanding of a basic question: "Where do herbs originate?" This involves reporting on the people, plants, and processes behind bringing botanicals and their finished products to consumers and exploring the intricacies of wild harvesting and cultivation of herbs in the global supply chain, which SHP prefers to refer to as the value network.

We began simply by asking these questions:

- Where do herbs come from?
- How are they gathered and produced?
- What is harvested, when, and by whom?
- If collected from the wild, are herbs harvested in an environmentally sustainable manner?
- Does wild harvesting affect plants' long-term capacity to thrive in the wild?
- Are individuals who harvest the herbs receiving a fair, living wage?
- If cultivated, are herbs produced within a context of responsible land use and regenerative soil health?

These and other questions are explored through stories about the plants and the people who harvest and trade them, by interviewing experts in the commercial value network, reviewing a broad range of information sources, and presenting the information in articles, blog entries, photo essays, and videos. These stories enable an understanding of where herbs originate and, in turn, inspire responsibility for ensuring that the people and places are adequately cared for.

These connections are important because a significant amount of herbs are used for human and animal wellness. As noted medicinal plant expert Josef Brinckmann, a research fellow with the herbal tea company Traditional Medicinals and an SHP advisory group member, explained: "Part of the effect of the herbs has a lot to do with the quality not only of the herbs, but of the ecosystem and the quality of life of the people involved."[1]

Or, putting this in terms of ecological medicine: "We can't be well until the planet is well," said author and Bioneers co-founder Kenny Ausubel in the film *Numen: The Healing Power of Plants*.[2]

Our wellness is inextricably connected with the health and wellness of the ecosystems in which we live — and, by extension, the health and wellness of the ecosystems in which the food and herbal remedies we ingest are grown, harvested, and manufactured. If the air we breathe, the water we drink, and the soils in which we grow our plants are filled with toxins, then no tea we drink or supplement we take will help.

SHP embraces the central premise that addressing sustainability in the herbal products industry begins with the whole production system and that the quality of the finished product ultimately is only as good as the quality of the ecosystems and culture of the entire value network.

Consumer attention to sustainable and ethical sourcing in the food industry is gaining traction. However, when it comes to herbs, outside of herbal community professionals, few consumers pay much attention to the crucial connections among the quality of the raw material, traceability in the value network, and the efficacy of the finished product. Consumers of herbal supplements tend to believe that by buying products made with botanicals, they are making an environmentally responsible choice. Even for those who seek to know more about their products, it is very difficult to find accurate information about the value network and human and environmental costs in an industry with complex intricacies. Moreover, sourcing botanicals from around the world is far more complicated than simply sourcing a single conventional food commodity such as wheat (*Triticum aestivum*, Poaceae) or corn (*Zea mays*, Poaceae). A single herb company may source 120 or more plant species, each with different handling requirements and sourced from countries with different regulations and standards. SHP believes that making changes in the system of getting herbs from fields and forests to consumers begins with understanding that system, which means understanding the challenges companies face and the efforts that are being made to address those challenges.

SHP Director Ann Armbrecht, PhD, launched SHP (then known as the Sustainable Herbs Project) with a successful Kickstarter campaign in 2016 that raised $65,000 from donations that averaged $30 each. With this seed money, Armbrecht set out to document the stories of the people behind consumer herb products.

The initial goals of SHP were to create a multimedia website geared toward herb consumers, educate them about the people and places behind the finished products, and outline steps they can take to ensure that those people and places are being cared for in a sustainable manner. An additional goal was

Sustainable Herbs Program
AMERICAN BOTANICAL COUNCIL

to find a long-term home for the project. The SHP website was launched in July 2017, and in the spring of 2018, a partnership with the American Botanical Council (ABC) was finalized for the Sustainable Herbs Project to become a program of ABC, with the name changed to the Sustainable Herbs Program. This partnership has brought the expertise of the ABC community, particularly that of ABC Founder and Executive Director Mark Blumenthal and long-time ABC trustee and noted author, botanist, and photographer Steven Foster. ABC also provides numerous additional resources to expand the depth and breadth of the program, including administrative and IT assistance, marketing and fundraising experience, and its vast experience in producing high-quality, authoritative educational content.

The natural products industry depends on raw materials from the earth, which creates a unique responsibility to regenerate and sustain those resources.

The first year of this partnership has focused on developing a platform for delivering visually engaging stories, most of which are told in videos (more than 40 as of October 2019) on the SHP website. Together, the SHP staff is working to bring the information to a much broader audience and introduce more people to concepts of sustainability and regenerative practices, to provide resources to both consumers and herb industry members, and to partner with others in the industry and the environmental and conservation communities to promote these issues. Further, the SHP Advisory Group, consisting of 17 medicinal plant conservation experts from five countries, was formed.

The challenges facing the botanical industry, like those facing the world right now, can feel overwhelming: from flooding, drought, and earlier springs due to climate change; loss of pollinators; loss of habitat; decline of biodiversity; and urban migration, reducing the number of people willing to continue or adopt a lifestyle of rural living, which includes the challenging work of harvesting wild herbs.

While SHP points out these challenges, SHP also focuses on what steps can be taken by individuals, trade and nonprofit organizations, and industry members that are innovating in providing sustainable herb supplies while regenerating the health of the planet, plants, and people. SHP's primary mission is to educate and inspire companies and consumers to support best practices in terms of sustainable sourcing, regenerative agriculture, and ethical value networks. SHP will continue to champion stories in which brands know their suppliers and in which engaging with the broader ecological-economic-cultural context is integral to bringing wellness to the end user. We don't want to gloss over obvious problems, but we do want to tell stories about how things are working to inspire further change.

As Sebastian Pole, co-founder of the UK-based herbal tea company Pukka Herbs, said, sourcing medicinal plants "might be complex, because of the nature of nature and the diversity within an herbal supply chain and all of the challenges around growing, but it's not complicated. The principle is very simple: Know where you get your herbs. Make sure you get good quality. Commit to long-term relationships, and everyone can work together."[1]

Implementing that level of commitment and engagement across a company's supply network is a tall order. The key is to begin. As Brinckmann advises, just pick one plant and follow it to its source. "I guarantee once you get there you will find things that need to be done. Just try it," he said. "There is so much to gain and little to lose by getting to know and trust everyone in your value chain."[3]

Changing the Paradigm

In her book *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants* (Milkweed Editions, 2014), Robin Kimmerer writes: "The market economy story has spread like wildfire, with uneven results for human well-being and devastation for the natural world. But it is just a story we have told ourselves and we are free to tell another."[4]

The natural products industry depends on raw materials from the earth, which creates a unique responsibility to regenerate and sustain those resources. This includes developing ways of doing business that regenerate the living systems on which those businesses depend. It is not only a matter of finding the right tools; it isn't simply about life cycle analyses, benchmarking, and metrics. A deeper shift is required, one that builds on seeing the whole ecosystem, human and non-human, as the heart of decisions made and actions taken. This shift begins with asking questions and seeking answers:

- What is best for the whole?
- What is best for the plants and the ecosystems in which they flourish?
- What is best for the communities whose livelihoods depend on those plants?
- How can companies work in ways that take into account all of these complexities, and how can buyers of their products support that work and encourage them to go further?

Taking action — shifting the paradigm — will take leadership, courage, and collaboration. SHP invites everyone to participate in this vital venture.

About the Sustainable Herbs Program

SHP was initiated with the invaluable support of 19 inaugural underwriters that represent leading stakeholders in the herbal supplement and natural products industries. These underwriters include botanical ingredient suppliers, branded product manufacturers, and a leading dietary supplement trade association. ABC and SHP are grateful to these underwriters for their generous and timely support:

- **Ingredient Suppliers**: Applied Food Sciences, Euromed, Indena, RFI, Valensa, and Verdure Sciences
- **Herbal Product Manufacturers**: dōTERRA, EuroPharma/Terry Naturally, FoodState/MegaFood, Gaia Herbs, HumanN, Integria/MediHerb, Nature's Way, New Chapter, NOW Foods, Pharmatoka SAS, Standard Process, and Thorne
- **Industry Trade Association**: United Natural Products Alliance

More information about SHP can be found at www.sustainableherbsprogram.com. HG

References

1. Video: What is sustainable medicine? Sustainable Herbs Program website. Available at: http://sustainableherbsproject.com/explore/what-is-sustainable-medicine/. Accessed October 24, 2019.
2. Armbrecht A, Youk T. *Numen: The Healing Power of Plants* [DVD]. Montpelier, VT: Brook Hollow Productions, Inc.; 2017.
3. Armbrecht A. Pick a Plant – Now What? Five (Easy) Steps for Herb Companies. June 20, 2019. Sustainable Herbs Program website. Available at: http://sustainableherbsproject.com/pick-a-plant/. Accessed October 24, 2019.
4. Kimmerer RW. *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants*. Minneapolis, MN: Milkweed Editions; 2014.

ABC and SHP Are Grateful to These Inaugural Underwriters:

Meta-analysis Shows Link between Green Tea Consumption and Reduction of Breast Cancer Risk and Recurrence

Reviewed: Gianfredi V, Nucci D, Abalsamo A, et al. Green tea consumption and risk of breast cancer and recurrence — A systematic review and meta-analysis of observational studies. *Nutrients*. December 2018;10(12):E1886. doi: 10.3390/nu10121886.

By Samaara Robbins

Tea is obtained from leaves and buds of the tea plant (*Camellia sinensis*, Theaceae). Green, oolong, white, pu-erh, and black teas are all produced from this species. Their distinction comes from how the plant is processed, with green tea being minimally processed. Fresh tea leaves are exposed to heat or hot steam immediately after picking, resulting in minimal oxidation of polyphenols, which are bioactive compounds believed to be responsible for some of the health benefits of green tea. Recent in vitro studies have found that phenolic compounds in green tea may inhibit angiogenesis (formation of new blood vessels) through various pathways and mechanisms.

Breast cancer (BC) is the most frequently diagnosed cancer in women and has the highest mortality rate worldwide. Previous studies are limited or provide inconclusive evidence to support an association between green tea consumption and BC risk. The purpose of this systematic review and meta-analysis was to evaluate green tea consumption and BC risk, recurrence, and risk in relation to menopausal status.

Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines were followed. A literature search was performed using PubMed, Scopus, and the Web of Science. The researchers used an extensive search strategy including search terms and filters. Observational studies (case-control studies, cohort studies, and cross-sectional studies) evaluating BC risk in adult populations were included. Selected studies evaluated green tea consumption using a questionnaire or interview. A total of 194 studies were retrieved. Of those, 39 were duplicates, 115 did not meet the inclusion criteria, an additional 25 were excluded because there was no differentiation between green tea and other teas consumed, and two were excluded because data were not extrapolated. In the end, 13 studies were included in the meta-analysis.

Of the 13 studies included, seven were conducted in Japan, five in China, and one in the United States. Participants varied between 20 and 87 years of age. Seven of the studies analyzed recurrence in women with a history of BC, and six studies followed healthy individuals to establish BC risk. The pooled sample size was 163,810 participants. There was an overall odds ratio (OR; a measure of the effect size) of 0.85 (95% confidence interval [CI] = 0.80-0.92, P = 0.000) on BC risk when comparing the highest versus the lowest category of green tea consumption.

Study Details: At a Glance	
Purpose	To assess the relationship between green tea consumption and breast cancer risk and recurrence
Study Design	Systematic review and meta-analysis
Included Studies	13 observational studies
Study Length	Various
Disclosures	None declared

Three of the seven studies with a focus on BC recurrence showed a possible protective effect of green tea consumption, while the analysis of the remaining four studies did not find a statistically significant correlation. The pooled effect size was 0.81 (95% CI = 0.74-0.88, P = 0.000). The pooled sample size was 13,956, and individual studies ranged from 472 to 6,928 participants. Statistically significant heterogeneity was observed (P = 0.001). The remaining six studies analyzed focused on the risk of a BC diagnosis. None of the studies showed statistical significance and the combined effect size was 0.97 (95% CI = 0.86-1.11, P = 0.684).

To determine a potential beneficial amount of green tea, a meta-analysis was performed with those studies that reported consumption of five cups of tea per day. The effect size was 0.97 (95% CI = 0.81-1.18, P = 0.783). The pooled sample size included 148,511 participants, and individual studies ranged from 427 to 67,422 participants.

In addition, a meta-analysis comparing the risk of BC in women before and after menopause was completed. A statistically significant protec-

tive role of green tea in pre-menopausal women was found with an effect size of 0.88 (95% CI = 0.79-0.99, $P = 0.035$). The pooled sample size was 1,729 participants, and individual studies ranged from 79 to 1,302 participants. No statistically significant heterogeneity was observed ($P = 0.385$). No protective effects of green tea consumption were observed in post-menopausal women.

A potential protective effect of green tea consumption was found with a 15% reduction in BC risk in the overall meta-analysis. A significant reduction in BC recurrence was also observed in the majority of cohort studies included in the meta-analysis; however, the same was not confirmed in the case-control studies. Results indicate that green tea consumption was not associated with the risk of a new BC diagnosis. Conversely, green tea consumption appears to significantly reduce BC recurrence by 19%. The authors concluded that "[t]he presented results highlight the important role of green tea in tertiary prevention rather than in primary prevention."

The authors note several limitations of the meta-analysis. The amount of green tea consumed varied considerably among the studies. Some studies reported the amount in grams, others in cups. Serving size ranged between 100 mL and 350 mL. The food frequency questionnaire (FFQ) was used by participants, but only five studies used validated tools. FFQs, which are not without potential bias, were measured at baseline only. Ongoing green tea consumption was not measured.

Other limitations of the analysis included demographics. The majority of the studies (12) were completed in Asia. Only one study from the United States was included, and no studies conducted in Europe were used in the analyses. Other factors, such as diet and cultural differences, were not considered.

In conclusion, the results of this study suggest a potential beneficial link between green tea consumption and BC risk, particularly a reduction in BC recurrence. The need for further studies is warranted. Future studies should include BC staging, accurate consumption amounts before, during, and at the conclusion of the studies, and inclusion of diverse demographical pool. HG

Tea *Camellia sinensis*
Photo ©2019 Steven Foster

Proprietary Ginkgo Extract Helps Alleviate Tinnitus and Dizziness in Patients with Dementia

Reviewed: Spiegel R, Kalla R, Mantokoudis G, et al. *Ginkgo biloba* extract EGb 761® alleviates neurosensory symptoms in patients with dementia: A meta-analysis of treatment effects on tinnitus and dizziness in randomized, placebo-controlled trials. *Clin Interv Aging*. June 13, 2018:13 1121-1127. doi: 10.2147/CIA.S157877.

By Heather S. Oliff, PhD

Tinnitus and dizziness frequently occur in patients with dementia. These symptoms may result from the impaired circulatory perfusion and mitochondrial function association with dementia, which can contribute to cochlear and vestibular dysfunction and sensory cell degeneration. Studies show that the proprietary ginkgo (*Ginkgo biloba*, Ginkgoaceae) leaf extract EGb 761® (Dr. Willmar Schwabe GmbH & Co. KG; Karlsruhe, Germany) improves inner ear and cerebral blood flow by decreasing blood viscosity and improves mitochondrial function and energy metabolism. The purpose of this meta-analysis was to evaluate whether EGb 761 was superior to placebo in alleviating tinnitus and dizziness in patients with dementia.

The following databases were searched for randomized, controlled trials (RCTs) that evaluated ginkgo preparations in patients with dementia: PubMed (inception to October 2017), EMBASE (January 2006 to October 2017), and PASCAL (inception to end of 2015). Included RCTs met the following criteria: (1) diagnoses were established in accordance with generally accepted diagnostic criteria, (2) treatment durations were at least 20 weeks, (3) outcome measures covered at least two of the three conventional assessment domains for dementia (cognition, global judgment, activities of daily living), (4) the presence and severity of tinnitus, dizziness, or both were assessed, and (5) assessments were conducted before the start and after the end of treatment. Only data from patients who had tinnitus or dizziness at baseline were included in the meta-analysis.

Five RCTs met the inclusion criteria. The authors did not report how many articles were screened for inclusion. All five studies assessed EGb 761, were sponsored by Dr. Willmar Schwabe GmbH & Co. KG, had a low risk for bias with Jadad scores of 3 (n = 2) and 5 (n = 3), and used the 11-point box scale (a type of visual analog scale) to evaluate the presence and severity of tinnitus and dizziness. EGb 761 is a standardized extract that contains 22%-27% ginkgo flavone glycosides and 5%-7% terpene lactones*

Study Details: At a Glance	
Study Design	Meta-analysis
Included Studies	5 RCTs (1,942 total patients)
Test Material	Ginkgo leaf extract EGb 761® (Dr. Willmar Schwabe GmbH & Co. KG; Karlsruhe, Germany)
Control	Placebo
Disclosures	The five RCTs were sponsored by Schwabe, and two authors are employees of Schwabe.

Ginkgo *Ginkgo biloba*
Photo ©2019 Steven Foster

* There was a typographical error in the original article that is corrected here; it should be noted that EGb 761 is always adjusted to 5%-7% terpene lactones.

(consisting of 2.8%-3.4% ginkgolides A, B, and C and 2.6%-3.2% bilobalide), and less than 5 ppm ginkgolic acids. The authors were unable to locate any RCTs that evaluated a ginkgo extract other than EGb 761 for tinnitus and dizziness. Dr. Willmar Schwabe GmbH & Co. KG provided individual patient data from the studies for the meta-analysis.

The five RCTs included a total of 1,942 patients aged 50-98 years with Alzheimer's disease (AD) (n = 904), vascular dementia (n = 374), or mixed dementia (n = 664). Patients were randomly assigned to receive 240 mg/day EGb 761 or placebo for 22-26 weeks. At baseline, 773 patients had tinnitus and 1,040 patients had dizziness; in both groups, the symptoms were mild-to-moderate at baseline. In all five studies, the severity of tinnitus decreased in the EGb 761 group compared with the placebo group. Meta-analysis of the data showed a significant improvement in tinnitus favoring the EGb 761 group ($P = 0.003$); the weighted mean difference corresponds to an improvement over placebo effects by 27%-40% of baseline severity. In four of five studies (96% of included patients), the severity of dizziness decreased in the EGb 761 group compared with the placebo group. Meta-analysis of the data showed a significant improvement in dizziness favoring the EGb 761 group ($P = 0.03$); the weighted mean difference corresponds to an improvement over placebo effects by 18%-31% of baseline severity.

The authors conclude that EGb 761 is effective in alleviating tinnitus and dizziness in patients with dementia. They state that the decrease "in tinnitus severity by 27%-40% over and above the placebo effect may represent clinically relevant effect sizes. The effects on dizziness are less pronounced but may still be clinically relevant in the given population."

The authors note that this population of older individuals is more prone to falling, and dizziness increases the fear of falling as well as the risk of falls. These factors may lead to decreased physical activity and cognitive function.

A limitation of the meta-analyses is that the subjective symptom ratings were self-reported by the patients, who have dementia. However, the authors point out that the patients had mild-to-moderate dementia (not severe) and were asked to complete the symptom survey about present symptoms, not past symptoms (i.e., recall not needed). A limitation of the individual studies is that auditory or vestibular function tests were not performed to assess underlying causes of the disturbance. HG

Aqueous Extract of Amla Improves Various Factors in Patients with Metabolic Syndrome

Reviewed: Usharani P, Merugu PL, Nutalapati C. Evaluation of the effects of a standardized aqueous extract of *Phyllanthus emblica* fruits on endothelial dysfunction, oxidative stress, systemic inflammation and lipid profile in subjects with metabolic syndrome: A randomised, double blind, placebo controlled clinical study. *BMC Complement Altern Med*. May 2019;19(1):97. doi: 10.1186/s12906-019-2509-5.

By Shari Henson

The National Cholesterol Education Program's Adult Treatment Panel III (ATP III) has identified these components of metabolic syndrome (MetS): abdominal obesity, insulin resistance with or without glucose intolerance, dyslipidemia, hypertension, and a prothrombotic state. These metabolic abnormalities can lead to endothelial dysfunction (ED), a predictor of cardiovascular disease, by affecting nitric oxide (NO) synthesis or degradation. Amla (Indian gooseberry; *Phyllanthus emblica* syn. *Emblica officinalis*, Phyllanthaceae) fruits, which are rich in polyphenolic compounds, are reported to have hypolipidemic, antidiabetic, anti-inflammatory, and antioxidant properties. The authors conducted a prospective, randomized, double-blind, placebo-controlled clinical study to evaluate the effects of two different doses of a standardized aqueous amla extract versus placebo on ED, oxidative stress, systemic inflammation, and lipid profiles in patients with MetS.

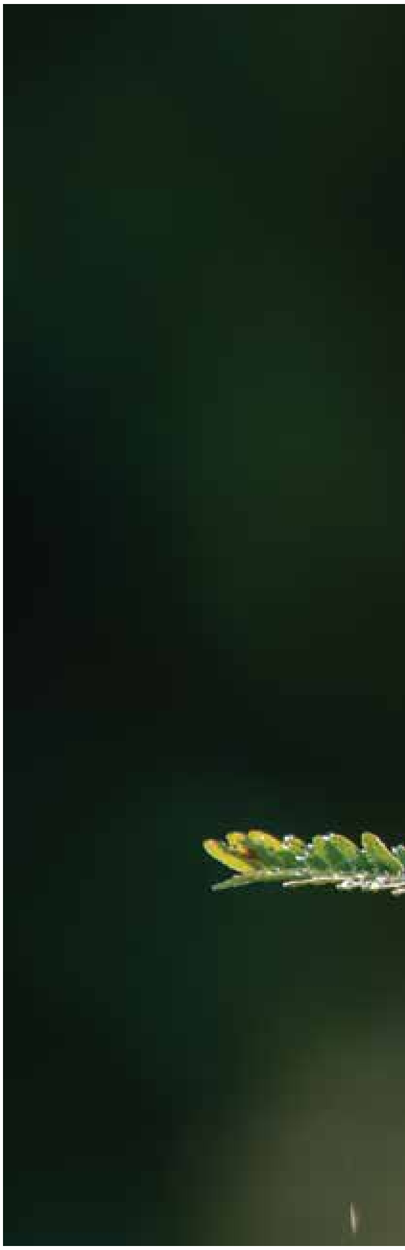
The study was conducted at the Department of Clinical Pharmacology and Therapeutics at Nizam's Institute of Medical Sciences in Hyderabad, India. Male and female patients aged 30 to 68 years who had ED and MetS were included. Of the 65 patients screened, 59 were selected for the study.

The treatments used were Capros® 250 mg and Capros® 500 mg (Natreon, Inc. USA; New Brunswick, New Jersey). Each Capros capsule contained an aqueous extract of amla fruit standardized to contain not less than 60% of low-molecular-weight hydrolyzable tannins, including emblicanin A, emblicanin B, pedunculagin, and punigluconin. Placebo capsules, also supplied by Natreon, Inc., contained microcrystalline cellulose, lactose, and magnesium stearate.

Study participants were randomly assigned to take one Capros 250 mg (n = 20), Capros 500 mg (n = 21), or placebo (n = 18) capsule twice daily for 12 weeks. A salbutamol challenge test was used to evaluate endothelial function by determining the reflection index (RI) using digital volume plethysmography, a predictor of vascular damage, at each visit. Adverse effects and compliance with the treatment protocol were assessed at each visit. At baseline and after 12 weeks, the patients underwent complete physical and laboratory examinations to determine serum levels of the oxidative stress markers NO, malondialdehyde, and glutathione; the systemic inflammation marker high-sensitivity C-reactive protein; lipids; and hepatic and renal function parameters. The primary efficacy outcome was a change in the RI greater than 6%. Secondary outcomes were improvements in lipid profiles and the markers of oxidative stress and inflammation.

Baseline RI was similar among the three groups. In the two Capros groups, RI was significantly reduced at weeks eight and 12 compared with baseline, indicating improved endothelial function ($P < 0.001$). The improvement was significantly greater in the Capros 500 mg group compared with the Capros 250 mg group ($P < 0.05$) and in the two Capros groups compared with the placebo group at weeks eight and 12 ($P < 0.05$ for each). In both Capros groups, improvements were seen in the oxidative stress and inflammation biomarkers after 12 weeks compared with baseline ($P < 0.001$

Study Details: At a Glance	
Participants	59 men and women with endothelial dysfunction and metabolic syndrome
Study Design	Prospective, randomized, double-blind, placebo-controlled clinical trial
Test Material	Amla fruit extract Capros® (Natreon, Inc. USA; New Brunswick, New Jersey)
Control	Placebo capsules containing microcrystalline cellulose, lactose, and magnesium stearate
Disclosures	Natreon provided the study medications and biomarker test kits; the authors declared no competing interests.



for each), with significantly greater improvements in the Capros 500 mg group compared with the Capros 250 mg group ($P < 0.01$ to $P < 0.001$). No significant changes were seen in the placebo group.

Significant improvements in lipid profiles were seen in the two Capros groups compared with baseline ($P < 0.001$ for both), with greater improvements seen in total cholesterol ($P < 0.05$), low-density lipoprotein cholesterol ($P < 0.001$), high-density lipoprotein cholesterol ($P < 0.001$), and triglyceride ($P < 0.01$) levels in the Capros 500 mg group compared with the Capros 250 mg group. No significant changes were seen in the placebo group.

No significant changes were observed in heart rate, hematological indices, or renal and hepatic functions in any of the groups. No serious adverse effects were reported. Two patients in the Capros groups experienced dyspepsia, and three patients in the placebo group reported mild diarrhea. Those effects were treated symptomatically.

In this study, the 250 mg and 500 mg amla extracts significantly improved endothelial function, oxidative stress, systemic inflammation, and lipid profile, with greater improvements observed with the 500 mg dosage. The authors conclude that Capros may "be used as an adjunct to conventional therapy (lifestyle modification and pharmacological intervention) in the management of MetS." HG

Amla *Phyllanthus emblica*
Photo ©2019 Steven Foster

Diversified Organic Cacao Agroforests in Ghana Serve as Reservoirs of Native Trees

Reviewed: Asigbaase M, Sjogersten S, Lomax BH, Dawoe E. Tree diversity and its ecological importance value in organic and conventional cocoa agroforests in Ghana. *PLOS One*. January 2019;14(1):e0210557. doi: 10.1371/journal.pone.0210557.

By Mariann Garner-Wizard

Study Details: At a Glance	
Purpose	To evaluate the potential of organic cacao agroforests to conserve native floristic diversity compared to conventional cacao agroforests
Study Design	Field study
Location	84 organic and conventional agroforestry plots in eastern Ghana
Disclosures	None declared

Deforestation for agricultural expansion threatens valuable tree species worldwide. Demand for cacao (*Theobroma cacao*, Malvaceae) is rising and large price increases are expected while land suitable for its production is predicted to shrink in Ghana and Côte d'Ivoire (Ivory Coast) due to climate change.

Cacao agroforestry is a production system in which farmers integrate shade trees in the same plot with food crops. In addition to providing vital shade, interplanting and/or conserving trees in situ suppresses weeds and insects, returns soil nutrients taken up by cacao trees, and improves microclimate resiliency and water retention. Producers are able to increase their income with such food, fruit, and timber products. However, the trend to replace native trees with food crops may lead to the use of agrochemicals. Smallholders often cannot bear the costs of chemical fertilizers and pesticides, so the trend to monoculture often leads to larger farms owned by fewer farmers. Higher costs of chemical-dependent farming drive the need for more land area and thus, deforestation.

Organic standards prohibit the use of synthetic chemicals. Most of Ghana's cacao production occurs under de facto organic conditions dating back to the crop's introduction in 1870, but organic agricultural certification is relatively new. Organic cacao monoculture relies on organic agrochemicals, while organic cacao agroforests use shade tree diversity to obtain the same results.

Diversified, organic agroforestry practices that conserve native trees and enhance biodiversity have been recommended for Africa. The large size of cacao-producing areas and their significant overlap with global biodiversity hotspots make quantifying the benefits of these practices essential. The authors compared the potential of organic cacao agroforestry to conserve native floristic diversity with conventional cacao agroforests (i.e., those that use synthetic agrochemicals). Indices of shade tree species richness (the number of different species in a defined area) and species diversity (the number and relative abundance of species in a defined area) were estimated from 84 organic and conventional plots. Species importance value index ("a measure of how dominant a species is in a given ecosystem") and conservation status were used to evaluate the conservation potential of shade trees in plots studied.

Cacao Farm Details

This study was conducted in seven randomly selected cacao-producing communities in Suhum Municipality in the Eastern Region of Ghana. Cacao trees were introduced to Ghana in the Eastern Region, where Suhum is home to some of the country's oldest organic cacao farms. Vegetation is mostly secondary forests, fallows, and cultivated areas. Shade-grown cacao systems are mixed with varying proportions of upper canopy shade and, increasingly, food and fruit trees. Farms are generally two hectares (4.9 acres) or smaller. Most have the recommended 12-18 shade trees per hectare that provide 30%-40% canopy cover. Major management practices include shade control, fertilizer application, pod harvesting, bean processing, and pest, weed, and disease control.

For this study, organic farms were defined as those managed for at least five years with only certified organic inputs. All organic farms in this study were registered and certified by Control Union, an international certification organization. In chosen communities, organic and conventional farms were randomly selected from lists provided by local cacao regulators. Farms were characterized as young (≤ 15 years old), mature (16-30 years old), and old (≥ 31 years old) cacao systems. Fourteen farms from each age group per farm type were selected (42 organic + 42 conventional = 84 total). Farms had similar management practices, land preparation methods, and cropping histories, and most were in neighboring communities.

Cacao yields on both types of farms ranged from 400-800 kg per hectare annually. Data were collected between April and August 2016. Within each farm, a 25 x 25 meter plot was randomly established. Within each determined plot, trees and shrubs were identified to species level, use of shade trees was determined, and the circumference and diameter of every cacao or shade tree greater than 5 cm was measured. In addition, every stem of multi-stemmed plants was measured. To compare the spatial structure of a plot, shade-providing species were grouped by whether or not they were maintained for food/fruit. To assess shade tree management, they were grouped by use for domestic (e.g., food and medicine), ecological/agroforestry (e.g., shade and nitrogen fixation), or economic (e.g., timber) needs. Residual plots and two-way analysis of variance (ANOVA) were used to assess differences between farm types overall and at each stage of maturity.

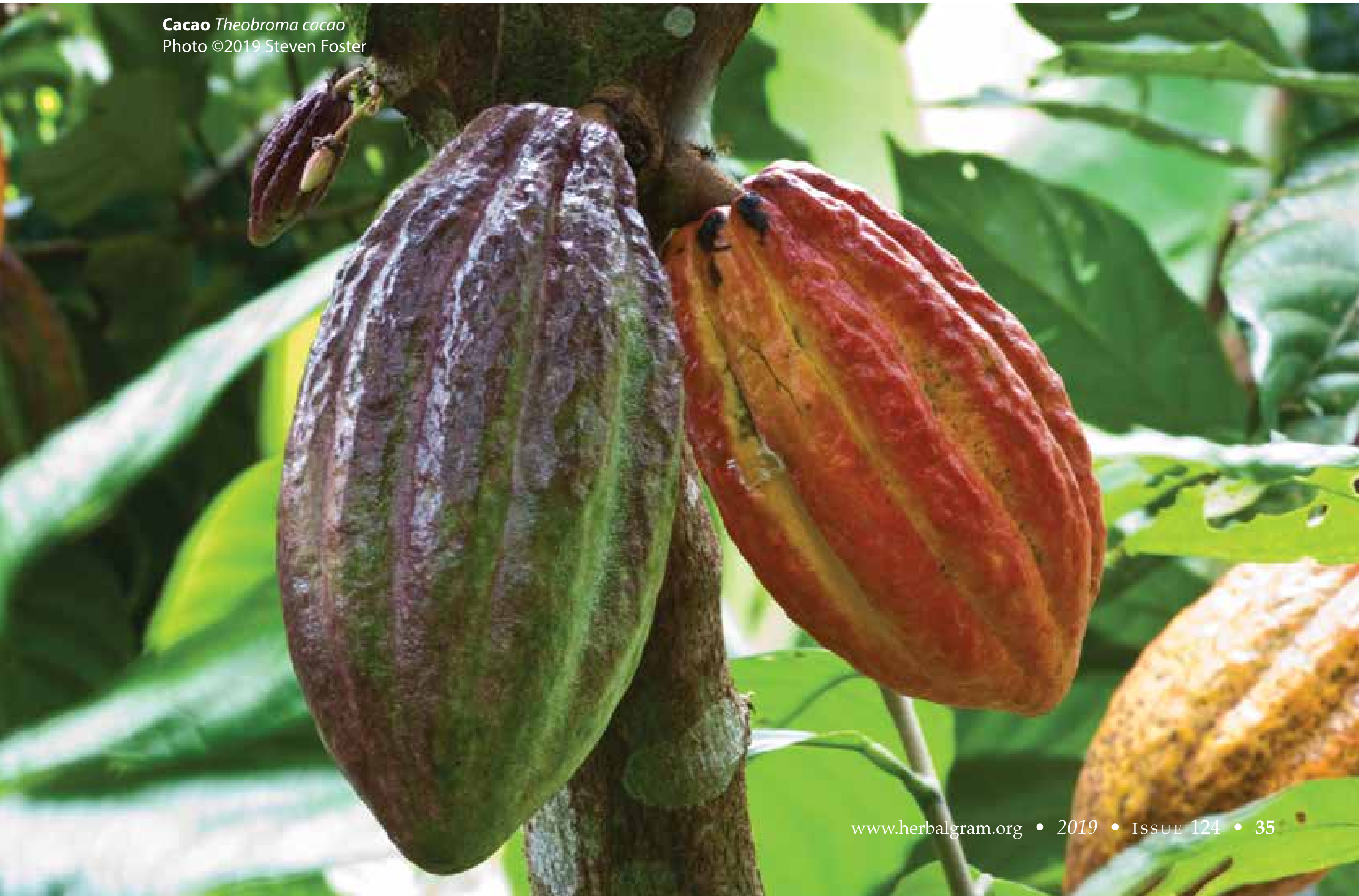
Results

In organic plots, 1,140 individual shade trees were counted in total; in conventional plots, 494 were counted. In organic young cacao systems, 41 species from 18 families were found; in conventional young cacao systems, there were 36 species from 18 families. Organic old cacao systems hosted 38 species from 19 families, and conventional old cacao systems had 27 species from 17 families.

The most abundant trees on both types of farms in all age groups were pioneer species used for timber, domestic construction, and/or medicine. (Pioneer species are the first species to colonize a certain environment.) Most were native species. Four of six food/fruit species found on all organic farms also grew on all studied conventional farms, but relative abundance of food/fruit species ranged from 77.5%-79.8% per hectare on organic farms and 45.4%-63.8% per hectare on conventional farms. Relative abundance of nitrogen-fixing plants was 6% per hectare on organic and 2.6% per hectare on conventional farms. Shade tree abundance averaged 5.10 per hectare on organic and 3.48 per hectare on conventional farms.

Organic farms had significantly higher mean species richness ($P = 0.004$) and significantly higher scores on the Shannon diversity index, Simpson's reciprocal index, and Margalef's diversity index ($P < 0.001$ for all). However, some medicinal and forest species were "notably important" on conventional farms. Despite higher total basal stem area in organic plots, conventional plots had similar shade tree stem density. Conventional young cacao systems may be trending toward greater species diversity to meet socio-economic goals. While some of the documented trees were found to have conservation concerns (14 species in the organic farms and 10 species in the conventional farms), 75% of the recorded species have not yet been assessed.

According to the authors, these results suggest that organic cacao farms "may contribute more significantly to native species conservation than conventional farms due to their high shade tree diversity and the maintenance of relatively higher levels of tree species with conservation concern." Therefore, manipulation of relative species density that does not compromise native species should be encouraged and perhaps required for organic certification, the authors concluded. HG



Cacao *Theobroma cacao*
Photo ©2019 Steven Foster

Schisandra and the Panda: Sustainable Management and Trade in Wild-harvested Schisandra in China

By Mariann Garner-Wizard

A recent study published in the *Journal of Ethnopharmacology* assessed the impacts of a research program on the sustainable management and trade of wild-harvested southern schisandra (*Schisandra sphenanthera*, Schisandraceae) fruit in China a decade after the progam's inception.[1] The five-year European Union-China Biodiversity Programme (ECBP) ran from 2007-2011 and was supported by the United Nations Development Programme (UNDP) and World Wide Fund for Nature-China (WWF-China).

The fruit of southern schisandra and northern schisandra (*S. chinensis*) are used interchangeably in traditional Chinese medicine (TCM) as an astringent active ingredient[2] for the treatment of a variety of conditions, including nocturnal emission, urinary incontinence, chronic diarrhea, palpitations, insomnia, chronic cough, and shortness of breath. Southern schisandra is used in the traditional medicine practices of at least four Chinese ethnic groups and in TCM as indicated in the *Chinese Pharmacopoeia*.[3]

The distribution of southern schisandra in mountainous forests overlaps with the habitat of the giant panda (*Ailuropoda melanoleuca*), China's iconic, vulnerable, bamboo-eating bear, both inside and outside of protected areas. The diet of the giant panda is composed almost exclusively of different plant parts of more than 60 species of bamboo in the Poaceae family.[4] Efforts to prevent the giant panda's extinction have resulted in stabilization of its population and increases in some parts of its range, but the region where giant pandas live is populated by humans, and panda corridors are threatened with development. Climate change is also expected to alter pandas' habitat. Climate change models predict a reduction of more than one-third of giant pandas' bamboo habitat over the next 80 years, with consequent population declines if this occurs.[5,6] The giant panda is no longer listed internationally as endangered but remains vulnerable as determined by the *IUCN Red List Categories and Criteria*.[7] Average income in the 41 counties in which pandas reside lags behind that of other parts of Sichuan province, where the highest density of wild pandas is found in Pingwu county. Improving rural incomes may help encourage conservation.

Traditional wild-harvesting and sun-drying of schisandra fruit by families in rural villages provides income for villagers and a supply of this much-used TCM herb, but these

Giant pandas (*Ailuropoda melanoleuca*) in the Chengdu Research Base of Giant Panda Breeding. Although southern schisandra habitat overlaps with giant panda habitat in southwestern China, pandas are not known to eat schisandra berries. Photo ©2019 J.A. Brinckmann

practices do not always result in a high-quality product and often cause ecosystem and habitat damage. Large schisandra vines twining up host trees may be pulled down with no fruits left for regeneration, and tree branches are sometimes torn off. Inferior immature fruits may be picked, scalded, and sun-dried to resemble mature berries.

A plan to improve schisandra harvesting practices arose in 2007 in an initial project of the ECBP that aimed to implement a strategic model of biodiversity conservation and sustainable development with a focus on collection within the giant panda habitat. A baseline survey by the ECBP resulted in the selection of southern schisandra as the first medicinal product to be tried in the new conservation model.

A proof-of-concept project was conducted in 2008 in a small village in Pingwu county in Sichuan province. With the participation of local wild harvesters and village and county officials, clear, accepted, and enforceable boundaries were established and marked for community management; wild harvesters received information on sustainable yields and practices; and the status of the resource at each management area was assessed. From this process, rules for resource management were developed, and the Pingwu Shuijing TCM Cooperative (PSTCMC), a community-based initiative focused on sustainable harvesting, resource management, and trade of plants used in TCM, was established. By 2016, the PSTCMC included 22 schisandra-harvesting villages with 262 households registered as harvesters, including 122 women. Improvements in processes, from sustainable harvesting methods to shade-drying, have brought increased production and income without depleting plant supplies.

Since the emergence of organic certification in the 1970s, the "moral economy" has grown to encompass a range of other certification standards, including fair trade and wildlife-friendly eco-labels. Businesses and producers, the 2018 article notes, must be willing to adopt new methods and standards, at all levels and significant cost, to achieve environmentally friendly goals.

Stakeholder involvement in developing verifiable, meaningful certification standards and processes is vital. Before their involvement in the initiative for panda-friendly south-

Schisandra *Schisandra sphenanthera*
Photo ©2019 Bryant DeRoy

ern schisandra, Traditional Medicinals (TM; Rohnert Park, California) initially had used only northern schisandra in its product and had supported a separate Wildlife Conservation Society (WCS) project (2004-2007) to develop "tiger [*Panthera tigris*]-friendly certified" schisandra efforts in the Russian Far East. While the WCS project did not succeed in the end, TM was invited to participate in the ECBP project (2007-2011). After determining feasibility, TM decided to reformulate its product using sustainably harvested "panda-friendly" southern schisandra, if pharmacopeial quality and producer reliability could be established. Because the herb is used as an extract, TM invited a Chinese extraction house, Draco/Shanghai Tian Yuan Botanicals Products Company (Shanghai, China), into the project in order to prepare the dry aqueous schisandra extract.

Guidelines for the sustainable wild collection of schisandra were developed and tested for the 2009 harvest and subsequently revised based on that experience. The species-specific harvesting and trading guidelines were based, in part, on the principles and criteria of the FairWild Standard[8,9] and the US Department of Agriculture National Organic Program wild-crop harvesting practice standard.[10] The PSTCMC was inspected by the Institute for Market Ecology (now Ecocert IMO; Kreuzlingen, Switzerland) in 2011 and received its first organic certification for wild collection of southern schisandra. It has maintained organic certification hitherto, switching to CERES (Shanghai) Certification Co., Ltd. in 2014.

Because the schisandra harvest was taking place within the giant panda habitat, a wildlife-friendly standard, the Standards for Giant Panda Friendly Products, also was developed and tested as an outcome of the ECBP and went on to become an official Chinese national standard in 2017. The panda-friendly standard requires harvested TCM ingredients to be "favourable or bring no harm to the maintenance and improvement of wild giant panda populations [and] habitat quality … during [the ingredients'] entire production, including wild-harvesting, cultivation, post-harvest processing, and sales."[1]

In 2012, the ECBP panda-friendly schisandra project received the UNDP Equator Prize, which is awarded to outstanding local initiatives that advance sustainable development for people, nature, and resilient communities.[11] Importantly, the initial five-year project supported by governmental and nongovernmental organizations is, according to this report, thriving at the 10-year mark as an independent, self-supporting, sustainable, long-term venture.

In September 2015, the PSTCMC announced its readiness to branch out to other TCM herbs in its management area. New ingredients proposed to be harvested under the panda-friendly, certified organic management plan include *dong quai* (*Angelica sinensis*, Apiaceae) root, gastrodia (*Gastrodia elata*, Orchidaceae) rhizome, magnolia (*Magnolia officinalis*, Magnoliaceae) flower bud, and Chinese rhubarb (*Rheum palmatum*, Polygonaceae) root and rhizome.

In the past few years, there has been a push to expand the range of panda-friendly ingredients, products, and production bases. Other cooperatives in other provinces within the giant panda habitat areas are working toward inspection and panda-friendly certification for a range of other botanicals, including Chinese salvia (*Salvia miltiorrhiza*, Lamiaceae) root and rhizome, coptis (*Coptis chinensis* or *C. deltoidea*, Ranunculaceae) rhizome, Dahurian angelica (*Angelica dahurica*, Apiaceae) root, sea buckthorn (*Hippophae rhamnoides*, Elaeagnaceae) fruit, Sichuan pepper (*Zanthoxylum bungeanum*, Rutaceae) fruit and peel, and turmeric (*Curcuma longa*, Zingiberaceae) rhizome, among others. HG

References

1. Brinckmann JA, Luo W, Xu Q, He X, Wu J, Cunningham AB. Sustainable harvest, people and pandas: Assessing a decade of managed wild harvest and trade in *Schisandra sphenanthera*. *J Ethnopharmacol*. 2018;224:522-534.
2. Committee of Chinese Medicine and Pharmacy. *Taiwan Herbal Pharmacopoeia*. 2nd Edition, English Version. Taipei City: Ministry of Health and Welfare; 2016.
3. Chinese Pharmacopoeia Commission. *Pharmacopoeia of the People's Republic of China (2015) Volume I*. Beijing: China Medical Science Press; 2015.
4. Wang H, Zhong H, Hou R, et al. A diet diverse in bamboo parts is important for Giant Panda (*Ailuropoda melanoleuca*) metabolism and health. *Sci Rep*. 2017;7:3377.
5. Li R, Xu M, Wong MHG, et al. Climate change threatens giant panda protection in the 21st century. *Biol Conserv*. 2015;182:93-101.
6. Tuanmu M-N, Viña A, Winkler JA, et al. Climate-change impacts on understorey bamboo species and giant pandas in China's Qinling Mountains. *Nat Clim Change*. 2012;3:249.
7. Swaisgood R, Wang D, Wei F. *Ailuropoda melanoleuca* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T712A121745669. 2016. Accessed November 5, 2019.
8. Meinshausen F, Winkler S, Bächi R, Staubli F, Dürbeck K. *FairWild Standards, Version 1*. Weinfelden, Switzerland: Institute for Market Ecology; 2006.
9. FairWild Foundation. FairWild Standard: Version 2.0. Weinfelden, Switzerland: FairWild Foundation; 2010.
10. United States Department of Agriculture. NOP 5022 Wild Crop Harvesting Internal Rev 01 07 22 11. Washington, DC: United States Department of Agriculture; 2011.
11. Lindstrom A. Sponsor of sustainable and panda-friendly Chinese schisandra project awarded a 2012 Equator Prize. *HerbalGram*. 2012(95):21.

Where Have All the Flowers Gone?*

By Josef A. Brinckmann

This opinion piece is based partly on direct observations from field work over the decades with communities in rural and remote areas who depend on wild collection and farming of medicinal plants for some or all of their household income. Flowering, fruiting, harvesting periods, and yields of many of these plants have become erratic.[1] My opinions also are informed by coming of age around the start of the modern environmental movement.[2] While 16-year-old Swedish environmental activist Greta Thunberg inspired teenagers across the world with her proclamation in January 2019 that "our house is on fire,"[3] which I applaud, I actually thought that "our house" was on fire 50 years ago.

This climate crisis didn't show up unannounced. Some readers of this opinion piece may not believe that the climate crisis has been caused by human activity — and, therefore, cannot be corrected by human intervention. However, many human-related issues, which have become worse over the last half-century, signal the need for immediate action.

These issues include: anthropogenic contamination (such as vehicle exhaust, heavy metals from industrial pollution,[4] the now-widespread nonpoint source pesticide pollution from conventional agriculture due to long-range atmospheric transport,[5] and microplastic particles detected in the air, soil,[6] and oceans[7]), land use changes over the centuries (e.g., converting meadows and forests to farmland and grazing land), loss of biodiversity, loss of habitat, plant relationships with pollinators disrupted by phenological changes,[8] pollinator disappearance, species extinctions, and so on.

A 2019 study by the Royal Botanic Gardens, Kew, and Stockholm University found that nearly 600 plant species have gone extinct since the publication of Swedish botanist Carl Linnaeus' 1753 *Species Plantarum*.[9,10] In 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) issued a report stating that the rate of species extinctions is accelerating: Up to one million plant and animal species face extinction, with agriculture cited as one of the main threats.[11]

Growing up in the United States in the 1950s and 1960s, several occurrences sounded existential alarm bells. Significant events, perhaps because they were so alarming, caused me to pay closer attention, transformed the way I experience the natural world, and made me take notice of how humans possess such a unique ability to muck it all up.

One could be tempted to view each anthropogenic hazard in a vacuum (i.e., as a separate or unconnected event). But, if one looks closely, one can see the connections among the seemingly separate dots. Contrary to the jarring "Control Voice" heard at the start and end of early 1960s episodes of "The Outer Limits" television show, something was, indeed, wrong with (what we were seeing on) the television set. In the meantime, some have attempted to "adjust the picture" and "take control of the horizontal and the vertical." Climatologists, conservation biologists, ecologists, environmentalists, naturalists, other "ists," and astute observers have been trying, in numerous ways, to explain what we were beginning to witness more than 50 years ago, which today is accelerating exponentially.

When I was a boy, one could not only smell the polluted air in industrialized and urban areas, but one could see it. It was brown and irritating to the nose and eyes. Occasional ozone alerts were issued by the authorities: "Stay indoors." "Don't breathe." The sky was falling, it seemed. The Cuyahoga River was on fire in Cleveland, Ohio[12]; an

Nova genera from Carl Linnaeus' *Species Plantarum* (1753) Artwork courtesy of Missouri Botanical Garden, Peter H. Raven Library.

* Title of a song written in 1955 by American folksinger and political activist Pete Seeger (1919-2014).

entire neighborhood in Niagara Falls, New York, built atop a 1940s chemical landfill site, was experiencing toxic fumes and explosions in homes and schools (the Love Canal disaster)[13]; and concerns about the effects of acid rain on ecosystem integrity entered the public discussion.[14] Air and water pollution in the United States probably reached their highest levels in the late 1960s.[15] Federal air pollution laws were passed in 1955, 1963, 1965, and 1967, culminating with the Clean Air Act of 1970 and the establishment of the Environmental Protection Agency (EPA) the same year.[16] The Clean Water Act became law in 1972.[17]

Although United States policy makers are inexplicably trying to deregulate and dismantle environmental protections, air and water quality have improved in the United States over the past 50 years due to the awareness built from the modern environmental movement and enforcement of environmental protection laws. The same cannot be said for the four other most populous countries in the world. Pollution and environmental degradation have reached dangerous levels in China, India, Indonesia, and Brazil.

In 1968, biologist Paul Ehrlich stirred up awareness about overpopulation and overconsumption with his controversial book *The Population Bomb* (Ballantine Books).[18,19] In 1971, Frances Moore Lappé's seminal book *Diet for a Small Planet* (Ballantine Books) aimed to illuminate and quantify the negative environmental impacts of large-scale meat production.[20] That book influenced my decision to become a vegetarian. Clear-cutting of ancient rainforests in the Amazon region was increasing, and fires were burning, and still are. Cattle ranching and cultivating soybeans (*Glycine max*, Fabaceae) for animal feed reportedly have been the main drivers of Amazon deforestation since 1970.[21]

In the mid-1970s, I recall being very excited to attend a lecture at the University of California, Berkeley by explorer and oceanographer Jacques-Yves Cousteau (1910-1997). It wasn't uplifting. The message from this remarkable scientist seemed to be that it may already be too late. "The oceans are dying" was his dark theme.[22] The Hanford Nuclear Reservation in Washington State was decommissioned back then, as well, but has, for decades, continued to threaten the Columbia River with radioactive contamination,[23] just as the 2011 Fukushima meltdown continues to threaten the seas, and all life dependent on the seas, with nuclear pollution.[24]

It now seems that idealistic hippies may have been right that everything in nature is interconnected.[25] This can be illustrated by the fact that residues of "legacy pesticides" (e.g., DDT) as well as new "current use pesticides" (CUPs) have been detected in Arctic ice caps, evidence of long-range atmospheric transport.[26] Wildflowers and bee pollen also are found to be contaminated by a wide range of pesticide chemicals used in conventional agriculture.[27] The phenomenon described as Colony Collapse Disorder (CCD) is a relatively new area of research associated with toxicity of agrochemicals and possibly other factors.[28] Insecticides, herbicides, and pesticides do not stay down on the farm. For example, the widespread use of glyphosate in conventional agriculture has led to global environmental contamination, now detected in soil, air, water, and human urine.[29] Despite the *Reinheitsgebot* (the German beer purity law of 1516, which is still in effect), glyphosate is now detectable in nearly all German beers.[30]

What does all of this have to do with the survival of medicinal and aromatic plants and herbal medicine? Everything, in my opinion. Climate change is observed to impact not only the quality and geographical distribution of wild plants — for example, the mountain forest liana *Schisandra sphenanthera* (Schisandraceae)[31] and high-altitude *Rhodiola* species (Crassulaceae)[32] — but also the ability of species to adapt to a rapidly changing environment, as reported for the desert steppe species *Glycyrrhiza uralensis* (Fabaceae).[33] It is not yet known whether certain species can adapt or migrate rapidly enough to survive. If they do survive, it is not known what changes in chemical composition and content may occur, and, correspondingly, what changes in pharmacological action would occur. In addition, animals need plants. It is already predicted that Australia's koala (*Phascolarctos cinereus*) may go extinct partly due to drought-driven changes in the chemistry composition of *Eucalyptus* spp. (Myrtaceae) leaves.[34] The koala is a specialist that depends almost entirely on eucalyptus trees for shelter and its leaves for nutrition. Similarly, the giant panda (*Ailuropoda melanoleuca*) is a specialist, dependent

In 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services issued a report stating that the rate of species extinctions is accelerating: Up to one million plant and animal species face extinction, with agriculture cited as one of the main threats.

on bamboo habitat. Climate change may reduce more than a third of the giant panda's bamboo habitat over the next 80 years.[35]

Rapid loss of biodiversity on this planet is an existential threat and corresponds to species extinctions; food, water, and medicine insecurity; climate events increasing in frequency and severity; and "climate refugees," or the growing number of people being displaced because they are not able to live in once-habitable areas (e.g., coastal regions) and farmers and pastoralists unable to survive due to prolonged droughts, desertification, and salinization of agricultural land.

It may not be fair to be upset with friends because they are asleep. But how many wake-up calls does one need to see the forest for the trees? It may be time to finally wake up, plant a tree or many trees, leave fossil fuels behind as fast as you can, and do something, anything — and everything — you are able to do. HG

References

1. Daniells S. The erosion of predictability: Climate change and the botancial supply chain. NutraIngredients-USA. March 22, 2018. Available at: www.nutraingredients-usa.com/Article/2018/03/22/The-erosion-of-predictability-Climate-change-and-the-botanical-supply-chain#. Accessed September 21, 2019.
2. Rome A. "Give earth a chance": The environmental movement and the sixties. *J Am Hist.* 2003;90(2):525-554.
3. Thunberg G. 'Our house is on fire': Greta Thunberg, 16, urges leaders to act on climate. *The Guardian.* January 25, 2019. Available at: www.theguardian.com/environment/2019/jan/25/our-house-is-on-fire-greta-thunberg16-urges-leaders-to-act-on-climate. Accessed September 21, 2019.
4. Serbula SM, Kalinovic TS, Ilic AA, Kalinovic JV, Steharnik MM. Assessment of airborne heavy metal pollution using *Pinus* spp. and *Tilia* spp. *Aeros Air Qual Res.* 2013;13(2):563-573.
5. USP Botanical Dietary Supplements and Herbal Medicines Expert Committee (Brinckmann JA, Dentali S, Fletcher E, Gafner S, and Marles RJ) and USP Staff (Okunji C, Sarma N, and Giancaspro GI). Stimuli to the revision process: Need for clear regulation of pesticide residue limits for articles of botanical origin. *Pharmacopeial Forum.* 2016;42(2):17 pages.
6. Corradini F, Meza P, Eguiluz R, Casado F, Huerta-Lwanga E, Geissen V. Evidence of microplastic accumulation in agricultural soils from sewage sludge disposal. *Sci Total Environ.* 2019;671:411-420.
7. van Sebille E, Wilcox C, Lebreton L, et al. A global inventory of small floating plastic debris. *Environ Res Lett.* 2015;10(12):124006.
8. Kharouba HM, Ehrlén J, Gelman A, et al. Global shifts in the phenological synchrony of species interactions over recent decades. *Proc Natl Acad Sci.* 2018;115(20):5211-5216.
9. Linné Cv, Salvius L. *Caroli Linnaei ... Species plantarum :exhibentes plantas rite cognitas, ad genera relatas, cum differentiis specificis, nominibus trivialibus, synonymis selectis, locis natalibus, secundum systema sexuale digestas.* Vol 2. Holmiae :: Impensis Laurentii Salvii; 1753.
10. Humphreys AM, Govaerts R, Ficinski SZ, Nic Lughadha E, Vorontsova MS. Global dataset shows geography and life form predict modern plant extinction and rediscovery. *Nat Ecol Evol.* 2019.
11. IPBES. *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.* Bonn, Germany: IPBES Secretariat; 2019.
12. Boissoneault L. The Cuyahoga River caught fire at least a dozen times, but no one cared until 1969. *Smithsonian Magazine.* 2019. Available at: www.smithsonianmag.com/history/cuyahoga-river-caught-fire-least-dozen-times-no-one-cared-until-1969-180972444/. Accessed September 19, 2019.
13. Phllips AS, Yung-Tse Hung, Bosela PA. Love Canal tragedy. *J Perform Constr Facil.* 2007;21(4):313-319.
14. Menz F, Seip H. Acid rain in Europe and the United States: An update. *Environ Sci Policy.* 2004;7:253-265.
15. Ahlers C. Origins of the Clean Air Act: A new interpretation. *Environ Law.* 2015;45:75-127.
16. Sullivan TJ, Driscoll CT, Beier CM, et al. Air pollution success stories in the United States: The value of long-term observations. *Environ Sci Policy.* 2018;84:69-73
17. Craig RK. Climate change comes to the Clean Water Act: Now what? *Wash & Lee J Energy Climate & Env't.* 2010;1(1):9-48.
18. Ehrlich P. *The Population Bomb.* New York, NY: Ballantine Books; 1968.
19. Carrington D. Paul Ehrlich: 'Collapse of civilisation is a near certainty within decades'. *The Guardian.* 2018. Available at: www.theguardian.com/cities/2018/mar/22/collapse-civilisation-

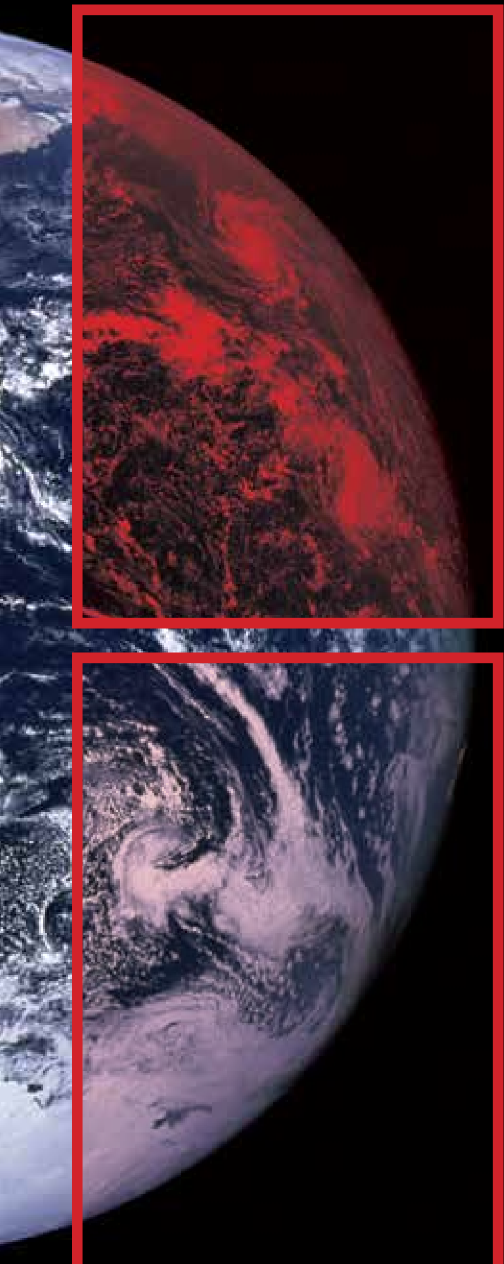
near-certain-decades-population-bomb-paul-ehrlich. Accessed September 19, 2019.
20. Lappé FM. *Diet for a Small Planet.* New York, NY: Ballantine Books; 1971.
21. Toliver Z. Is the meat industry fueling the record-breaking Amazon rainforest fires? PETA. 2019. Available at: www.peta.org/blog/meat-industry-amazon-rainforest-fires/. Accessed September 19, 2019.
22. Cousteau J. Our oceans are dying. *The New York Times*. November 14, 1971:E13.
23. Cary A. Deadly radioactive sludge safely away from Columbia River. What's next for Hanford? *Tri-City Herald.* 2019. Available at: www.tri-cityherald.com/news/local/hanford/article234969917.html. Accessed September 19, 2019.
24. Liang XS, Rong Y-N. Nuclear Pollution in the East China Sea from the Fukushima Disaster. In: Liang XS, Yuanzhi Zhang, eds. *Coastal Environment, Disaster, and Infrastructure - A Case Study of China's Coastline.* London, United Kingdom: IntechOpen; 2018.
25. Shipley M. Hippies and the mystic way: Dropping out, unitive experiences, and communal utopianism. *Utop Stud.* 2013;24(2):232-263.
26. Zhang X, Meyer T, Muir DCG, Teixeira C, Wang X, Wania F. Atmospheric deposition of current use pesticides in the Arctic: Snow core records from the Devon Island Ice Cap, Nunavut, Canada. *Environ Sci Process Impacts.* 2013;15(12):2304-2311.
27. David A, Botías C, Abdul-Sada A, et al. Widespread contamination of wildflower and bee-collected pollen with complex mixtures of neonicotinoids and fungicides commonly applied to crops. *Environ Int.* 2016;88:169-178.
28. López-Uribe MM, Simone-Finstrom M. Special issue: Honey bee research in the US: Current state and solutions to beekeeping problems. *Insects.* 2019;10(1):22.
29. Landrigan PJ, Belpoggi F. The need for independent research on the health effects of glyphosate-based herbicides. *Environ Health.* 2018;17(1):51.
30. Umweltinstitut München e.V. *Glyphosat im Bier: Wie belastet sind deutsche Biere 2017?* München, Deutschland: Umweltinstitut München e.V.; 2017.
31. Guo Y, Wei H, Lu C, Gao B, Gu W. Predictions of potential geographical distribution and quality of *Schisandra sphenanthera* under climate change. *PeerJ.* 2016;4:e2554.
32. You J, Qin X, Ranjitkar S, et al. Response to climate change of montane herbaceous plants in the genus *Rhodiola* predicted by ecological niche modelling. *Sci Rep.* 2018;8(1):5879.
33. Huang J, Wang P, Niu Y, et al. Changes in C:N:P stoichiometry modify N and P conservation strategies of a desert steppe species *Glycyrrhiza uralensis*. *Sci Rep.* 2018;8(1):12668.
34. Reckless HJ, Murray M, Crowther MS. A review of climatic change as a determinant of the viability of koala populations. *Wildlife Res.* 2017;44(7):458-470.
35. Brinckmann JA, Luo W, Xu Q, He X, Wu J, Cunningham AB. Sustainable harvest, people and pandas: Assessing a decade of managed wild harvest and trade in *Schisandra sphenanthera*. *J Ethnopharmacol.* 2018;224:522-534.

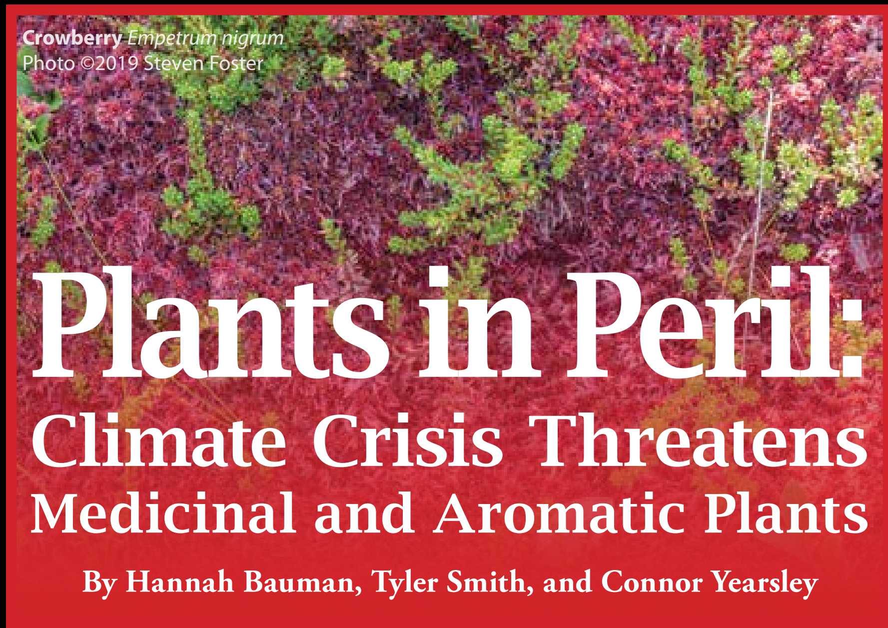
Rhodiola *Rhodiola rosea*
Photo ©2019 Steven Foster

Labrador tea *Rhododendron groenlandicum*
Photo ©2019 Steven Foster

Motherwort *Leonurus cardiaca*
Photo ©2019 Steven Foster

Rhodiola *Rhodiola rosea*
Photo ©2019 Petra Illig





Crowberry *Empetrum nigrum*
Photo ©2019 Steven Foster

Plants in Peril:

Climate Crisis Threatens Medicinal and Aromatic Plants

By Hannah Bauman, Tyler Smith, and Connor Yearsley

Introduction

***HerbalGram* issue 81, published in 2009, featured an extensive article by then-Managing Editor Courtney Cavaliere about the effects of climate change on medicinal and aromatic plants (MAPs).[1] In the decade since then, the situation has intensified, and new insights have emerged.**

HerbalGram issue 81

In the face of climate change, plants, including MAPs, may move, adapt, or go extinct. Indeed, large-scale changes in plant distributions, flowering times, and community assemblages are occurring across the globe due to climate change. For now, there is little evidence of plant extinctions caused by climate change, but extinctions are expected to occur if plants cannot move or adapt quickly enough and current trends continue.[2] A recent report found that 1 million plant and animal species are threatened with extinction, with climate change listed as the third biggest driver of "change in nature."[3]

Levels of carbon dioxide, a prevalent, heat-trapping greenhouse gas, are higher now than at any time in the past 400,000 years, as shown by ancient air bubbles trapped in ice. In 2013, carbon dioxide levels surpassed 400 ppm for the first time on record.[4] Forestation can remove, or sequester, atmospheric carbon dioxide. A 2019 study found that, under the current climate regime, the Earth can support an additional 0.9 billion hectares of continuous forest (excluding existing trees and agricultural and urban areas). This has the potential to reduce current atmospheric carbon dioxide by up to 25%, to levels last seen almost a century ago. However, as temperatures rise, suitable land area for forests decreases. Preserving existing forests and phasing out fossil fuels remain vital, since new forests take decades to mature.[5,6]

According to a 2018 study, Earth's climate could resemble that of the mid-Pliocene (3-3.3 million years ago) by 2030, and, without emission reductions, it could resemble Early Eocene climates (ca. 50 million years ago) by 2150. This suggests that humans are rewinding the climate clock by about 50 million years and reversing a multimillion-year cooling trend in less than two centuries.[7]

All species on Earth today have an ancestor that survived these epochs, but "large climate changes expected for the coming decades will occur at a significantly accelerated pace compared with Cenozoic climate change and across a considerably more fragmented landscape, rife with additional stresses," the authors wrote. Plus, over the past 50 million years, species have adapted "away from hothouse climates to a world that was cooling, drying, and characterized by decreasing atmospheric CO_2." The potential rapid reversion to Eocene-like climates causes serious concerns about the adaptive capacity of species, including MAPs.[7]

Some news outlets have started changing their style guides to emphasize the situation's seriousness. For example, in May 2019, *The Guardian* stated that the publication's preferred terms are "climate emergency, crisis or breakdown…. The phrase 'climate change,' for example, sounds rather passive and gentle when what scientists are talking about is a catastrophe for humanity."[8]

Medicinal and Aromatic Plants in the Arctic

The Arctic is the region above the Arctic Circle and the northernmost region on Earth.[9] While Earth's average surface temperature has increased about 1°C (1.8°F) since the 1880s, the Arctic has warmed more than twice as fast. Although the tundra, which is home to hardy flora and fauna, is one of the coldest and harshest biomes on Earth, it is also one of the fastest warming. Shrubs are growing taller, and some plants are migrating north, an indication of the greening of the Arctic.[10]

According to one model, by 2036, Arctic summers may be so hot that most of the sea ice that forms in winter will melt. That means that the Arctic Ocean will be navigable except for the last remaining ice along the northern Canadian islands and Greenland, and much of the surrounding land is expected to be green. By mid-century, the Bering

According to one model, by 2036, Arctic summers may be so hot that most of the sea ice that forms in winter will melt.

A depiction of Arctic sea ice on September 12, 2013, the day before the National Snow and Ice Data Center estimated sea ice extent at its annual minimum. The yellow line shows the 30-year average minimum extent.
Credit: NASA Scientific Visualization Studio/Cindy Starr

Sea, which lies between Alaska and Russia, will likely be open most of the year, and algae that grow on ice and are part of a food web that extends to fish and whales will likely disappear.[10]

Melting sea ice is not believed to increase sea levels since sea ice is already part of the ocean's mass, but land ice melting into the ocean, in the Arctic and elsewhere, is causing rising sea levels. Also, water expands as it warms (i.e., thermal expansion), which also contributes to sea level rise.[9,10] In addition, permafrost (ground that remains frozen year-round) is thawing, causing the ground to collapse and visibly changing the Arctic.[11] As snow and ice melt, large amounts of carbon dioxide, previously trapped for millennia in the ocean and permafrost, are being released. Climate change will continue to speed up because of this and what is called ice-albedo feedback. That is, snow and ice reflect most incoming sunlight back into space. Open water, however, is much less reflective and absorbs more heat. Melting means more open water, a "feedback loop" that causes more warming.[9-11]

Warming in the Arctic is also extending the ranges of animals, which can have significant impacts on the landscape. For example, beavers, which are attracted by larger and more abundant shrubs, are colonizing northern Alaska, moving at about five miles per year.[11] They reportedly mostly prefer to chew down trees in the willow (Salicaceae) family, like *Populus* and *Salix* species.[12] When beavers dam up creeks, this process creates new ponds and lakes, causing permafrost to collapse and changing the land. Large foragers like moose also are moving into new areas, affecting Arctic vegetation.[11] While a warmer Arctic may enable access to new fishing grounds; vast deposits of gas, oil, and minerals; and open shipping lanes (which will cause more carbon emissions), it has significant and far-reaching implications for plants, people, and animals.[10,11]

Since he was quoted in *HerbalGram*'s 2009 article, Alain Cuerrier, PhD, an adjunct professor at the University of Montreal and botanist at the Montreal Botanical Garden, has conducted more research and made new observations about Arctic plants.

Cuerrier and his colleagues have analyzed phenol and/or terpene concentrations of various plants and observed that concentrations typically increase with latitude until the plants seem to reach their northern limits. "We have done studies on Labrador tea [*Rhododendron groenlandicum*, Ericaceae], mountain ash [*Sorbus decora* and *S. americana*, Rosaceae], and a carnivorous pitcher plant [*Sarracenia purpurea*, Sarraceniaceae]," Cuerrier wrote (email, October 1, 2019). "Climate change may affect (lower) the concentrations, because the plants do not need to combat photoinhibition."*

Cuerrier also has studied berries growing in small open-top chambers that mimic warming (1-2°C), but, according to him, antioxidant levels were not significantly differ-

* According to Cuerrier, photoinhibition can cause cell death that disturbs photosynthesis. The problem occurs when light intensity is high and either or both water deficit/temperature are low, creating free radicals through lack of carbon dioxide production. This phenomenon is more relevant in places like the Arctic or at high altitudes.

Cloudberry *Rubus chamaemorus*
Photo ©2019 Alain Cuerrier

ent between those berries and berries growing in control plots, "although we could see that antioxidant activity was dropping, but not significantly on the basis of a few years."

One of the new concerns voiced by Inuit (a group of indigenous peoples, most of whom inhabit northern Canada) is seashore erosion, according to Cuerrier. "This is where rhodiola [*Rhodiola rosea*, Crassulaceae] thrives," he wrote. "So, some Inuit have seen rhodiola plants being washed away." Root preparations of rhodiola have been used for many purposes, including the treatment of altitude sickness and boosting energy, and are considered adaptogenic (i.e., they can increase the state of non-specific resistance to stress).[13]

Cuerrier added that all plants growing on the shore are vulnerable to inundations from melting snow and ice. "In Canada, this includes rhodiola, honckenya [*Honckenya peploides*, Caryophyllaceae], willows [*Salix* spp., Salicaceae], and some Northern Labrador tea [*Rhododendron tomentosum*]," he wrote.

Besides the rhodiola example, Cuerrier is not aware of any notable die-offs of Arctic medicinal plants. "I am more concerned with lower concentration of metabolites [i.e., the plants' chemistry], thus the quality of medicinal plants," he wrote.

According to Cuerrier, it is too soon to say whether any native medicinal plant species are being harmed noticeably because of new competition from other species. "With more tamarack/larch [*Larix laricina*, Pinaceae] and spruces [*Picea mariana*, Pinaceae], the [Canadian] landscape, from a local perspective, will definitely change," Cuerrier wrote. "We obviously need to understand the ecology of the northern mosses and lichens."

A 2019 study, co-authored by Cuerrier, summarized data from 191 interviews that assessed the relationships of Inuit peoples to different berry species in the Canadian territories of Nunavut, Nunavik, and Nunatsiavut. For the Inuit, berry picking is an important cultural practice and contributes to physical and mental health. In fact, berries are reportedly the most widely harvested plants by the Inuit today and are used for food, medicine, fuel, and bedding. In addition, berries have been important famine food for the Inuit. However, in some places, climate change and other factors are impacting berry availability, accessibility, and possibly quality. Over the last century, many areas where berry picking is important have seen milder winters and warmer and drier summers.[14]

All Inuit interviewees were considered knowledge holders, and most were elderly. The most commonly harvested berries were blueberries (*Vaccinium uliginosum*, *V. caespitosum*, Ericaceae), lingonberries (*V. vitis-idaea*), cloudberries (*Rubus chamaemorus*, Rosaceae), and crowberries, also called blackberries (*Empetrum nigrum*, Ericaceae). Bearberries (*Arctous rubra*, *A. alpina*, Ericaceae)

Mountain ash *Sorbus americana*
Photo ©2019 Steven Foster

Lingonberry *Vaccinium vitis-idaea*
Photo ©2019 Steven Foster

Cloudberry *Rubus chamaemorus*
Photo ©2019 Steven Foster

also are found at most of the interview sites but are harvested at only one site. Most of the Inuit who were interviewed pick berries at the end of summer before the first frost. Previously, berries also were harvested throughout the year as they ripen, under the snow or right after snowmelt. Some Inuit also described past practices of preserving the berries by storing them in the ground in hide pouches, fish swim bladders, caribou stomachs, and other containers. It is unclear from the study if climate change has affected these practices, however. Throughout the Arctic, berries often are mixed with fat, blubber, fish, and other fruits and vegetables. They also are used to make jams.[14]

Some Inuit thought drier conditions have changed the berries' taste. Because climate change is associated with increasing height and cover of erect shrubs, this has reduced the accessibility of some berry patches. "In some instances, shrubs are perceived to diminish berry productivity while in others, like during a warm and dry summer, they may provide shade and thus have a positive influence on the quality of the berries," the study authors wrote. Other studies have shown "that the cover and productivity of berry species usually diminished under erect shrubs." The authors noted that the Inuit historically have had to adapt to fluctuations in climate, animal populations, and plant productivity, but suggested that berry picking should be considered in land-use planning, especially since food insecurity and consumption of low-quality foods are important issues in the Canadian Arctic.[14]

According to a 2010 study, Alaskan tribal communities noted that berries can be compromised or enhanced by climate fluctuations. Wild berries are an important dietary component for native peoples in Alaska and are rich in polyphenolic compounds that can help treat disorders such as obesity and diabetes. This study analyzed five Alaskan berry species — Alaska blueberry (*Vaccinium ovalifolium*), *V. uliginosum*, cloudberry, salmonberry (*Rubus spectabilis*), and crowberry — from different tribal communities and found significant site-specific variations in some berry constituents.[15]

Joshua Kellogg, PhD, lead author of the study and assistant professor in the department of veterinary and biomedical sciences at Pennsylvania State University, explained: "We could not definitively say that climate was the driving force of the chemical differences between the collection sites…. But…the colder, 'harsher' environment further north seemed to correlate with more potent berry chemistry. Definitely, there is a need for a follow-up study on a more longitudinal scale that also can determine the contributions that the climate, environment, and genome have on the berries' chemistry and bioactivity" (email, October 1, 2019).

Petra Illig, MD, a physician and resident of Anchorage, Alaska, who in 2008 started a rhodiola cultivation effort in Alaska, said she is "extremely concerned" about the potential effects of climate change on the plant (email, September 28, 2019).

Crowberry *Empetrum nigrum*
Photo ©2019 Steven Foster

"I don't know if climate change is going to translate to better or worse conditions for rhodiola," Illig wrote. "Rhodiola cultivation in Denmark and northern Germany is going well, and they seem to get their plants to maturity a year or so sooner than we do in Alaska. But there are so many variables that it is difficult to assign one cause. One wonders if rhodiola will do better in a somewhat milder climate, as long as it gets the long summer daylight and enough moisture. But if climate change brings drier conditions, then that may not be a good thing for this succulent plant."

She noted that many unknowns come with climate change, so it is difficult to predict. "But, for sure, things will be quite different from before. We may even get more rhodiola farms further north in Alaska, which would be nice." The first Alaskan rhodiola harvest occurred in 2013, because the plant takes four or five years to reach maturity, so there has not yet been enough time to notice if and how climate change may impact the plant in Alaska, according to Illig. "Except, some growers further north in the interior have had a couple of very hot and dry summers," she wrote. "If this continues, growers in the interior of Alaska, far from the wetter coastal areas, may need to consider irrigation."

According to Illig, potential changes in the therapeutic properties of rhodiola as a result of climate change "would only be noticeable over a long period of time and with a large, well-defined patient population. Quality of rhodiola products has more to do with the country of origin, method of harvest, processing of roots, and manufacturing of the end product."

Illig suspects climate change may have a significant negative effect on the natural habitat of wild rhodiola. This species has "a niche in hostile environmental conditions where other plants cannot grow," she wrote. "However, it does not compete well with many other plants, so if climate change invites other larger species, such as tall grasses and brush, they may crowd out natural rhodiola habitat much higher up in elevation where it now grows well. I worry about its native habitat. Combined with overharvesting, especially in China, rhodiola may struggle to survive as a species."

NordGen (the Nordic Genetic Resource Center), an organization based in Alnarp, Sweden,[16] sees "large possibilities using genetic resources to try to solve future challenges regarding food security, agricultural productivity, climate change, and sustainable environmentally friendly agriculture," wrote Ulrika Carlson-Nilsson, PhD, a senior scientist at NordGen (email, October 3, 2019). "NordGen is a Nordic gene bank that conserves accessions originating from, or having been of great importance and relevance to, one or more of the countries in the Nordic region [part of which lies above the Arctic Circle]." NordGen's gene bank includes accessions of MAPs and crop wild relatives.

All accessions are preserved as seeds, which are kept dried in freezers (at –20°C) at NordGen's storage facility in Sweden, with a backup collection in Denmark and at the Svalbard seed vault situated near Longyearbyen at Svalbard, the remote Norwegian archipelago in the Arctic Ocean.

Svalbard Global Seed Vault located near Longyearbyen, Norway.
Photo ©2019 Einar Jørgen Haraldseid

The main part of the collection is free to order for scientists, breeders, museums, and schools. Hobbyists can also order via NordGen's web shop.

One NordGen project involved collecting cultural relict plants mainly in Denmark and Sweden. Relict plants are plants that were once, but are no longer, cultivated in a specific area, where part of the population still exists but is no longer maintained. According to Carlson-Nilsson, these relict plants are most often MAP species that have survived at places where people used them centuries ago. Some of them originated from Europe and were brought to the Nordic area by monks to their monasteries. Relict species collected by NordGen include angelica (*Angelica archangelica*, Apiaceae), black horehound (*Ballota nigra*, Lamiaceae), chicory (*Cichorium intybus*, Asteraceae), houndstongue (*Cynoglossum officinale*, Boraginaceae), and motherwort (*Leonurus cardiaca*, Lamiaceae.

Angelica *Angelica archangelica*
Photo ©2019 Steven Foster

Medicinal and Aromatic Plants in Alpine Areas

Alpine regions generally are defined as high-altitude environments situated above the treeline, the point at which trees are unable to grow. These areas can be found in mountain ranges in many different climate zones around the world, including tropical, continental, and polar.[17] Alpine ecosystems are typically rugged, remote, and sparsely populated, accounting for roughly 3% of the global land area[18] and housing an estimated 4% of all known vascular plants.[19]

As plant cell growth is reduced significantly at near-freezing temperatures, alpine plants are usually small, slow-growing, long-lived herbaceous perennials and small shrubs.[20] Although they have adapted to the harsh conditions of high-altitude regions, these plants "live at the edge of adequate warmth" and remain vulnerable to fluctuations in temperature and precipitation. To retain heat, alpine plants grow close to the ground, and many are reliant on snow cover for shelter from extreme cold and wind. They also benefit from limited competition for resources above the treeline.[17]

Because of the specific tolerances of alpine plants and limited human interference in alpine regions, both alpine plants and the alpine zone are of particular interest to scientists studying the effects of climate change.[21] "As an ecosystem at a climate extreme — one that is very temperature dependent — the alpine zone is a sensitive indicator of climate changes," explained Jim Bishop, PhD, a botanist with the United States Forest Service, in a presentation on alpine plants and climate change. "And it is an ideal habitat to observe globally for biological change. Understanding the environmental stresses on alpine plants, and their adaptations, is the foundation for viewing their climate responses."[17]

The effects of climate change on alpine regions are well documented. Mountain surface air temperatures in alpine zones in North America, Europe, and Asia are increasing faster than the global average, at a rate of approximately 0.3°C per decade, according to the Intergovernmental Panel on Climate Change (IPCC) *Special Report on the Ocean and Cryosphere in a Changing Climate* (SROCCC), published in September 2019. The SROCCC cites greenhouse gas emissions as the primary driver of recent rising temperatures, noting that "anthropogenic influence is the main contributor to surface temperature increases." The report also describes precipitation changes, including increased summer drought and likelihood of extreme rainfall, both of which the IPCC attributes with a high degree of certainty to climate change.[22]

These changes in temperature and precipitation patterns have a direct impact on alpine flora. Rising temperatures in a highly temperature-dependent ecosystem produce a domino effect. As alpine regions warm, treelines begin to advance upward, which can have both positive and negative effects. For lowland species, such as trees and larger shrubs, advancing treelines result in population increases and new, larger growing areas. Endemic alpine plants, however, are forced to compete with the encroaching tree and shrub species or migrate further upslope. In some regions, this leads to a so-called "nowhere to go" scenario, which results in decreased populations or even local extinctions.[23,24]

In general, slow-growing, long-lived alpine plants are not well-suited to adapt to climate change.[25] "As a whole, the simulations performed have demonstrated that the adaptability of the plants cannot keep up with the fast climate changes," explained Anne Marie Panetta in a 2018 research article on alpine plants. "The circumstance that older indi-

Because of the specific tolerances of alpine plants and limited human interference in alpine regions, both alpine plants and the alpine zone are of particular interest to scientists studying the effects of climate change.

GLORIA field work on Ghacktkogel, Hochschwab, Austria, in the northeastern Alps. Photo ©2019 Schronkovie

viduals persist in a worsening environment hides the fact that an extinction debt is slowly developing."[24]

Much of the research on the effects of climate change on alpine plants has used modeling studies and simulations, but field work and analyses of data from permanent research sites on mountain summits around the world have provided valuable insights, particularly in the well-studied regions of Himalaya and the Alps.[26]

Effects in Himalaya

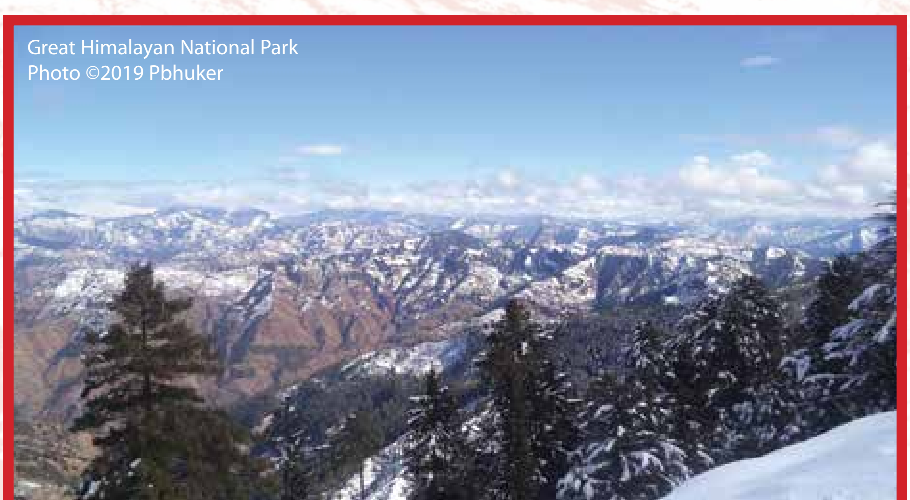
The Himalayas are the highest mountain chain on Earth and separate the Indian subcontinent from the Tibetan Plateau. Himalaya is one of the 36 global Biodiversity Hotspots determined by Conservation International,[27] and the Great Himalayan National Park Conservation Area, which is home to approximately 805 vascular plant species, is designated as a UNESCO World Heritage Site for its environmental significance.[28]

According to the SROCCC, "the Himalaya are predicted to experience a rise in temperature of 5-6°C and precipitation increases of 20-30% by the end of the twenty-first century making them among the most threatened non-polar regions of the world. The rapid changes in temperature and precipitation have earned them the monikers, 'thermometer of the world' and 'early detection tool for global warming.'"[22]

Climate change research in Himalayan alpine regions has confirmed that temperature and precipitation changes already are impacting local flora, including medicinal plants. Although much research has focused on the physical changes to the environment — including upslope migration of species, glacial retreat, and precipitation changes — and their impacts on flora, these changes also are affecting local human populations.[29-31] "Human dimensions of climate change are of great consequence in the Himalaya, where alpine habitats are especially important to indigenous populations as collection grounds for medicinal plants," wrote Jan Salick, PhD, the emeritus senior curator of ethnobotany at the Missouri Botanical Garden, who has conducted extensive climate change research in the Himalayas.[31]

In recent years, the popularity and price of Himalayan caterpillar fungus, or cordyceps (*Ophiocordyceps sinensis*, Ophiocordycipitaceae), have skyrocketed, driven largely by increased demand from Chinese consumers, who value the fungus for its many claimed medicinal benefits. In 2017, the price per kilogram of high-quality cordyceps was twice that of gold, and, in Tibet, sales of wild-harvested cordyceps make up a "substantial proportion" of the region's gross domestic product. In a 2018 paper, researchers used multiple methods, including interviews with harvesters and ecological and statistical models, to assess the impact of climate change on this so-called "high-altitude organic gold." They concluded that "climate change may be amplifying the negative effects of harvesting and playing a role in the ecosystem degradation observed by some collectors, thus interacting with collection pressure to affect the status of this resource."[32]

In 2014, Salick's research team analyzed data from sites in the Himalayas that are part of the Global Observation Research Initiative in Alpine Environments (GLORIA) network to assess the effects of climate change on alpine vegetation.[31] As discussed in Cavaliere's 2009 *HerbalGram* article, GLORIA is a program that "operates a world-wide long-term observation network with permanent plot sites



Great Himalayan National Park
Photo ©2019 Pbhuker

in alpine environments … to discern trends in species diversity, composition, abundance, and temperature, and to assess and predict losses in biodiversity in these fragile alpine ecosystems which are under accelerating climate change pressures."[26]

Salick found that elevation and precipitation had a significant effect on alpine vegetation. "Our results … corroborate predictions that climate change — increasing temperature and precipitation — will greatly affect Himalayan diversity," she wrote in the 2014 article. "The outlook for useful, rare, and endemic Himalayan alpine species, left with nowhere to go, is of great concern for conservation."[31]

In 2019, Salick and colleagues re-surveyed plots on 11 summits in the eastern Himalayas to assess vegetation changes over the past seven years. They found that the number, frequency, and diversity of alpine plants increased significantly during this time period. Surprisingly, they found that the number and frequency of *endemic* species also are increasing. "Plants newly colonizing the mountain summits came from other Himalayan alpine areas, perhaps contradicting a summit trap hypothesis; rather than species moving up the mountains and getting stranded on mountain tops, they appear to be dispersing among distant summits," Salick explained in the paper. "Nonetheless, to the extent that plant ranges 'track' the upward movement of temperature, Himalayan 'sky islands' will be reduced in area as vegetation colonizes higher elevations."[33]

Effects in European Alpine Regions

Although alpine zones compose only 3% of Europe's total land area, they are home to roughly 20% of its native vascular flora — an estimated 2,500 species.[34] In her article, Cavaliere discussed a 2009 study by Grabherr et al. that used GLORIA's alpine summit monitoring stations to assess the effects of climate change in European alpine zones.[1] The study found "that vegetation extends to higher elevations than previously, that species numbers have increased (except where precipitation is decreasing), and that rare and endemic species make up a smaller proportion of the flora."[35]

Since then, GLORIA's global network has grown, and studies have continued to monitor and investigate alpine ecosystems. In 2012, in a study described then as "the largest and most comprehensive of its kind in the world," Grabherr and colleagues analyzed 867 plant samples collected in 2001 and 2008 from 60 European mountain summits.[34] GLORIA's Michael Gottfried, PhD, the lead author of the study, was quoted as saying: "We expected to find a greater number of warm-loving plants at higher altitudes, but we did not expect to find such a significant change in such a short space of time. Many cold-loving species are literally running out of mountain. In some of the lower mountains in Europe, we could see alpine meadows disappearing and dwarf shrubs taking over within the next few decades."[36] According to one modeling study of European mountain flora, researchers projected that 36%-55% of alpine plant species would lose at least 80% of their habitat by 2070-2100.[37]

In a separate study, using data from GLORIA's permanent site on Schrankogel, a mountain in the Central Alps in Austria, Lamprecht et al. analyzed plant data from 1994, 2004, and 2014. They found increased species richness for the entire period and noted that "changes in species cover and plant community composition indicate an accelerating transformation towards a more warmth-demanding and more drought-adapted vegetation, … which would favour a period of accelerated species declines."[38]

IPCC's 2019 report notes that these human-induced changes in climate will continue to have significant impacts on ecosystems in the future. "Current trends in cryosphere-related changes in high-mountain ecosystems are expected to continue and impacts to intensify (very high confidence)," the report explains. "While high mountains will provide new and greater habitat area, including refugia for lowland species, both range expansion and shrinkage are projected, and at high elevations this will lead to population declines (high confidence). The latter increases the risk of local extinctions."[22]

Medicinal and Aromatic Plants in Other Regions

The Royal Botanic Gardens, Kew's 2017 *State of the World's Plants* report discusses how some biomes have higher percentages of plant species with traits that make them more resilient to climate change. Identifying these traits can inform efforts to ensure the future survival of rare, endangered, and important plants, including MAPs.[2]

Traits allowing plant species to better tolerate drought are higher wood density (enabling movement of water and solutes through the plant; as seen in forests); thicker leaves (preventing water loss; in grasslands, savannas, and shrublands); higher water-use efficiency (or more frugal water use; in forests and desert); and deeper roots (enabling plants to reach water lower in the soil; in grasslands). Traits enabling tolerance of higher temperatures are plant height (taller plants seem more tolerant in grasslands, while shorter plants seem more tolerant in forests), thicker leaves (in grasslands), and greater below-ground biomass (enabling access to resources; in grasslands).[2]

Traits enabling tolerance of more frequent fires are thicker bark (protecting the cambium; in forests), ability to resprout (in forests), and serotinous cones (which require burning to melt the resin covering the seeds, releasing them for wind distribution). Some studies suggest that increasing carbon dioxide levels may cause some plants to improve water-use efficiency that may help them tolerate other climate changes. Plants with a combination of these traits will likely cope better with climate change, while plants without these traits will likely be less tolerant and should be the focus of conservation efforts.[2]

Since he was quoted in *HerbalGram*'s 2009 article, Will McClatchey, PhD, a former professor of botany at the University of Hawaii at Manoa, has studied ecosystem management in the Solomon Islands off northeastern Australia.

According to him, foreign logging and fishing in that country are having dramatic impacts on local health because of destruction of resources that people have used for millennia (email, September 30, 2019). "Local fishing is decreasing in quality and quantity," McClatchey wrote. "Local medicinal plants from native forests are harder to find. However, the vast majority of plants that people use as medicines are weedy and grow around gardens or in disturbed areas of secondary forest, so in some sense there is an increase in the availability of medicinal plants. However, I am quite certain that this is more than offset by decreased food quality and subsequent health problems from diseases that are more impactful on people eating lower quality diets."

In the 2009 article, McClatchey said that Pacific plants generally are more resilient to climate change partly because they are well adapted to storms and often resistant to saltwater. "I think that the general observation that medicinal plants [in the Pacific] are relatively resistant to climate change still holds true, with the important exception of unusual endemic species that are not used regularly…and because of environmental degradation are now less likely to be used and therefore passed on to future generations," he wrote.

Sea levels have not yet risen enough to seriously affect specific Pacific plants, but the ecology of mangrove swamps and coastal strand zones is changing, according to McClatchey. "These systems are where most people in the tropical Pacific islands live and are the main places where medicinal plants grow," he wrote. "I don't think we have yet reached the tipping point, but in places with low atolls, such as the Marshall Islands, this is just a matter of time."

McClatchey thinks that the Pacific islands and their diverse peoples could be viewed as canaries in a coalmine. "These peoples, and peoples in the Arctic, are living in and managing the most sensitive kinds of environments, and as they go, so do the rest of us," he wrote, adding that it is important to monitor levels of foreign versus local medicines and foods used in Pacific communities. He noted that greater use of local rather than foreign resources is more sustainable and more reinforcing of local conservation and traditions, which often leads to better health for people.

"Climate change is causing people to make choices, and many of our international aid systems respond by trying to change local practices, adopting international (foreign) practices for landscape management, health, food, etc.," McClatchey wrote. "These generalized strategies, which may be [well-intentioned], leave people with less knowledge of their own environments, less ability to deal with climate change, and fewer future choices."

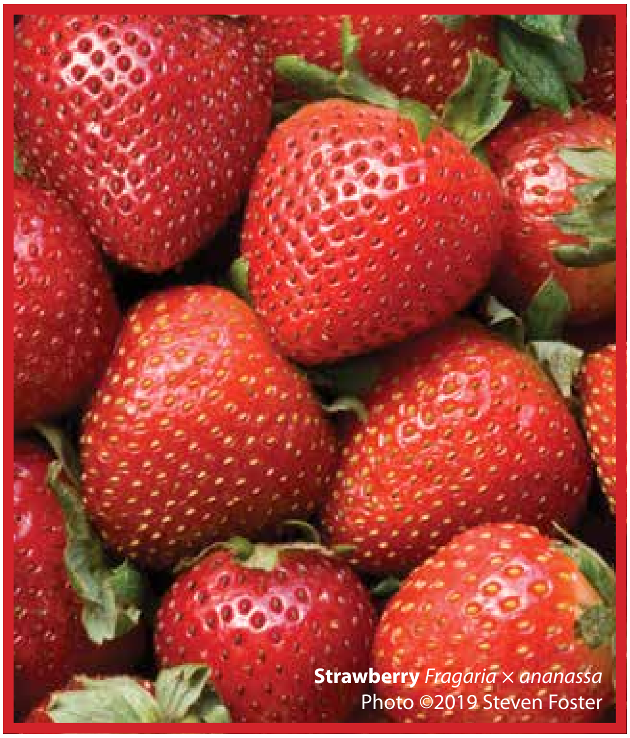
Sea levels have not yet risen enough to seriously affect specific Pacific plants, but the ecology of mangrove swamps and coastal strand zones is changing.


Will McClatchey on his farm.
Photo courtesy of Will McClatchey

In 2015, McClatchey moved home to Oregon, where he and his wife, Valerie, operate a five-acre farm south of Eugene with about 3,000 fruit trees. "We wanted to work together on a focused project examining the ecology of orchard management systems and how some are more resilient to climate change," McClatchey wrote. "We will need at least another four or five years before we have something of substance to report, but we already believe that the integrated orchard-garden systems of Spain and Italy, sometimes called *huerta*, are far more productive and resilient to [climate] change than the other systems we are developing."

All of McClatchey's experiments involve apple (*Malus* spp., Rosaceae) trees and are based on techniques he learned in several parts of Europe while studying how orchardists were growing apples to produce cider. In one system he is testing, which is a simplified version based on methods he learned in Spain and Italy, each apple tree is surrounded by a species from the mint (Lamiaceae) family (e.g., species in the genera *Lavandula*, *Melissa*, *Mentha*, *Nepeta*, *Ocimum*, and *Origanum*). These are then surrounded by different species in the celery (Apiaceae) family and legume (Fabaceae) family. Strawberries (*Fragaria* × *ananassa*, Rosaceae) also are mixed in. This mix is intended to help with nutrient cycling and insect control. The other experimental models McClatchey is testing, which are based on other European methods, have much less diversity and do not seem to be as effective so far.

Brian Boom, PhD, vice president for conservation strategy and the Bassett Maguire Curator of Botany at the New York Botanical Garden, noted that, since *HerbalGram*'s 2009 article, the "potential impacts of a changing climate on MAPs, and all plants for that matter, have come into sharper focus, and the urgency of finding ways to mitigate and/or adapt to [climate change] is all the more keen" (email, October 4, 2019).



Strawberry *Fragaria × ananassa*
Photo ©2019 Steven Foster

Boom pointed to a recent study in the Andes that found that, due to warming, tree species are migrating up in the mountains to cooler elevations, but that the rate of migration is probably not fast enough to avoid species' loss.[39] A separate study in Amazonia analyzed the effects of 30 years of climate change on trees in more than 100 plots in the Amazon Forest Inventory Network (RAINFOR). They found that the composition of the forest is changing in response to greater warming and drought, but the changes are not keeping up with the rate of climate change. As the climate got hotter and drier, species that are adapted to those conditions moved in, but not as fast as the less drought-tolerant trees died out.[40]

"The take-home message from these two unrelated studies is that in the face of climate change, human interventions are going to be needed more than ever to keep desired MAPs growing and producing products for people," Boom wrote. "Species can move up to cooler environments in the Andes or to moister sites in Amazonia, but probably not fast enough for many of them."

Another study determined that the implications of climate change for the wine industry would be "substantial." The climate change models that were used in the study predicted that, by 2050, viticulture suitability will decrease in many traditional wine-producing regions (e.g., the Bordeaux and Rhône valley regions in France and Tuscany in Italy) and increase in more northern regions of North America and Europe, for example.[41]

"Wine grape [*Vitis vinifera*, Vitaceae] growers are already planning for their future livelihoods and actively searching for higher, cooler locations for their vineyards," Boom wrote. "Places as far-flung as Tasmania, central China, and in the region of Yellowstone National Park in the United States are all being considered. The future health of much of the MAP industry could depend on strategic, proactive transitioning to new plant sourcing locales over the next several decades and not assuming that the plants will be able to migrate on their own fast enough to where growing conditions are suitable."

Dan Metcalfe, PhD, a senior lecturer in the Department of Physical Geography and Ecosystem Science at Lund University in Lund, Sweden, is investigating what happens to cloud forests without clouds. Near Wayqecha Biological Station in the Andes of southern Peru, Metcalfe's experiment involves a large wall of loosely woven fabric that stretches through the forest. Fog rolling up the hill blows into the fabric, and the fog's moisture is trapped, so that the area behind the curtain is clearer and drier than normal.[42,43]

Tropical montane cloud forests (TMCF) and *páramo*, a set of alpine ecosystems above some TMCF, are home to thousands of unique species. In fact, TMCF are among the most biodiverse ecosystems on Earth. Trees in TMCF often are covered in epiphytes (plants that grow on other plants but are not parasitic), which are adapted to obtain water specifically from the air, not through the ground. Monarch butterflies overwinter, by the millions, in TMCF of Central Mexico. A recent study found that in less than 25-45 years, "70–86% of páramo will dry or be subject to tree invasion, and cloud immersion declines will shrink or dry 57–80% of Neotropical TMCF, including 100% of TMCF across Mexico, Central America, the Caribbean, much of Northern South America, and parts of Southeast Brazil." Warmer air temperatures may force air to travel further up mountains before it cools enough to form clouds, reducing TMCF humidity or area. This may have significant implications for TMCF plants that are uniquely adapted to mist and fog.[44]

Metcalfe's research is ongoing, and he claims it is the only large-scale experimental manipulation of cloud abundance in the world (email, October 5, 2019). "We now have around two years of a wide range of ecological and climatological measurements showing a variety of poten-

"Many cold-loving species are literally running out of mountain. In some of the lower mountains in Europe, we could see alpine meadows disappearing and dwarf shrubs taking over within the next few decades."

Apple *Malus* spp.
Photo ©2019 Steven Foster

tially significant impacts of cloud reduction on various ecosystem processes," Metcalfe wrote. "Broadly, cloud reduction appears to affect the growth and survival of both mature trees and a range of epiphytic plant groups."

According to Metcalfe, four species that are used by the local Andean communities for various purposes, including medicinal, have been planted in the experiment: *Alnus acuminata* (Betulaceae), *Clethra cuneata* (Clethraceae), *Clusia sphaerocarpa* (Clusiaceae), and *Prunus integrifolia* (Rosaceae).

Metcalfe hopes to keep the experiment going for at least another 10 years to observe the longer term ecological effects of cloud changes. "I expect and hope the experiment will contribute some of the clearest direct evidence yet for the likely ecological impacts of future shifts in cloud abundance on tropical cloud forests," he wrote.

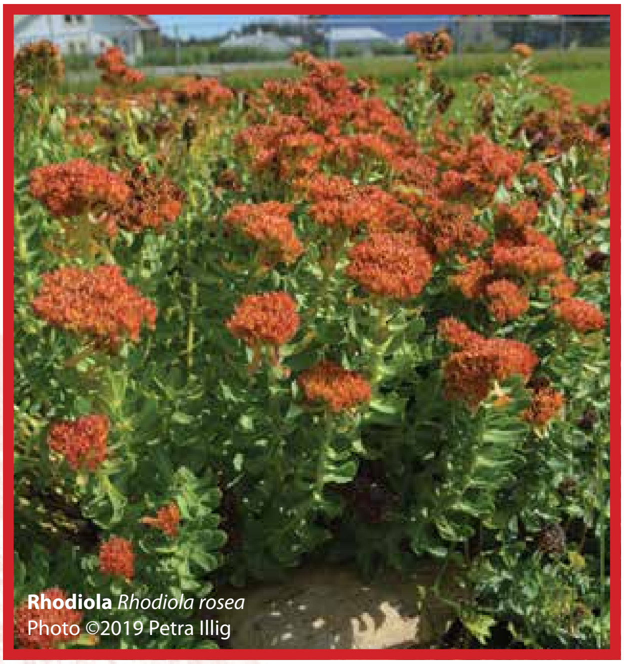
The Impact of Phenology and Shifting Ranges

Changes in Phenology

Phenology, or the study of the seasonal activities of organisms, involves the intricate relationships between the climate and plant life cycles. This can include interactions between plants and animals that depend on seasonal cues. Long-term monitoring of these activities, such as the emergence of leaves and flower buds and the movements of pollinators and fruit dispersers, can provide insights about climate change. If one factor in this web shifts, the repercussions may be felt in various ways, up to and including the ultimate survival of a plant's population in a certain area.

Research in this area requires more, longer-term observations, but patterns have emerged regarding the relationship between plant phenology and climate. In general, phenology has changed for many plants, particularly in more temperate areas, according to Kathy Gerst, PhD, associate research scientist and data product coordinator of the USA National Phenology Network (USA-NPN) (oral communication, September 27, 2019). "In places that are more water-limited, such as the Mediterranean regions of California or the [US] desert southwest, we know a little bit less about how the timing of the seasons have been changing, because a lot of species [there] are really driven by precipitation," said Gerst. "But most broadly, a trend toward warming springs has been documented. The timing of spring is getting earlier and earlier."

Plants that rely on temperature to begin their seasonal activities, rather than moisture and precipitation, are more likely to be susceptible to the phenomenon of false spring, in which the temperature warms to the point of cueing the production of buds and leaves, but the last frost has yet to occur. For frost-sensitive plants, including many commercially grown crop species, a false spring can devastate the plant and its production. Fruit trees, such as apple and pecan (*Carya illinoinensis*, Juglandaceae), are particularly vulnerable to false springs. Further testing and observation of the rela-



Rhodiola *Rhodiola rosea*
Photo ©2019 Petra Illig

tionship between plant performance and climate change will require data on a greater variety of species across communities and environmental conditions.[45]

For plant species that are active later in the season, these shifts in timing can cause what is known as a "phenological mismatch": flowers that bloom before pollinators become active or fruits that appear after birds and other fruit dispersers have migrated to other areas.[46] These plants may also be at a disadvantage when competing for resources with species that are active earlier in the season. These conditions tend to favor invasive species.

According to Gerst: "A lot of invasive species have been found to be more phenologically labile, or variable, in their ability to take advantage of different climatic situations, [which] can lead to competitive advantages for invasive species over a native species because [the invasive species] can sort of 'turn on' and start growing earlier."

Plant species that can better "track" changes in temperature increase their performance, and those that do not "track" temperature often decline with climate warming.[46] This suggests that phenological monitoring may be one strategy to set future conservation priorities for both wild and cultivated medicinal species. However, species performance is not limited to phenological sensitivity, but also other responses including physiology and interspecies interactions. The species most vulnerable to climate warming are those that not only fall victim to false springs and phenological mismatch, but those that are also less mobile and cannot shift to where conditions are more favorable.[47]

"In the future, we'll see more people use more sophisticated methods to forecast phenology," said Gerst, "and I think it helps us better dial in on … the implications of those shifts, because we can do it for multiple species and communities and also look, at the same time, at how our species distributions are changing."

Changes in Native Ranges

In the face of a changing world, plants have choices: die out, move, or adapt. As temperatures increase and spring comes earlier, wild species with the ability to migrate are being found outside their native ranges, either creeping to higher latitudes and altitudes to find lower temperatures or settling into new territory where conditions are now more favorable to their life cycles. The ecological implications can be immense.

Loss of species in an area may result in a decline of the ecosystem, since diverse plant, animal, and insect life is considered a sign of a strong, adaptive environment.[48] As noted during a controlled, 10-year observation of an area of grassland in Germany, loss of species was correlated with "future impairment of ecosystem functioning, potentially decades beyond the moment of species extinction." A simple example of this phenomenon is the practice of monoculture, or the cultivation of only one species on a plot of land, as is often used in commercial agriculture. This practice was found to decrease soil health over time, which led to the introduction of crop rotation and allowing fields to lie fallow for a period of time.

A review of surveys of European mountain summits dating back to 1871 found a significant increase in species over 145 years, with a significant acceleration in species gain over the past 20 to 30 years that is " strikingly synchronized with accelerated global warming," the authors wrote.[49] The observed summits gained an average of 5.4 species from 2007 to 2016, as compared to an average of 1.1 species from 1957 to 1966. With these changes happening on an accelerating time scale, it is difficult to make long-term predictions about which species will thrive and which will be negatively impacted by different competitors.

Gerst said: "The process [of movement and adaptation] happens on longer time scales than what plants need to do right now to adapt to climate change…. We are kind of creating novel communities where different species are interacting with each other that didn't before."

For plants that adapt to their new climate, these changes may impact their medicinal value. Many active plant secondary metabolites are the result of environmental stressors. Without these stressors, or with different stressors than before, the production of metabolites may decrease or disappear altogether. Though the plant "wins," people who depend on the plant for pharmacopeial-grade material may lose a

Many active plant secondary metabolites are the result of environmental stressors. Without these stressors, or with different stressors than before, the production of metabolites may decrease or disappear altogether.

source of income and medicine. For example, when foxtail millet (*Setaria italica*, Poaceae) plants were exposed to varying levels of salt, to mimic poor soil conditions, researchers observed that 29 proteins produced by the plant were significantly up- or down-regulated in response to this stress.[50] Similarly, several species of eucalyptus (*Eucalyptus* spp., Myrtaceae) showed changes in leaf metabolites in response to drought simulation, though many species in this genus are drought-tolerant or drought-resistant.

Seeding the Future

In the realm of commercial cultivation, farmers and producers have been adapting to shifts in phenology and range for years. In viticulture, as previously mentioned, growers are adjusting where certain grape varieties are planted depending on temperature and soil quality. Data gathered through organizations such as the USA-NPN, which supplies data to government bodies such as the US Environmental Protection Agency (EPA), can help growers predict the onset of spring.[51] With this information, crops can be protected against false springs and invasive competitors and planted in optimal areas to ensure the ideal number of growing days.

Long-term observations and data still need to be gathered to recognize broad patterns in the relationship among climate change, phenology, and ecosystem survival. The ability to forecast is a large and relatively new development in this area of study, said Gerst. The overall positive and negative outcomes of rapidly shifting plant lifecycles and ranges also remain to be seen. Existing studies provide strong evidence that sensitivity to shifting conditions is a good indicator of species performance but "are limited to localized regions and need to be interpreted with the awareness that many factors, including temperature, have changed over time," wrote the authors of a 2012 review.[46] In the future, the ability to track and forecast phenology and range will play a large part in the conservation of both wild and cultivated plants.

Conclusion

Over millions of years, plants have adapted to tolerate a wide range of environmental conditions. Plants can be found on remote, moisture-rich tropical islands as well as some of the most extreme ecosystems on Earth, from the cold, harsh Arctic tundra to barren mountaintops. Since the industrial era, plants have been exposed to an entirely new environmental variable: anthropogenic global heating and climate change. For the 10-year period from 2006 through 2015, the global average surface temperature was estimated to be 0.87°C warmer than the pre-industrial (1850-1900) average. By the end of this century, that number is projected to reach 1.5-2.0°C. According to the IPCC, more frequent and intense weather extremes have been observed during periods with warming of only 0.5°C.[22]

Although a change in temperature of one or two degrees may seem inconsequential, global heating is changing ecosystems on a large scale, and researchers are continuing to investigate how these changes are impacting plants. In just the past decade, researchers have provided striking evidence that climate change is affecting medicinal plants and the humans who rely on them. Communities in the Arctic, for example, are seeing medicinal plants being washed away with coastal


Motherwort *Leonurus cardiaca*
Photo ©2019 Steven Foster


Grape *Vitis vinifera*
Photo ©2019 Steven Foster

erosion, and collectors in Himalaya who depend on wild-harvested medicinal plants for income are seeing populations decline. These changes are compounded by existing threats to medicinal plants, including overharvesting, exploitation, and habitat destruction to name just a few.

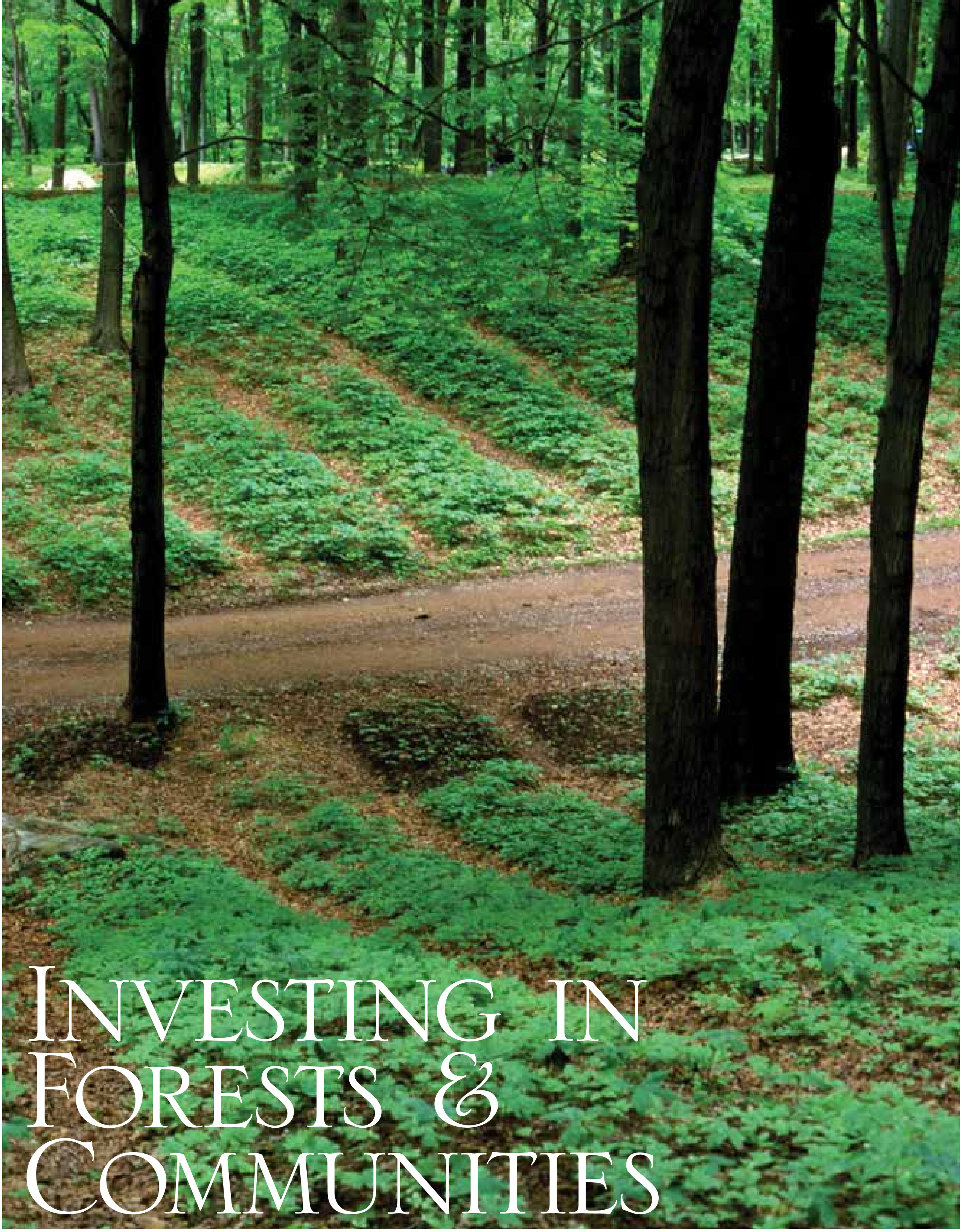
Without significant efforts to reduce carbon emissions, medicinal plants — and all life on Earth — will become increasingly threatened. In November 2019, writing in the journal *BioScience*, the independent Alliance of World Scientists expressed their concerns for the future: "[W]e declare, with more than 11,000 scientist signatories from around the world, clearly and unequivocally that planet Earth is facing a climate emergency.… The climate crisis has arrived and is accelerating faster than most scientists expected. It is more severe than anticipated, threatening natural ecosystems and the fate of humanity," the authors wrote.[52] "To secure a sustainable future, we must change how we live. … The good news is that such transformative change, with social and economic justice for all, promises far greater human well-being than does business as usual."[52] HG

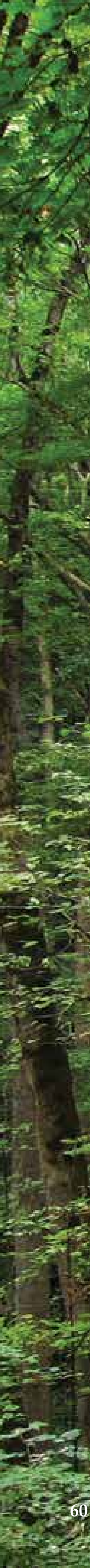
References

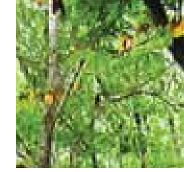
1. Cavaliere C. The Effects of Climate Change on Medicinal and Aromatic Plants. *HerbalGram*. 2009;81:44-57.
2. State of the World's Plants Report – 2017. Royal Botanic Gardens, Kew website. Available at: http://stateoftheworldsplants.org/2017/report/SOTWP_2017.pdf. Accessed October 7, 2019.
3. IPBES. *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.* Bonn, Germany: IPBES Secretariat; 2019.
4. Graphic: The relentless rise of carbon dioxide. NASA website. Available at: http://climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/. Accessed October 14, 2019.
5. Bastin JF, Finegold Y, Garcia C, et al. The global tree restoration potential. *Science*. Jul. 2019;365(6448):76-79.
6. Leahy S. How to erase 100 years of carbon emissions? Plant trees—lots of them. *National Geographic* website. July 4, 2019. Available at: www.nationalgeographic.com/environment/2019/07/how-to-erase-100-years-carbon-emissions-plant-trees/. Accessed October 15, 2019.
7. Burke KD, Williams JW, Chandler MA, Haywood AM, Lunt DJ, Otto-Bliesner BL. Pliocene and Eocene provide best analogs for near-future climates. *Proc. Natl. Acad. Sci.* Dec. 2018;115(52):13288-13293.
8. Carrington D. Why The Guardian is changing the language it uses about the environment. The Guardian website. May 17, 2019. Available at: www.theguardian.com/environment/2019/may/17/why-the-guardian-is-changing-the-language-it-uses-about-the-environment. Accessed October 14, 2019.
9. Arctic. World Wildlife Fund website. Available at: www.worldwildlife.org/places/arctic. Accessed October 2, 2019.
10. The Arctic is Heating Up. *National Geographic*. September 2019:42-49.
11. Welch C. The Threat Below. *National Geographic*. September 2019:74-99.
12. Beavers and Trees. Ecology Info website. Available at: www.ecology.info/beaver-trees.htm. Accessed October 2, 2019.
13. Brown RP, Gerbarg PL, Ramazanov Z. *Rhodiola rosea*: A Phytomedicinal Overview. *HerbalGram*. 2002;56:40-52.
14. Boulanger-Lapointe N, Gérin-Lajoie J, Collier LS, et al. Berry Plants and Berry Picking in Inuit Nunangat: Traditions in a Changing Socio-Ecological Landscape. *Human Ecology*. February 2019;47(1):81-93.
15. Kellogg J, Wang J, Flint C, et al. Alaskan Wild Berry Resources and Human Health Under the Cloud of Climate Change. *J. Agric. Food Chem*. 2010;58(7):3884-3900.
16. What is NordGen? NordGen website. Available at: www.nordgen.org/en/about-us/. Accessed October 7, 2019.
17. Bishop J, Bishop C. Alpine Plants as Indicators of Climate Change. Presentation given at the 28th Annual Desert Symposium. April 2014. Available at: www.fs.fed.us/psw/cirmount/gloria/pdf/2014_Desert-Sym_Bishop_talk.pdf. Accessed October 9, 2019.
18. Körner C. *Alpine Plant Life: Functional Plant Ecology of High Mountain Ecosystems*. 2nd ed. Berlin, Germany: Springer Verlag, Berlin, Germany; 2003
19. Nagy L. Alpine Biome. *Oxford Bibliographies* in Ecology. Available at: www.oxfordbibliographies.com/view/document/obo-9780199830060/obo-9780199830060-0150.xml. Last modified May 26, 2016. Accessed October 9, 2019.
20. Rundel PW, Millar CI. Alpine Ecosystems. In: Zavaleta, E.; Mooney, H., eds. *Ecosystems of California*. Berkeley, California: University of California Press: 613-634. Chapter 29. Available at: www.fs.fed.us/psw/publications/millar/psw_2016_millar003.pdf. Accessed October 9, 2019.
21. Pauli H, Gottfried M, Reiter K, Grabherr G. High Mountain Summits as Sensitive Indicators of Climate Change Effects on Vegetation Patterns: The "Multi Summit-Approach" of GLORIA (Global Observation Research Initiative in Alpine Environments). In: Visconti G, Beniston M, Iannorelli ED, Barba D, eds. *Global Change and Protected Areas. Advances in Global Change Research*. Vol 9. Dordrecht, The Netherlands: Springer; 2001.
22. Adler C, Cáceres C, Gruber S, et al. High Mountain Areas. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*. Geneva, Switzerland: The Intergovernmental Panel on Climate Change; 2019. Chapter 2. Available at: https://report.ipcc.ch/srocc/pdf/SROCC_FinalDraft_Chapter2.pdf. Accessed October 9, 2019.
23. You J, Qin X, Ranjitkar S, et al. Response to climate change of montane herbaceous plants in the genus *Rhodiola* predicted by ecological niche modeling. *Scientific Reports*. 2018;8. doi: 10.1038/s41598-018-24360-9. Available at: www.ncbi.nlm.nih.gov/pmc/articles/PMC5897335/. Accessed October 10, 2019.
24. Panetta AM, Stanton ML, Harte J. Climate warming drives local extinction: Evidence from observation and experimentation. *Science Advances*. 2018;4(2). doi: 10.1126/sciadv.aaq1819. Available at: https://advances.sciencemag.org/content/4/2/eaaq1819. Accessed October 9, 2019.
25. Cotto O, Wessely J, Georges D, et al. A dynamic eco-evolutionary model predicts slow response of alpine plants to climate warming. *Nature Communications*. 2017. DOI: 10.1038/ncomms15399. Available at: www.nature.com/articles/ncomms15399. Accessed October 8, 2019.
26. Global Observation Research Initiative in Alpine Environments: Background. GLORIA website. Available at: https://gloria.ac.at/scope/background. Accessed October 9, 2019.
27. Biodiversity Hotspot: Himalaya. Critical Ecosystem Partnership Fund website. Available at: www.cepf.net/our-work/biodiversity-hotspots/himalaya. Accessed October 9, 2019.
28. Great Himalayan National Park Conservation Area: UNESCO World Heritage Nomination. UNESCO website. Available at: https://whc.unesco.org/en/list/1406/documents/. Accessed October 9, 2019.
29. Telwala Y, Brook BW, Manish K, Pandit MK. Climate-Induced Elevational Range Shifts and Increase in Plant Species Richness in a Himalayan Biodiversity Epicentre. *PLoS One*. 2013. https://doi.org/10.1371/journal.pone.0057103. Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0057103. Accessed October 16, 2019.
30. Freeman BG, Lee-Yaw JA, Sunday JM, Hargreaves AL. Meta-analysis: Expanding, shifting and shrinking: The impact of global warming on species' elevational distributions. *Global Ecol Biogeogr*. 2018;27:1268-1276. doi: 10.1111/geb.12774. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/geb.12774.
31. Salick J, Ghimire SK, Fang Z, Dema S, Konchar KM. Himalayan Alpine Vegetation, Climate Change and Mitigation. *J Ethnobiol*. 2014;34(3):276-293. Available at: https://bioone.org/journals/Journal-of-Ethnobiology/volume-34/issue-3/0278-0771-34.3.276/Himalayan-Alpine-Vegetation-Climate-Change-and-Mitigation/10.2993/0278-0771-34.3.276.full. Accessed October 9, 2019.
32. Hopping KA, Chignell SM, Lambin EF. The demise of caterpillar fungus in the Himalayan region due to climate change and overharvesting. *PNAS*. 2018;45:11489-11494. Available at: www.pnas.org/content/115/45/11489/tab-figures-data. Accessed October 16, 2019.

33. Salick J, Fang Z, Hart R. Rapid changes in eastern Himalayan alpine flora with climate change. *Am J Bot*. 2019;106(4):1-11. https://doi.org/10.1002/ajb2.1263.
34. Gottfried M, Pauli H Futschik A, et al. Continent-wide response of mountain vegetation to climate change. *Nature Climate Change*. 2012;2:111-115. doi: 10.1038/NCLIMATE1329.
35. Grabherr G. Biodiversity in the high ranges of the Alps: Ethnobotanical and climate change perspectives. *Global Environmental Change*. 2009;19(2):167-172. Available at: www.sciencedirect.com/science/article/abs/pii/S095937800900020X. Accessed October 9, 2019.
36. Climate change is altering mountain vegetation at large scale. Science Daily website. Available at: www.sciencedaily.com/releases/2012/01/120108143550.htm. Accessed October 9, 2019.
37. Engler R, Randin C, Thuiller W, et al. 21st century climate change threatens mountain flora unequally across Europe. *Global Change Biology*. 2011;17(7):2330-2341. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2486.2010.02393.x. Accessed October 16, 2019.
38. Lamprecht A, Semenchuk PR, Steinbauer K, Winkler M, Pauli H. Pauli et al. Climate change leads to accelerated transformation of high-elevation vegetation in the central Alps. *New Phytologist*. 2018;220(2):447-459. Available at: https://nph.onlinelibrary.wiley.com/doi/10.1111/nph.15290. Accessed October 9, 2019.
39. Fadrique B, Báez S, Duque A, et al. Widespread but heterogeneous responses of Andean forests to climate change. *Nature*. Nov. 2018;564:207-212.
40. Esquivel-Muelbert A, Baker TR, Dexter KG, et al. Compositional response of Amazon forests to climate change. *Global Change Biology*. Nov. 2018;25(1):39-56.
41. Hannah L, Roehrdanz PR, Ikegami M, et al. Climate change, wine, and conservation. *Proc. Natl. Acad. Sci*. Apr. 2013;110(17):6907-6912.
42. Grossman D. What's a cloud forest without clouds? WHYY website. August 17, 2017. Available at: http://whyy.org/segments/whats-a-cloud-forest-without-clouds/. Accessed October 8, 2019.
43. The Cloud Curtain Project. Cloud Curtain website. Available at: http://cloudcurtain.org/. Accessed October 8, 2019.
44. Helmer EH, Gerson EA, Baggett LS, Bird BJ, Ruzycki TS, Voggesser SM. Neotropical cloud forests and páramo to contract and dry from declines in cloud immersion and frost. *PLoS One*. 14(4): e0213155. https://doi.org/10.1371/journal.pone.0213155.
45. Pau S, Wolkovich EM, Cook BI. Predicting phenology by integrating ecology, evolution and climate science. *Global Change Biology*. 2011;17:3633–3643.
46. Cleland EE, Allen JA, Crimmins TM, et al. Phenological tracking enables positive species responses to climate change. *Ecology*. 2012;93(8):1765-1771.
47. Piao S, Liu Q, Chen A, et al. Plant phenology and global climate change: Current progresses and challenges. *Global Change Biology*. 2019;25(6):1922-1940.
48. Meyer ST, Ebeling A, Eisenhauer N, et al. Effects of biodiversity strengthen over time as ecosystem functioning declines at low and increases at high biodiversity. *Ecosphere*. 2016;7(12):e01619.
49. Steinbauer MJ, Grytnes JA, Jurasinski G, et al. Accelerated increase in plant species richness on mountain summits is linked to warming. *Nature*. 2018;556:231-234. Available at: www.nature.com/articles/s41586-018-0005-6. Accessed October 9, 2019.
50. Fraire-Velázquez S, Balderas-Hernández VE. Abiotic stress in plants and metabolic responses. In: Vahdati K, Leslie C, eds. *Abiotic Stress — Plant Responses and Applications in Agriculture*. London, UK: IntechOpen Ltd.; 2013.
51. Models and Maps. USA-NPN website. Available at: www.usanpn.org/data/maps. Accessed October 6, 2019.
52. Ripple WJ, Wolf C, Newsome TM, Barnard P, Moomaw MR. World scientists' warning of a climate emergency. *BioScience*. November 2019. https://doi.org/10.1093/biosci/biz088.


Chicory *Cichorium intybus*
Photo ©2019 Steven Foster







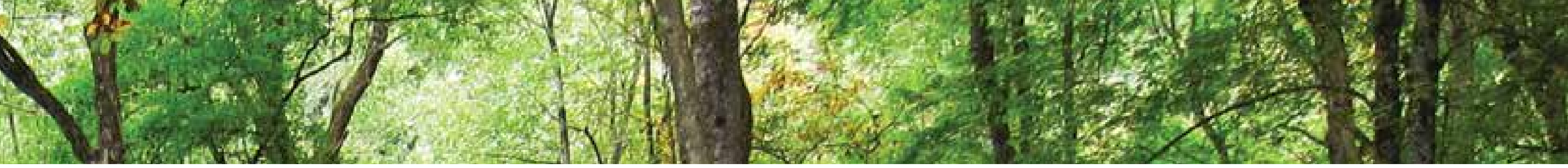
Investing in Forests & Communities

A Pathway to a Sustainable Supply of Forest Herbs in the Eastern United States

By Holly K. Chittum, MS,[ab] 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 practiced, 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.

Wild yam *Dioscorea villosa*
Photo ©2019 Eric Burkhart

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.


American ginseng *Panax quinquefolius*
Photo ©2019 Priya Jaishanker

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 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]

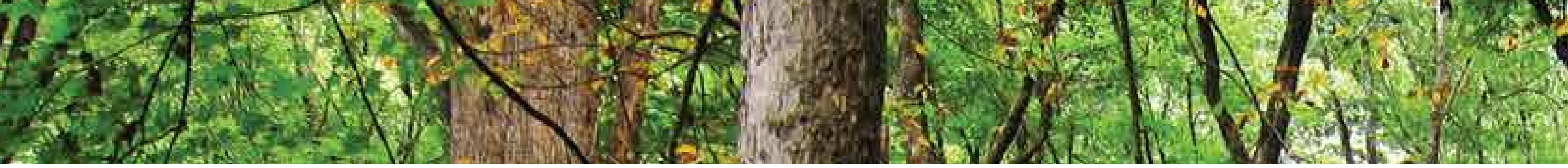
This scientific evidence confirms what traditional systems have practiced historically in regard to harvest. However, goldenseal collectors frequently harvest wild goldenseal at any time during the growing season at the harvester's convenience and in response to demand. Appalachian root buyers begin 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.

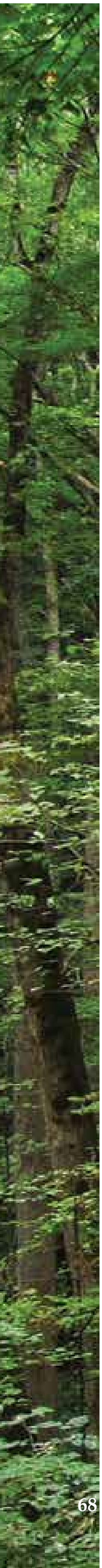
American Ginseng and Sustainability

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 forestlands. 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]

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

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 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 Center[65] 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	*Panax quinquefolius*	Rhizome, roots, leaves	Wild: 59,000-160,000[c] (Wild volumes only)	Not applicable[c]	\$150–\$1,300 (Wild prices only)[c]
Bethroot	*Trillium erectum*	Rhizome, roots	Wild: 402–2,999 Cultivated: 0	0%	\$0.75–\$12.50
Black cohosh	*Actaea racemosa*	Rhizome, roots	Wild: 117,843–343,771 Cultivated: 149–9,862	< 1–3%	\$2–\$6.75
Bloodroot	*Sanguinaria canadensis*	Rhizome, roots	Wild: 3,306–48,674 Cultivated: 5–26	< 1%	\$5–\$18.50
Blue cohosh	*Caulophyllum thalictroides*	Rhizome, roots	Wild: 3,934–8,803 Cultivated: 79–160	2%	\$0.50–\$6.25
Cranesbill	*Geranium maculatum*	Rhizome, roots	No data	No data	\$1–\$9
False unicorn root	*Chamaelirium luteum*	Rhizome, roots	Wild: 3,306–6,300 Cultivated: 35–1,400	1–18%	\$20–\$125
Goldenseal	*Hydrastis canadensis*	Rhizome, roots, leaves	Wild: 31,802–105,099 Cultivated: 11,070–47,559	26–31%	\$8–\$55
Mayapple	*Podophyllum peltatum*	Rhizome, roots	No data	No data	\$0.50–\$9
Slippery elm	*Ulmus rubra*	Inner bark	Wild: 78,380–352,727 Cultivated: 1,731–10,200	2–3%	\$1–\$5.75
Solomon's-seal	*Polygonatum biflorum*	Rhizome, roots	No data	No data	\$0.50–\$15
Stone root	*Collinsonia canadensis*	Rhizome, roots	No data	No data	\$0.75–\$4.25
Virginia snakeroot	*Endodeca serpentaria*	Rhizome, roots	Wild: 17–353 Cultivated: 0	0%	\$10–\$125
Wild yam	*Dioscorea villosa*	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.

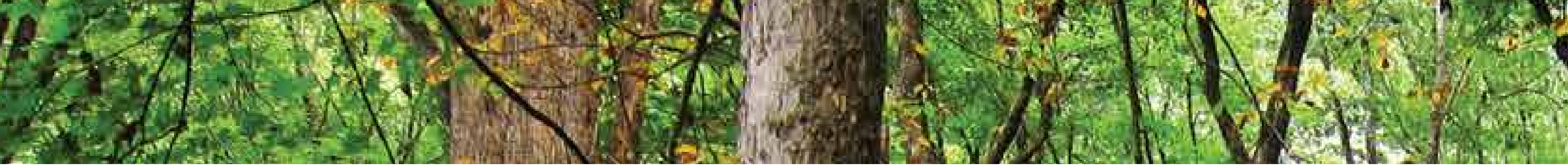
not be profitable for producers or even feasible (i.e., producers will not break even) at recent historic prices.[2] Wholesale market prices are far below production costs for many species, and significant price differences exist between species with approximately the same production requirements and 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.

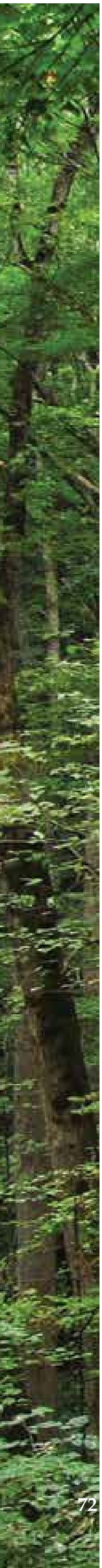
For example, black cohosh prices per pound have remained low, especially in relation to inflation. Between 2000 and 2018, the price paid per pound of dried black cohosh root averaged \$2-\$3. This price, when examined out of context, does not tell the story of what it means to produce black cohosh and 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 permission 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.

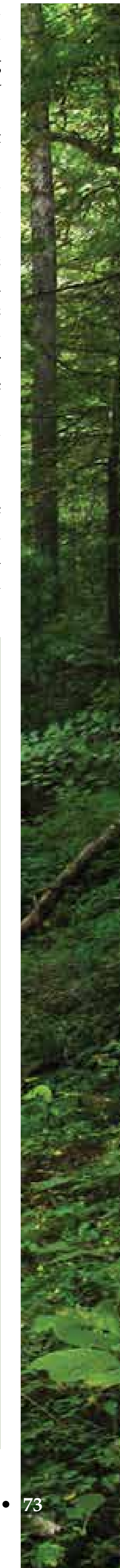
Mentorship, training, and professional development is a common component of gainful employment in the United States, and though it may seem unconventional in regard to wildcrafting, it may allow harvesters to receive a fair wage so they can continue their chosen work over the long term, keeping in stride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

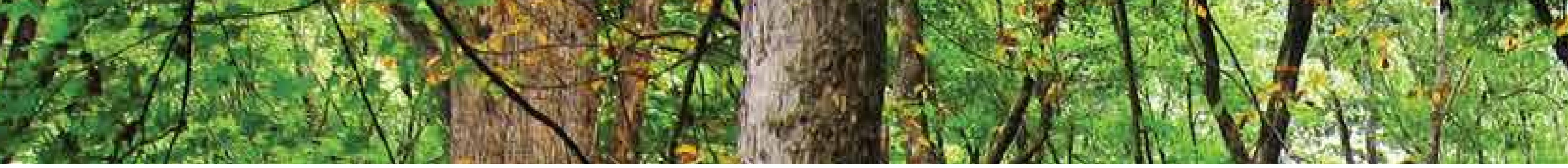
The United Plant Savers (UpS), another founding ABFFC partner organization, administers the Forest Grown Verification (FGV) label, a third-party certification program that originated from a partnership between Penn State and Pennsylvania Certified Organic, with input from NGOs, state and federal agency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

PCO VERIFIED Forest Grown



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.

American ginseng *Panax quinquefolius*
Photo ©2019 Eric Burkhart

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 Dalfsen 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. Durgnat 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.herbalgram.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.herbalgram.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. Pelsmacker 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).

David Barnes
1961–2019

By Hannah Bauman

David Barnes, PhD, died unexpectedly at the age of 57 on February 27, 2019, at his home in Mount Bethel, Pennsylvania. Barnes was a natural products researcher who sought to inspire consumer trust with verified data and focused on the study of the gut microbiome and its role in health and wellness.

Barnes was born on September 9, 1961, in Newton, Massachusetts. He grew up in California and attended the University of California – Davis for his bachelor's, master's, and doctoral degrees, the latter in nutritional biochemistry. After earning his PhD, he eventually returned to academia for an MBA with a focus on international business at the University of Wisconsin – Whitewater. He taught as an assistant professor at the University of Wisconsin – Madison from 2000 to 2004.

Barnes entered the natural products industry in 2004, serving as the director of research and development at Standard Process, a dietary supplement manufacturer based in Palmyra, Wisconsin. During his 10 years at the company, Barnes oversaw the clinical study of ingredients used in Standard Process product lines, providing evidence-based research and publishing multiple papers. His interest in the synergistic effects of the constituents in food ingredients led to the study of glucosinolates from cruciferous vegetables, aqueous mushroom extracts, antioxidants from buckwheat (*Fagopyrum esculentum*, Polygonaceae), and the interaction of probiotic bacteria and prebiotic fibers on gut flora, for example.

Barnes' expertise was highly sought, and during a keynote speech at the University of Wisconsin – Milwaukee's Spring 2011 Research Symposium, he was quoted as saying: "While the current paradigm in scientific research has served us well to this point, now we have a great opportunity to look at research in a new way. In fact, I argue that we must shift from a reductionist perspective to a more holistic view if we are to understand the complex interactions between our food and our health."[1]

This holistic approach defined Barnes's philosophy toward his work. Loren Israelsen, president of the United Natural Products Alliance and a close friend of Barnes, commented: "When [David] and I would have long talks, it would be about the industry. What does all this mean? How do we think about the work that we do? … He always believed that we should be able to raise people's hopes and expectations for what natural health products can do, but we needed to back it up, go beyond our beliefs and be able to show meaningful evidence" (oral communication, September 29, 2019).

Barnes left Standard Process to serve as the chief operating officer of Marine Ingredients, a manufacturer of fish oil ingredients. The market knowledge and business relationships Barnes built, including with Danish researcher and fish oil pioneer Jørn Dyerberg, MD, gave Marine Ingredients a high-profile and excellent reputation. When the company, now known as KD Nutra, merged with KD Pharma Group, Barnes became the head of global research and development at KD Pharma. He held this position from January 2017 until his death. In this role, he continued to study and produce nutraceutical and veterinary products with an emphasis on omega-3 fatty acid supplements.

In his personal life, Barnes is remembered as a kind man who chose happiness. Israelsen recalled: "He was a lovely guy. A true gentleman and scholar, by the classic definition. Very accomplished, multiple interests and hobbies, just a very well-rounded guy. Modest — you'd never know that he had such a distinguished background. He was the guy who would listen and watch, and then have a wise perspective at the end."

David Barnes was an avid biker, marathoner, and aspiring chef who built his own pizza kiln and loved to entertain his friends and family. He was predeceased by his sister Debbie and is survived by his parents Peter and Judith; Cassandra, his wife of 26 years; children Gabriella and Jacob; and siblings Laura Barnes, Jessica Green-Barnes, and Ken Barnes. HG

Reference

1. University of Wisconsin-Milwaukee's Research Symposium Features Dr. David Barnes of Standard Process Inc. [press release] April 14, 2011. Palmyra, WI: Standard Process, Inc. Available at: www.standardprocess.com/About-Us/Newsroom/Research-Symposium-Features-Dr-David-Barnes. Accessed October 15, 2019.

Publications

American Herb Association Quarterly Newsletter: $20/yr. AHA, P.O. Box 1673, Nevada City, CA 96969.

Australian Journal of Herbal Medicine: Quarterly publication of the National Herbalists Association of Australia (founded in 1920). Deals with all aspects of Medical Herbalism, including latest medicinal plant research findings. Regular features include Australian medicinal plants, conferences, conference reports, book reviews, rare books, case studies, and medicinal plant reviews. AUD/$96 plus AUD/$15 if required by airmail. National Herbalists Association of Australia, P.O. Box 696, Ashfield, NSW 1800, Australia.

Medical Herbalism: Subtitled "A Clinical Newsletter for the Herbal Practitioner." Edited by Paul Bergner. $36/yr, $60/2 yrs. Canada $39/yr. Overseas $45/yr. Sample/$6. Medical Herbalism, P.O. Box 20512, Boulder, CO 81308.

American College of Healthcare Sciences: ACHS.edu is a DEAC accredited, fully online college offering Graduate and Undergraduate degrees, diplomas, and career-training certificates in holistic health and herbal medicine. ACHS is committed to exceptional online education and is recognized as an industry leader in holistic health education worldwide. Federal financial aid available to those who qualify. Educational resources available to the public include: ACHS Health and Wellness Blog, Master Lecture Webinar Series, and eBooks. For more information: visit www.achs.edu, call (800) 487-8839, or stop by the College campus located at 5005 SW Macadam Avenue, Portland, OR 97239.

Other

Interns, get hands-on experience before you graduate! If you're a future pharmacist or dietitian, you can choose a rotation through ABC's internship program. You'll get a comprehensive introduction to phytomedicines, researching the medicinal, culinary, and cosmetic uses of herbs, answering ABC members' questions, working with medicinal plants in ABC's 2.5 acres of herbal gardens, and preparing herbal salves, tinctures, or meals. For more information, call 512-926-4900 x114 or email education@herbalgram.org.

Herb/Berry/Vegie farm seeking assistance with cultivation, processing, landscaping, web work, and GMP certification. Agri-Tourism startup. Work not hard but steady. Profit Sharing. Starting immediately in the Virginia Blue Ridge, Zone 7. hootinanney@yahoo.com.

Stock Photography that doesn't look like Stock: Steven Foster Group, Inc. Photography, Consulting, Publications. Specializing in medicinal and aromatic plants, along with the places they grow, our stock photo files include more than 124,000 images shot around the world for over 30 years. Contact us at our location in the heart of the Ozarks in Eureka Springs, Arkansas. Visit our website: www.stevenfoster.com or email: sfoster@stevenfoster.com.

Considering supplying herbal products in Europe? Ann Godsell Regulatory can offer consulting advice on regulatory strategy, and data requirements. Services for dossier preparation & submission also available. For more information email regulatoryinfo@anngregulatory.eu.

Montana YewTip™ products, the natural Taxane source, Pacific Yew (*Taxus brevifolia*). Sustainably wildcrafted and manufactured exclusively by Bighorn Botanicals, Inc., Noxon, Montana. Capsules, tea, powder, tincture, oil, salve, lotion, soap, and lip balm. To review our products, go to www.bighornbotanicals.com. For more information, including ethnobotany, sustainable harvest protocols, safety, and biological activities, click on the "Plant Profile." Order online or call toll-free 1-888-847-1243.

Herbal Medicine Apprenticeship with Chanchal Cabrera, MSc, FNIMH, RH(AHG), four & eight week residential sessions. Gardening, Harvesting, Medicine Making plus Classes and Field Trips. Innisfree Farm and Botanic Garden, Vancouver Island. www.chanchalcabrera.com.

Photograph by Eric P. Burkhart, PhD
Captured with a Nikon D90, ISO 50, f/6.3, 1/60

Blue Cohosh

Caulophyllum thalictroides, Berberidaceae

Blue cohosh is a perennial native to central and eastern North America, with a range that stretches from Canada to Georgia. It is not related to other plants called "cohosh," such as black cohosh (*Actaea racemosa*, Ranunculaceae), red cohosh (*A. rubra*), or white cohosh (*A. alba*). Blue cohosh root and rhizome have more than 30 recorded uses among Native American tribes, including as an anticonvulsive, sedative, remedy for toothache, and emetic.[1] However, the plant was most commonly used as a gynecological aid during and after childbirth and as an emmenagogue (a substance that increases or stimulates menstrual flow) and abortifacient. Secondary metabolites present in blue cohosh root include the saponins cauloside A, B, C, and D, which have shown anti-inflammatory and antibacterial effects in vitro.[2] HG

References

1. *Caulophyllum thalictroides* (L.) Michx. Native American Ethnobotany Database website. Available at: http://naeb.brit.org/uses/species/806/. Accessed October 21, 2019.
2. Lee Y, Jung J-C, Ali Z, Khan IA, Oh S. Anti-inflammatory effect of triterpene saponins isolated from blue cohosh (*Caulophyllum thalictroides*). *Evid Based Complement Altern Med*. 2012;2012:798192. doi: 10.1155/2012/798192.

Photo Finish Contest

Send us your best original medicinal plant photographs for a chance to have one featured on this page.

Winners receive a complimentary one-year ABC Professional Membership — a $150 value. Learn more about the perks of ABC membership at www.herbalgram.org.

To enter the contest, send your botanical photos to tyler@herbalgram.org.

Individuals, organizations, and companies support ABC through membership

The American Botanical Council Invites You To Join Us

The American Botanical Council is the leading nonprofit education and research organization using science-based and traditional information to promote the responsible use of herbal medicine.

Founded in 1988, the member-supported American Botanical Council:

- SERVES members in more than 80 countries worldwide
- EDUCATES consumers, healthcare professionals, researchers, educators, industry and the media on the safe and effective use of medicinal plants
- ADVOCATES responsible herbal production and use
- ADVISES the media on emerging herbal science
- PROMOTES a healthier world through responsible herbal use.

Join Us!

In return, you'll receive access to a wealth of herbal data via:

- ABC's acclaimed quarterly journal, *HerbalGram*
- 10 online databases of herbal information (depending on membership level)
- Frequent electronic updates on herbal news that matters to you
  - 12 monthly HerbalEGrams, 51 weekly Herbal News & Events updates, Botanical Adulterants Monitors, and 360 HerbClips per year, plus Member Advisories
- And much more.

Learn more at

www.herbalgram.org

or contact Denise Meikel at denise@herbalgram.org or (512) 926-4900 ext. 120.

Botanical Adulterants Prevention Program

ADOPT-AN-HERB HerbMedPro™ PROGRAM

Sustainable Herbs Program American Botanical Council

HERBALGRAM

HerbClip™ Summaries and critical reviews of seminal herb articles

HerbMedPro™

AMERICAN BOTANICAL COUNCIL SINCE 1988