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Introduction

The growing popularity of herbal medicine and essential oils has increased the demand of multiple healing plants to the point of serious over harvesting. Essential oils, stored in the tiny secretory structures, require a large amount of plant material, up to 100 times or more, to make one tiny bottle of oil. For those plants whose population is dwindling to the point of scarcity, it is unethical to harvest and produce oils in a way that jeopardizes their earthly existence. This article will focus on identifying and describing specific plant species used for making essential oils whose population is threatened from excessive harvesting.

Below is a list of plants who have species or subspecies in danger. Please visit the websites discussed for more detailed and up to date information before purchasing essential oils from these botanicals. It is the duty of a responsible consumer to reduce the demand on vulnerable species. The main species of concern include:

- Frankincense (*Boswellia carteri*, *B. sacra*, *B. frereana* and multiple other *Boswellia* species)
- Rosewood (*Aniba rosaeodora*, multiple *Ocotea* species, and multiple *Dalbergia* species)
- Sandalwood (*Santalum album*, *S. spicatum*, *S. austrocaledonicum*, and multiple other *Santalum* species along with *Osyris lanceolata* and *Pterocarpus santalinus*)
- Spikenard (*Aralia racemosa*, *A. californica* and other *Aralia* species along with *Nardostachys grandiflora* and *N. jatamansi*)
- Agarwood (*Aquilaria crassna* and all *Aquilaria* species along with all *Gyrinops* species)
- Cedarwood atlas (*Cedrus atlantica*, other *Cedrus* species, many *Juniperus* species, and *Widdringtonia whytei* Rendle)

Research Websites:

- www.iucnredlist.org – This is the main authority for information on species in danger. Please note the following terms in which this organization classifies threatened species that will often be mentioned in this paper: “Near Threatened,” “Vulnerable,” “Endangered,” “Critically Endangered,” “Extinct in the Wild,” and “Extinct.”
- www.unitedplantsavers.org – This group focuses on threatened American plant species.
- www.cites.org – The Convention on International Trade in Endangered Species of Wild Fauna and Flora creates international agreements between governments to protect species.

Additional websites that provide information about at risk plant species include:

- www.saveplants.org
- www.traffic.org
- www.asnapp.org
- www.saveourspecies.org
- www.phytotrade.com
- www.peopleandplants.org

Threatened Essential Oil Species:

Frankincense (*Boswellia sacra*, *B. frereana* and other *Boswellia* species)

Also called Olibanum, *Boswellia sacra*, is classified as “Near Threatened” on the 2017.1 IUCN Red List.¹ This sacred tree is found in Northern Somalia, Oman, and Yemen.² In some areas, like Oman, it is “Critically Endangered.”³ Several *Boswellia* species located in Yemen have a dangerously declining habitat and were listed as “Vulnerable” on the IUCN Red List of Threatened Species in 2017, such as *B. ameero*, *B. bullata*, *B. dioscoridis*, *B. elongate*, *B. nana*, *B. popoviana*, and *B. socotrana*.⁴ *B. ovalifoliolata* from India and *B. ogadensis* from Ethiopia are also vulnerable.^{5,6} *Boswellia papyrifera* genetic variety is dwindling in Western Ethiopia and conservation strategies need to be implemented.¹⁰ This tree resin has been a highly valuable plant extract since ancient times, with the Horn of Africa trading it as a lucrative commodity for 2,000 years.⁷ Today, it is used in Western medicine for inflammation, and as an anti-carcinogenic.⁸ Further studies indicate it may be effective in treating bladder cancer.⁹ It is harvested by precisely cutting into the bark and allowing the resin to slowly ooze out and then solidify; with the cuttings repeated two or three times in the five month harvest season.⁷

Somiland, which is not technically a country, is an area where frankincense is especially overharvested and under protected. Here, the resin is purchased from the harvester by a middleman for an extremely low price, then sold in the Middle East for a much higher price to an international market. Thus, the Somali farmer is exploited with no government control of frankincense sales. Rising food prices and scarce opportunity for other jobs in the area has a negative effect on the trees with illegal harvesting beyond the season and excessive cutting of the bark. The price to pay for this valuable resin overharvesting is the life of the trees.⁷ Further, drought conditions and no government to protect the trees is an issue, but designating the forest area as “Protected” would help the trees.⁷

An additional issue associated with frankincense is the exploitation of poor people for labor. It is The Horn of Africa’s biggest export after livestock, with an estimated 10,000 families financially dependent on the crop.¹⁰ The women process the resin after it is harvested by the men, typically sitting on a concrete floor 12 hours a day, and making 50 cents to two dollars a day.⁷ Working with Fair Trade organizations to have frankincense certified may help set a fair price for harvesters and sustain the trees.⁷ Creating a harvesters’ cooperative will further promote fair trade, reduce underbidding, and set sustainability standards.⁷

Rosewood (*Aniba rosaeodora*, genus *Dalbergia* ssp., and genus *Ocotea* ssp.)

Rosewood has a rich burgundy color and is used in making high-end furniture, musical instruments, and oil extracts. It is a South American plant whose precious oil is known to have been used in famous perfumes.¹¹ *Aniba rosaeodora* is listed on the 2017.1 IUCN Redlist as “Endangered” and is also listed along with 19 *Dalbergia* ssp. on CITES.^{1,12} Many *Ocotea* species are “Near Threatened,” “Vulnerable,” “Endangered,” or “Critically Endangered” on the 2017.1 IUCN Red List.¹ “Critically Endangered” are: *O. harrisii*, *O. lancilimba*, *O. monteverdensis*, and *O. pachypoda*, endangered are *O. basicordatifolia*, *O. jorge-escobarri*, and *O. staninoides*, and ten *Ocotea* species are listed as “Vulnerable.”¹ Unfortunately, trees of all sizes are harvested and destroyed for rosewood oil extraction and other uses.¹³ In the Atlantic rainforest of Brazil, heavy harvesting based on a high value of timber and essential oil has rendered many species “Vulnerable” to “Extinct.” Fragmented and reduced populations of these

species are causing the loss of rare alleles; like inbreeding, this will result in a reduction of genetic diversity.¹⁴ Further, it is important that even small populations on fragmented pieces of unprotected land play a role in species survival and improved genetic diversity.¹⁴ Illegal logging is also a problem, with issues like cross-border logging in the Cambodian–Lao region.¹⁵

As for *Ocoetea porosa*, selective logging in the Southern Brazilian state of Parana over the past century may have contributed to a lower quantity of the larger trees, which could impact the rate of reproduction and cause local extinction.¹⁶ The canopy openness and gap openings in a cohort composed of more juvenile plants dangerously creates less height variety for the species.¹⁶ Other species in danger include *O. obtusata*, considered “Critically Endangered,” and *O. mascarena*, which is “Endangered” by the country of Mauritius.³

With the CITES listing of Brazilian rosewood, logging then shifted to Madagascar.¹⁷ In Madagascar, Malagasy rosewood, including *D. baronii*, *D. louvelli*, and *D. madagascariensis*, is one of the most sought after hardwood crops in the world.¹⁸ Illegal logging is happening at an alarming rate and severely threatening Madagascar rainforests. Local residents are cutting for a very low profit and selling to criminal exporters who have corrupted officials.¹⁹ This happens even though the Marojejy National Park has been established as a UNESCO World Heritage Site.¹⁸ Madagascar is one of the world’s key threatened bio diverse areas with an immediate risk for rosewood species extinction and has been recently protected under CITES. Even though the Malagasy government has prohibited rosewood logging and export as of 2010, weak penalties and poor enforcement prolong the problem.¹⁷ The rosewood logging involves cutting down hundreds of unused trees to get to the bigger trees, ratifying landscapes, decreasing soil fertility, and increasing potential fires; thus affecting the local ecosystem of many other plant and animal species.¹⁷

Multiple species of rosewood are at risk. Siamese rosewood (*Dalbergia cochinchinensis* Pierre) of Thailand and Laos is in very high demand and has been illegally logged for the past few decades, affecting genetic diversity.⁶³ *Aniba rosaeodora* is “Endangered” on the 2017.1 IUCN Red List and found in South America, with trees of all sizes indiscriminately harvested illegally.^{1,13} Multiple *dalbergia* species are “Endangered,” “Vulnerable,” and “Near Threatened” due to overharvesting by the perfume industry; *D. oliveti* and *D. cochinchinensis* are listed as “Priority Tree Species for Gene Conservation” in Cambodia, and in Nepal, *D. latifolia* is a “Vulnerable” species, *D. sissoo* is considered a “Threatened” tree by the country of Pakistan, *D. retusa* is considered “Vulnerable” by the country of Nicaragua, and *D. retusa* is considered “Endangered” by Panama.^{11,3}

Sandalwood (*Santalum album*, *S. spicatum*, *S. austrocaledonicum*, and more)

S. album is listed as “Vulnerable” on the 2017 IUCN Red List.¹ Exploitation has drastically affected this parasitic tree, with the rate of extraction far exceeded the rate of growth for many years.¹¹ Spike disease, grazing animals, and fire have further been a problem for *S. album*, especially in the Timor Islands.⁶⁴ Australian sandalwood (*S. spicatum*) has been used as a replacement but has also recently been over-exploited and historically used by major perfume companies.¹¹ Heavy international demand with poor regulation contributes to the problem.²⁰ Further, due to a low supply and high demand, prices have skyrocketed, increasing illegal harvesting.²¹ Synthetic fragrances have been manufactured to help reduce the demand on this scarce resource. In addition, to save this plant, a key issue that needs addressed is the low genetic variability, with inbreeding that causes important missing alleles and poor sexual

reproduction.²²

Before the 1900s, sandalwood was used mainly to burn incense and for attars and oils. Then, in 1918, India's first sandalwood oil factory was established, using the heartwood from the tree to manufacture shampoos, soaps, perfumes, and cosmetics at an industrial scale.²³ From 1950-1970 about 480,000 *S. album* trees were harvested per year in India's southern state of Karnataka. Then in 1974, only a fraction of the trees were left in Karnataka and the species was near extinction, with the government putting a halt to harvesting.²³ Smugglers then made big money on the tree, with one man in particular, Veerappan, who became very rich off the illegal trade, thus becoming an embarrassment to Indian police.²³ Before 9/11, the hunt for Veerappan was the largest and most costly in Asia. He was finally killed by police in 2004, but other smugglers have since taken his place.²³

Santalum album Linn, in the East Nusa Tenggara of Indonesia, is an important natural commodity representing about 40% of the Province's income from 1986-1992.²⁴ In the past two decades, the alarming decrease in tree population has forced a governmental ban on harvesting from 1997 – 2003.²⁴ Local farmer participation in cultivating sandalwood has been low because of strict government policies, with the Regional Regulation Act No. 16/1886 making all sandalwood property of the government regardless of if it was grown on private or state lands.²⁴ Some districts have since issued new regulations giving more rights to the people, including the cutting and selling of trees, thus encouraging planting.²⁴

Unsustainable harvesting in the Timor islands with farmers using uncontrolled fire as a method to clear land is a key threat to that local subspecies.¹⁹ Unfavorable legislation in the Timor Islands that is trying to protect the trees, discourages farmers to plant because if they illegally cut or mistreat the sandalwood, they could face criminal charges. This provides a disincentive for local people to help grow more trees.¹⁹

In Sri Lanka, boundary demarcation, declared conservation forests, and increased park staff where implemented to protect and conserve sandalwood, but fire and grazing continue to be a main cause of destruction. In 2010, an effort was made to educate local farmers of the damage caused by fire and grazing and the importance of the sandalwood to future generations.²⁵

S. austrocaledonicum from the islands of Vanuatu and New Caledonia is of serious concern, with little remaining of its natural habitat. During the 1840's, sandalwood traders discovered these trees and began overharvesting.²⁶ In 1987, the government restricted quantities logged, but the land was never properly reforested due to disputes of ownership.²⁶

Below is a list of more sandalwood species in danger:

- All *Santalum* species of Hawaii are on the "At Risk" list of United Plant Savers.²⁷
- *S. fernandezianum* of the Juan Fernandez Islands has a status of "Extinct" by the WCMC.¹¹
- *S. freycinetianum* of Polynesia is "Endangered" with a need for a moratorium on tree cutting and land conservation and *S. insulare* is "Vulnerable," and the only other sandalwood species of Polynesia.^{28, 29}
- *S. lanceolatum* is "Endangered" in parts of Australia.²²
- *S. macgregorii* is "Endangered" on the 2017.1 IUCN Red List.¹ Located in Papua New Guinea, there are very few mature trees due to overexploitation.³⁰
 - *Santalum yasi* has been overharvested in Fiji and Tonga, causing a low density and small size of adult trees.³¹
- *Osyris lanceolata* is "Endangered" in Kenya and declining in Tanzania; and has been listed on CITES since 2013.¹²

- *Pterocarpus santalinus*, red sandalwood, of India is “Endangered” on the IUCN 2017.1 Red List and trade is monitored through CITES with new plantations being established.^{1, 12, 32}

Spikenard (various *Aralia* and *Nardostachys* species)

Rhizomes of the spikenard plant are used in essential oil for insomnia, stress, and tension with the drug industry using it for various degenerative diseases.³³ CAMP reported a population decline in India of 75-80%, classifying the plant as “Endangered,” with biodiversity under serious threat.³⁴ Exports of the plant have been banned, resulting in an absence of commercial cultivation that has led to untrained extraction, habitat destruction, and premature harvesting. This, along with an increased market price, has resulted in heavy adulteration that creates an essential oil without the same medicinal constituents.³⁵

A. chinensis, *A. debilis*, *A. javanica*, *A. malabarica*, and *A. tibetana*, are all on the 2017.1 IUCN Red List as “Vulnerable.”¹ *A. racemosa* and *A. californica* are on the “To Watch List” of United Plant Savers.²⁷ *Nardostachys grandiflora* (Jones) DC of the Himalayas was banned for export from Nepal in 1993, and listed in CITES in since 2007.¹²

N. jatamansi is listed as “Critically Endangered” on 2017.1 IUCN Red List, and *N. jatamansi* DC is on the verge of extinction from over harvesting and degradation of its environment in India, Pakistan, Nepal, Tibet, China, and Yunan.^{1, 33} Unregulated root collection and loss of habitat needs to be addressed.³⁶ Further, The Red Data Book of Indian Plants lists 17 species, including *N. jatamansi* DC. RAPD is a method used in measuring biodiversity of a species: polymorphism, and characterizes variability. *N. jatamansi* DC was collected and analyzed from India and Nepal to determine better propagation strategy to maintain diversity and conserve the plant in high demand for its medicinal properties.³⁷

Agarwood Oil (*Aquilaria crassna* and *Gyrinops* species)

Also called oud, agalocha, gaharu, aloeswood, eaglewood, and kiara, *Aquilaria Crassna* is “Critically Endangered” on 2017.1 IUCN Red List, and multiple species are listed on CITES.^{1, 12} In high demand and reputed to be the most expensive wood in the world, it can be found in North Eastern India, Bhutan, South East Asia, and Thailand. The aroma from agarwood is created when a fungus infects the tree. *Aquilaria crassna* is also protected by the Vietnam government, with overharvesting causing a population reduction of over 80%.³⁸ It is a very expensive essential oil and overharvesting has resulted in seven other *Aquilaria* species being designated as “Vulnerable” on the 2017.1 IUCN Red List and all species of *Aquilaria* and *Gyrinops* were placed on the CITES Appendix II list of International Trade in Endangered Species.^{1, 39} The Indian Forest Act bans extraction and export, to reduce genetic erosion via CIMAP 1997.¹¹

Cedarwood atlas (*Cedrus atlantica* and many *Juniperus* species)

Cedarwood oils are obtained from three main species. In America, *Juniperus ashei* Buch is found in Texas and *Juniperus virginiana* L. is found in Virginia. In Morocco and India, there is the *Cedrus* species and in China, it is the *Cupressus* species. It is the *Cedrus* species whose populations are of the most concern. The essential oil has been marketed for being antiseptic, anticatarrhal, as an expectorant, and as a circulatory stimulant.⁴⁰ It is also used for furniture,

carpentry, construction, tar making, and as an insect repellent.

Especially in Morocco, *C. atlantica* is on the 2017.1 IUCN Red List as “Endangered” with up to a 75% decline in population between 1940 and 1982 and continuing to dwindle.^{1, 41} The Atlas Mountains of Morocco are a Mediterranean Red Alert area with 10,000 km² of the forest disappearing from 1940 to 1982 and a 40% loss over the past three decades.⁴⁰ The World Wildlife Fund (WWF) classifies the conifer forests of North Africa, Morocco, North Tunisia, and North West Algeria as “Critically Endangered.”⁴⁰ Pest outbreaks and a more arid climate have worsened the situation along with overgrazing and fires.⁴¹ *C. deodara* (Himalayan cedarwood), and *C. libani* of Lebanon are additional *Cedrus* species listed on the 2017.1 IUCN Red List.¹ Further, the 1991 – 1996 drought has rendered the area ecologically fragile and susceptible to desertification, erosion, demineralization, and dehydration.⁴⁰

Juniperus procera, Kenyan cedarwood, was listed as “Endangered” by the FAO Forestry Dept. in 1986, listed as “Endangered” in Saudi Arabia and Malawi, and listed on IUCN 2010 Red List of Threatened Species.⁴⁰ *Juniperus cedrus* of the Canary Islands is “Endangered” with a population of only 600 sexually mature trees and decreasing.⁴² Problems for this species have included exploitation of the wood for aromatic timber, a severe fire in 2007 in the El Teide National Park, and overgrazing.⁴² Poor genetic diversity needs to be addressed as part of the conservation plan, and the reintroduction of more raven and wintering ring ouzel birds could aid in the long range seed dispersal.⁴³ Recently, in 2000, all goats were removed to improve growth.⁴² *Juniperus communis* subsp. *Hemisphaerica* was identified by the nation of Morocco as “Critically Endangered” and *Juniperus thurifera* was listed as “Vulnerable.” *Widdringtonia whytei* Rendle, Mulanje cedarwood of Tropical Africa is “Critically Endangered” on the 2017.1 IUCN Red List, being heavily exploited for over 200 years. Illegal logging, fires, lack of regeneration, invasive species, and pests could cause a decline of over 809% by 2030, with wood being used to build houses and illegal cutting also being a major problem.^{1, 44}

Discussion

Consumers have a moral responsibility to avoid purchasing at risk plant species. In many cases, “Fair Trade” goes along with this issue, where both the plants and the poor people of an area are equally exploited by big businesses who profit highly from the sales of rare essential oils in danger of extinction. The quickest way to look up a species status is at www.iucnredlist.org, however a species may be overharvested before making it onto the IUCN’s list. Also do a query in Google Scholar of “plant species name” and “threatened” or “endangered” to find additional scholarly status updates, often written by local experts. In doing research, the author has noticed multiple essential oil suppliers selling listed endangered species. In this instance, it is suggested to call the company and discuss the latest status of the species and how they get their supply before purchasing.

The use of alternative essential oils with similar healing properties can be considered as a way to avoid endangered and threatened species. Myrrh comes from the same plant family as frankincense: *Burseraceae*, and both species are small trees growing in dry climates. The resin extracted from both frankincense and myrrh consists mainly of terpene hydrocarbons along with sesquiterpenes.⁴⁵ Both oils can be used for skin healing, immunity strength, and as a decongestant, and have been used as a spiritual incense since Biblical times. Coriander seed (cilantro) from *Coriandrum sativum* may be a good replacement for rosewood. Both are very high in linalool and have a sweet, spicy, woody scent.

As it relates to sandalwood, it seems easiest to recommend avoiding any varieties coming from India, Hawaii, Vanuatu, and New Caledonia unless the educated consumer investigates their source. Alternative species from Australia include *Eucaria spicata*, *Fusanus spicatus* R. Brown, and *S. cygnorum*. *Brachyleana hitchensii*, also called Muhuhu, may be a viable source out of Kenya and *Amyris balsamifera*, also called West Indian sandalwood, comes from Haiti. Some essential oil companies suggest Ho wood oil (*Cinnamomum camphora*) as an alternative to Indian sandalwood, but this tree is also in danger.⁴⁶ Agarwood is an endangered tree whose resin is also highly prized. Its smell is often described as sandalwood like, and the species listed above may be viable replacements. With cedarwood, there are species across the world and the Moroccan variety seems to be in the most jeopardy, while in Texas, *Juniperus ashei* is in abundance.

Honeysuckle is in the same valerian family as spikenard, so it may be a likely alternative, but it is very costly to extract essential oil from honeysuckle flowers. An idea would be to make a honeysuckle infused oil; however the following recipe involves the flowers and not the roots, as in spikenard:

- Pick the honeysuckle flowers and allow them to dry for a few hours, but not too much longer as these very delicate flowers may wilt and lose their smell. Put the same quantity of flowers to base oil in a glass jar and set out in the sun each day for two weeks, bringing inside in the evening. After two weeks, strain the herbs out of the oil using several layers of muslin cloth. It may be necessary to then re-infuse the strained oil with a fresh picking of more lightly dried honeysuckle in the same method for two more weeks to strengthen the scent. The infused oil can be preserved by adding benzoin. Valerian root may be another alternative to spikenard, however, as indicated in the appendix of this paper, it has multiple species on the IUCN Red List.¹

Conclusion

Certain species of frankincense, rosewood, sandalwood, spikenard, agarwood, and cedarwood atlas all make amazing essential oils, but not worth purchasing at the cost of species survival. Research has shown stories of overharvesting, human exploitation, and lost habitat that has cost these plants dearly.

- Frankincense resin from the Horn of Africa has a history of being fraught with corruption and exploitation.
- Rosewood has been stripped in Brazil and has spread to Madagascar with deforestation that is affecting many plant and animal species.
- Sandalwood, with a valuable history to the economy of India, may be overprotected by the government to the point that it discourages farmer cultivation. Multiple species from Australia to Hawaii have also gone extinct or are in serious danger.
- Spikenard export has been banned, resulting in a heavily adulterated essential oil.
- Agarwood has a threatened genetic diversity, with a lack of variation affecting the species.
- Cedarwood atlas has seen its conifer forest habitat shrink drastically.

The solution to saving these plants can start with the consumer. Stopping the purchase sends the message to the supplier that no oil is worth the cost of losing species.

Appendix: Additional Essential Oil Species of Concern

Argon oil <i>Argania spinosa</i> Morocco	In Morocco, <i>Argania spinosa</i> is “Endangered” and its genetic diversity is severely threatened. ⁴⁷ In addition, <i>Aquilaria malaccensis</i> is “Endangered” and protected worldwide by CITES since 1995. ¹²
Buchu oil from <i>Agathosma betulina</i> South Africa	Lucrative for its camphor components, buchu oil has many medicinal uses. It is primarily harvested from the wild, but cultivation is providing more supply to go along with the increasing international demand and to help the poor local population earn income. However, sustainable harvesting is an issue due to the local practices of poverty stricken people and poor legislation. ⁴⁸
Calamus oil from <i>Acorus calamus</i> India, Pakistan	This ginger-like plant has become “Endangered” in Pakistan, rare in India, and listed as a VU Threatened Medicinal Plant in S. India. ¹¹ Highly sought for the medicinal value of its root, it was banned from export during 1997 to save the crop from extinction in the wild. ⁴⁹ Multiple <i>Calamus</i> species are on the 2017 IUCN Red list. ¹
Chaulmoogra from <i>Hydnocarpus pentandrus</i> & <i>H. kurzii</i> India	Chaulmoogra is “Vulnerable” on the First Red Data List for S. India and CIMAP, 1997. ¹¹ In India, the seed oil is used to treat many ailments, with loss of habitat and unsustainable collection. ⁵⁰
<i>Coleus forskohlii</i> India	<i>Coleus</i> is “Endangered” in India, and is a member of the mint family whose roots are collected for Asian healing methods. ⁵¹
Gugguli from multiple <i>Commiphora</i> species India, Pakistan	Multiple <i>Commiphora</i> species are on the 2017.1 IUCN Red List, 2010. ¹ Unsustainable harvesting of the gum, called Guggulu, which is used for medicinal purposes, causes a death of the plant. Located in India and Pakistan, the Indian government has banned export of the species. ⁵⁰
Costus oil from <i>Saussurea costus</i> India	This “Critically Endangered” plant is on the 2017.1 IUCN Red List and harvested for the medicinal value of its roots. ^{1,5} It is also listed in the Wildlife Protection Act of India, 1995. ¹¹ Habitat loss, illegal harvesting, and uncontrolled yak grazing has threatened the species. ⁶²
Elemi from <i>Canarium luzonicum</i> Philippines	This plant had a status of “Vulnerable” on the 2017 IUCN Red List. ¹ It is highly regarded in Europe for use to reduce skin wrinkles and to soothe muscles.
Fir: Nordman <i>Abies nordmanniana</i> Turkey	This Fir was on 2017 IUCN 2010 Red List. ¹ Northwestern Turkey has experienced a loss of mature trees due to illegal logging, acidic rain caused by sulphur dioxide from a nearby power plant, habitat degradation, and fire, with a decreasing population trend. Excessive visitors to the National Park, especially during the annual Sarikiz Festival and around Mt. Olympus have caused further issues for the trees. ⁵²
Galbanum or giant fennel, multiple	Multiple <i>Ferula</i> species are on the 2017 IUCN Red List are: <i>F. caucasica</i> and <i>F. latpinna</i> as “Vulnerable,” <i>F. sadleriana</i> as “Endangered,” and <i>F. mervynii</i> as “Critically Endangered.” ¹

<i>Ferula</i> species Europe	
Gentiana <i>G. kurroo</i> Royle Himalaya	Gentiana has many of its 300 subspecies identified as “Rare” or “Threatened.” <i>G. kurroo</i> Royle of Northwestern Himalaya is “Critically Endangered” and the roots are used as a bitter tonic for many medicinal purposes. ⁵³
Gurjun from multiple <i>Dipterocarpus</i> species India	This balsam tree of India has many species “Endangered,” “Critically Endangered,” and “Extinct” on the 2017 IUCN Red List. ¹
Hinoki wood <i>Chamaecyparis</i> species Japan	Hinoki wood is highly prized for holy buildings but suffers from excessive logging with slow growth. ⁵⁴ As an essential oil, it has a spicy lemon scent. <i>C. formosensis</i> is on the IUCN Red List as “Endangered,” while <i>C. iawsoniana</i> , and <i>C. obtuse</i> are “Near Threatened.” ¹
Ho wood oil from <i>Cinnamomum</i> <i>camphora</i> China	Ho wood oil, coming from a blend of <i>Cinnamomum camphora</i> subspecies trees, has been blocked from cutting in China as of 2007, and is listed as “Vulnerable.” ¹¹ The camphor tree of South China is a valuable timber for furniture, artwork, and architecture and as an oil used in medicine and perfume. ⁴⁶ In the past decades, this tree was overharvested, but recent reforestation activities have improved quantities. However, most of the seedlings planted were from low quality trees and higher quality breeds of camphor trees need to be planted to improve quality. ⁴⁶ Many <i>Cinnamomum</i> species are listed as “Endangered” on the IUCN Red List. ¹
Holy wood from multiple <i>Guaiacum</i> species FL & Central America	Holy wood (<i>Guaiacum sanctum</i>) is listed as “Endangered” in the IUCN Red List. ¹ <i>G. coulteri</i> and <i>G. officinale</i> are also listed on the 2015 IUCN Red list. ¹ Found in Florida, North and Central America, <i>G. sanctum</i> is also listed by CITES. ¹² <i>Bursera glabrifolia</i> , a variation of the plant in Mexico, was almost locally extinct in 2003. ¹¹ <i>Bulnesia sarmientoi</i> is a species listed by CITES and <i>Bulnesia carrapo</i> is listed on the IUCN Red List as “Endangered.” ^{1,12}
Pushkarmoola <i>Inula racemosa</i> North West Himalaya	<i>Inula racemosa</i> is a “Critically Endangered” alpine herb of the Himalayas, which is used for multiple medicinal purposes. North West Himalaya has seen a huge increase in illegal extraction of its medicinal plants, causing an over-exploitation that has drastically decreased populations of some species. ⁵⁵
Galangal <i>Kaempferia</i> <i>galangal</i> , <i>K.</i> <i>rotunda</i> , and <i>H.</i> <i>spicatum</i> Smith Tropical Asia	Galangal or galgant spice lily is an aromatic ginger medicinal plant of tropical Asia facing extinction. ⁵⁶ <i>Hedychium spicatum</i> Smith is a very highly valued medicinal plant with a status of “Vulnerable.” It is of the Indian Himalayan Region and is also called Kapoor or ginger lilly. ⁵⁷
Auracacia oil from <i>Neocallitropsis</i> <i>pancheri</i> New Caledonia	<i>Neocallitropsis pancheri</i> , known for its Auracacia oil, has been heavily overharvested for its resin used in perfumery. The total population of this plant is under 10,000 and decreasing, and is listed as “Endangered” on the IUCN 2017.1 Red List. Fires and mining activity have also been a key threat to its existence. ^{1,58}
<i>Origanum</i>	<i>Origanum</i> is a small spicy shrub with some species endemic to the Middle East

– multiple species Middle East	classified as “Vulnerable” or “Near Threatened” on the IUCN Red List, including <i>O. cordifolium</i> , <i>O. dictamnus</i> and <i>O. ehrenbergii</i> . Commercial plantations of palm oil have threatened multiple species. ^{1, 11}
Ginseng <i>Panax ginseng</i> C. A. Meyer Korea & America	<i>Panax ginseng</i> C. A. Meyer is wild forest ginseng of Korea, and used in pharmacological products. It is believed to be endangered in Korea, and the American ginseng plant was listed on CITES to protect it from extinction. ⁵⁹
Norway spruce <i>Picea abies</i> Norway	Norway spruce is on the 2011 Norwegian Biodiversity Information Center’s Red List. Additional varieties of Spruce are listed on the IUCN Red List. ^{1,60}
Pine Multiple <i>Pinus</i> species	Pine has over 100 subspecies marked as “Threatened,” including <i>Pinus halepensis</i> Miller, <i>P. cembra</i> L., <i>P. roxburghii</i> Sarg., <i>P. merkusii</i> Jungh & De Vriese, <i>P. radiata</i> D. Don, <i>Pseudotsuga menziessi</i> (Mirbel) Franco, <i>P. pumila</i> (Pall.) Regel, <i>P. silvestris</i> L., <i>P. sibirica</i> Du Tour, <i>P. elliotii</i> Englm, <i>P. strobus</i> L., <i>Pinus kesiya</i> , and <i>Pinus merkusii</i> . ¹¹
Ravensara oil <i>Ravensara aromatica</i> Madagascar	Ravensara oil of Madagascar is excessively overharvested for its stem bark by one particular essential oil company to the point of threatening the species. ¹¹
Siam wood <i>Fokienia hodginsii</i> Southeast China and Vietnam	Siam wood or Fujian Cypress is on the IUCN 2017.1 Red List as “Vulnerable.” ⁶¹ Its timber is heavily prized in Vietnam for its aroma and weight and its roots are distilled to make oil for cosmetics and medicine.
Valerian root Multiple <i>Valeriana</i> species Nepal & Pakistan	<i>Valeriana jatamansi</i> of the Himalayas is “Endangered” in Pakistan and “Vulnerable” in Nepal. ¹¹ Several <i>Valeriana</i> species are harvested for the medicinal properties of their roots and are threatened by forest degradation. <i>V. asterothrix</i> , <i>V. buxifolia</i> , <i>V. cernua</i> , <i>V. coleophylla</i> , <i>V. leschenaultia</i> , and <i>V. secunda</i> are on the 2015.2 IUCN Red list. ⁵⁰
White sage <i>Salvia apiana</i> California	White sage of California is on the “To Watch” list by United Plant Savers. ²⁷
Wintergreen oil <i>Gaultheria franrantissima</i> Wall India, Java, Nepal, and China	Wintergreen oil (<i>Gaultheria franrantissima</i> Wall) of India, Java, Nepal, and China is considerably depleted according to S. India CIMAP. ¹¹

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