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An Overview of American Ginseng through the Lens of Healing, Conservation and Trade

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Abstract

American ginseng (*Panax quinquefolius*) is an herbaceous plant found in the eastern United States and Canada. Due to the high demand for ginseng roots on the Chinese market, it has been harvested at unsustainable rates. If this continues, overharvest along with other environmental factors will lead it to become extinct in the wild. American ginseng became popular due to its similarities with Asian ginseng, (*Panax ginseng*), a related plant that has been used in Chinese medicine for hundreds of years. Since there is so little Asian ginseng left in the wild, American ginseng now helps satisfy the demand for wild roots. Due to differences in appearance, wild ginseng roots are highly valued over cultivated ginseng. Despite the establishment of the cultivated ginseng industry, the demand for wild roots remains high. As China's middle and upper classes grow, the demand for these expensive roots increases even more. Meanwhile, the poor economy of the Appalachian region leads more people to harvest ginseng, legally or illegally, as a second source of income. Encouraging the use of wild-simulated ginseng may be one way to reduce the rate of harvest of wild roots.

Introduction

A rare wild herb in the forests of the Eastern U.S. is hidden in obscurity to the average American, but for those who know of it, this herb can represent an enormous profit, a cure to an illness or a conservation crisis. American ginseng (also known as *xiyangshen* 西洋參 or *Panax quinquefolius*) is a plant that has been adopted by Chinese medicine, and now subsequently suffers the curse of a highly valued organism. Just as elephants are hunted for their valuable tusks and tigers for their valuable furs, American ginseng is harvested for its root which can be sold for hundreds and sometimes even thousands of dollars per pound.[1] In the process of overharvesting, it has become a vulnerable plant, and if this continues, it may become extinct in the wild.

The demand for the American ginseng is rooted in traditional Chinese medicine (abbreviated as TCM). Before American ginseng was introduced to the Chinese, a related plant *Panax ginseng*, also known as Asian ginseng, was an extremely valuable herb used in TCM.[2] It was used to treat such a wide variety of different afflictions that it was given the Latin name *Panax* meaning "panacea" or "cure-all". [2] However, due to its high value, through centuries of unsustainable harvest Asian ginseng has become practically extinct in the wild[2].

Although it is difficult to determine the pre-settlement abundance of American ginseng, by examining historical shipping records, it is clear that it has decreased significantly. In the 1800s, the total harvest of wild ginseng annually was nearly ten times the amount harvested in a year in the 2000's [3]. The valuable part of ginseng is the root, which is used to make teas and other medicinal products. The rhizome is also important in determining the age of the plant and a harvested root without the rhizome is virtually worthless. [2] Root harvesting kills the entire ginseng plant, and it cannot regenerate the next year as it could in the case of deer browsing

where the root remains intact. In addition, ginseng faces several other threats, including habitat fragmentation, predation, competition, and problems related to climate change.

The loss of ginseng in the wild would be a tragedy simply considering its intrinsic value, but its cultural value must be considered as well. As a medicinal, plant ginseng is important to the Chinese, as well some Native American tribes. The practice of harvesting ginseng also goes back generations and is a meaningful tradition to some families while providing an extra source of income to people who are struggling economically. To provide a better understanding of what can be done to preserve wild American ginseng, this paper will explore the historical and cultural context of ginseng, the anthropogenic factors threatening ginseng's decline, and the ginseng trade industry.

A Brief History of Chinese Medicine and Ginseng

American ginseng is a product of the New World and was only introduced to China in the 1700s.[2] When it arrived in China, it was incorporated into a knowledge system that had already existed and developed for thousands of years. It is a common misconception today that so-called traditional Chinese medicine is a system that remained constant and fixed since its beginning, but in reality it represents knowledge comprised over time. The *Yellow Emperor's Classic of Internal Medicine*, (*Huangdi Neijing*, 黃帝內經) a work still considered an essential canon of Chinese medicinal knowledge up to today, has been supplemented, rearranged and annotated since it was first compiled over 2000 years ago.[4] As new knowledge, new materials and new cultural influences have been introduced, they have been incorporated into the practice of Chinese medicine. For example, during the Tang dynasty (618-907 CE), Buddhism became more popular and medical concepts in Buddhist texts were integrated into Chinese medicinal practice.[5]

For example, personal hygiene practices such as bathing and brushing teeth were encouraged due to the influence of Buddhism.

More recently, beginning in the 1980s, in order to help Chinese medicine rise to the world stage, certain practices were systematically standardized and regulated by the PRC government.[6] Making Chinese medicine more consistent and eliminating specific regional characteristics increased its international appeal, while simultaneously excluding other healing practices with competing interests. Thus, the so-called traditional Chinese medicine that has spread across the globe today may not be nearly as "traditional" as it may seem. Additionally, Chinese medicine has become more and more integrated with biomedicine within the last century.[6] Today, a typical English language TCM materia medica (a book of healing materials) will not only feature an explanation of the Chinese medicinal functions or herbs, but also mention chemical constituents and pharmacological information.[7][8][9] Despite the change in Chinese medicine over hundreds and thousands of years, it is still important to consider the influence that older medical literature holds. The majority of people who promote ginseng as a health product use its long history as a reason to use it.[10] Chinese medicine's extensive history helps it be perceived as more legitimate in contrast to newer systems of medicine and healing.

American ginseng has entered into Chinese medicine relatively recently, thus, examining the history of its relative, Asian ginseng (also known as *renshen* 人蔘 or *Panax ginseng*), can provide much insight into how American ginseng is used today. The history of the harvest of Asian ginseng also reflects current trends in American ginseng. Asian ginseng is first mentioned in the *Herbal Classic of Shennong*, (*Shennong Bencao Jing*, 神農本草經) the first compilation of Chinese herbal knowledge, written around 100 CE. The first literature on its actual medical uses and applications is found in the *Treatise on Cold Injury* (*Shanghan Lun*, 傷寒論) written

about a hundred years later, and which is still a relevant TCM text today.[10] It is evident here that Asian ginseng was a relevant herb, being an ingredient in 21 of the 107 formulas in the book. From the beginning of ginseng's use through the end of the Ming dynasty (1644), wild, rather than cultivated ginseng was consumed.

Because of the slow life cycle of the plant, wild Asian ginseng populations receded with continuous harvesting. By the late 1400s, the plant was all but extinct in central China, and harvesters had to venture to increasingly inaccessible places in northeast China and Manchuria in order to find it.[2] The root became increasingly rare, leading it to become so expensive only the rich could afford it. [10] Despite ginseng's inaccessibility to the majority of people, it was still mentioned frequently in medical literature. Since it was not as common as other medicinal herbs, it was easy for ginseng sellers to greatly exaggerate the benefits of ginseng without any basis. There are instances of families who wasted their life saving on ginseng in order to save a dying relative, and when the relative died anyway, ginseng was blamed for the death. [10] While people used ginseng to help those on the brink of death, they thought that it was harmful if misprescribed. In some cases, ginseng would only make a condition worse, as described by a saying, "Nourishing the body with tonics when a pathogen is present is like inviting a robber into a comfortable home; he would gladly enter and not leave, taking time to steal all its valuables" (Dharmanada) [10] The rarity of ginseng also led to other cheaper herbs such as *dangshen* (黨參 or *Codonopsis pilosula*) to be used as substitutes by the Qing dynasty.

As wild ginseng became increasingly rare, it began to be cultivated domestically in the 1400s.[11] In the 1500s, Ming physician Li Shizhen (李時珍) wrote the *Compendium of Materia Medica* (*Bencao Gangmu* 本草綱目) where he sorted through the large amounts of herbal information and misinformation, creating a book that would be essential in Chinese herbal

medicine for centuries to come.[10] This would contain first treatise specifically on Asian ginseng, providing a more detailed explanation of its uses.

A couple centuries later, on the other side of the world, a new type of ginseng would be discovered. In 1716, in New France, through an encounter with Mohawk women, the Jesuit missionary Joseph-François Lafitau discovered American ginseng.[12] With further information, Lafitau recognized the resemblance between American ginseng and Asian ginseng as well as their role in culture as medicinal plants. Not only were they morphologically similar, but both plants were used for medicinal purposes, and even had the same name; both the Chinese and Iroquoian word roughly meant "resemblance of a man" (referring to the root-structure which looks like a pair of legs). Lafitau thought that American ginseng was part of a larger migration of plants and people from the Old World and was much more concerned with the intellectual implications of these similarities. [12] Unintentionally however, he uncovered a global trade opportunity with his findings, due to the high demand for ginseng in the East. Lafitau doubted that widespread harvesting of the root would be sustainable, however, and he was concerned that his knowledge might fall into the hands of people more interested in trade than cultural commerce with Native Americans.

Nonetheless, word got out to the Europeans. They already knew that ginseng was "worth its weight in gold" in China, so the harvest and trade of American ginseng exploded. Merchants had little regard for the role of ginseng for Native Americans, and ignored the cultural context that Lafitau emphasized in his writing. In 1752, harvesters took around 15,685 kilograms of ginseng from the forests of New France.[12] The amount of ginseng exported from the New World grew and grew. The huge quantities of roots exported indicate that the population densities of American ginseng were much larger than they are today. In 1841, over 290,000 kilograms of

ginseng were exported from America, representing at least 64 million roots.[3] The high levels of harvesting would gradually decrease the ginseng population, making it harder to find. In the end, the Indigenous people who helped Lafitau in his intellectual pursuits became the victims of the global market, a pattern that unfortunately repeated itself throughout the world.[12]

American ginseng first arrived in China through a port in Hong Kong, giving it the alternative name "Guangdong ginseng". It was first mentioned in 1751 by Wu Yiluo (吳儀洛) in the *Thoroughly Revised Materia Medica* (*Bencao Cong Xin*, 本草從新).[8] Since American ginseng was imported from Guangdong, it was considered a southern product in contrast with Asian ginseng, which was considered a northern product, coming from Manchuria.[10] Because of this, Chinese medical practitioners considered American ginseng as good for nourishing *yang* (an element that must be balanced with the element *yin* to retain good health), although this view shifted over time. The effects and proper use of American ginseng has been the subject of controversy since its arrival. While some praised the new root, others saw it as a useless novelty.[9]

By the end of the 1800s, American ginseng became scarce enough that people made efforts to cultivate ginseng. Some of these growers in Wisconsin and Ontario succeeded in the commercialization of farmed ginseng, and the industries in these two areas continue to this day. Despite the availability of cultivated ginseng, wild ginseng was, and still is, much more valuable on the Chinese market. The gnarled, twisted shape of wild ginseng was upheld by consumers.[8] In addition, Harrison et al. explain:

> Ginseng roots shaped like the human body are considered highly desirable. In particular, old roots (some may be nearly a century old) are prized because their longevity is claimed to be transferred to the person who consumes them.[13]

The age, along with root morphology, were important factors in determining a root's value. In the modern day, many proponents of ginseng argue that the potency of wild ginseng is much higher than the cultivated type.[10] While the primary market of American ginseng has been East Asia, a growing interest in alternative medicine in the West has expanded the market. Today, American ginseng, whether in its wild or cultivated form, is one of the top ten herbs sold on the US market, and is heavily traded in the west.[14] In 1975, American ginseng was listed on Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), which includes species that are deemed to be susceptible to extinction if there are no trade controls implemented.[3] The regulations laid out by CITES and well as the American government did not fix everything, however. Many laws on ginseng harvesting are nearly impossible to enforce. Unlike endangered animal products which can raise a red flag at customs, ginseng is a relatively unassuming plant that can easily go unnoticed. And unlike the poaching of animals, the harvest of ginseng is a quiet affair and can also easily go unnoticed.[15] There are no loud gunshot sounds, and the tools used to dig up ginseng can be hidden easily, along with the plant itself.

Today there are 19 U.S. States where ginseng can be harvested legally and plants must be at least five years old in order to be harvested (and at least ten years in Illinois). Additionally, ginseng may only be harvested within the State's designated harvesting season for the plant. These regulations allow ginseng to reach reproductive age before it is harvested in order to ensure the wild populations continue to exist, although compliance with these regulations is not consistent. While the U.S. does not list American ginseng as an endangered species, the states of Maine and Rhode Island do, and many others recognize the plant as vulnerable, threatened or of special concern.[16]

A Profile of American Ginseng

American ginseng is an herbaceous perennial plant from in the ivy family, *Araliaceae*. While it is primarily found in the Ozark and Appalachian areas of the U.S., it has a range throughout southeastern Canada and northeastern US. American ginseng.[3]

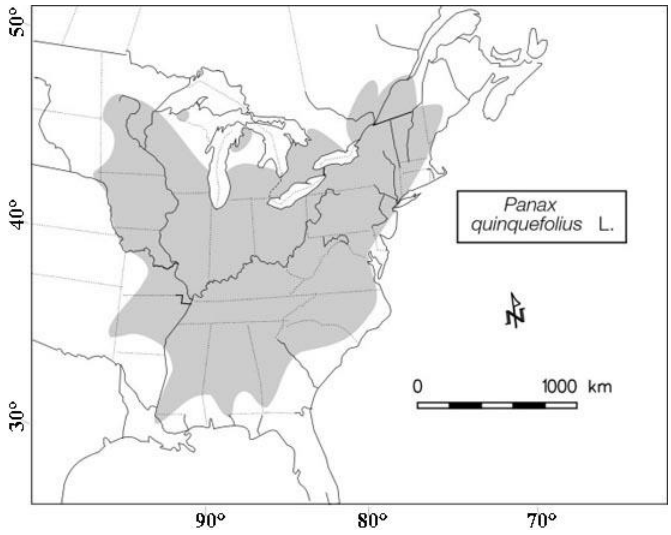

Figure 1 A map of the American ginseng's natural range (in grey) [16]

The type of habitat ginseng is found in is relatively diverse.[3] They are found in hardwood forests, but the tree composition of these forests can vary widely. Ginseng can be found in relatively dry forests, as well as moist ones, and on flat to relatively steep hillsides. The soil texture ranges from silty clay to loamy sand and the acidity can range from neutral to moderately acidic. The large geographic range and environmental gradient of ginseng distinguishes it from many other rare plant species that often prefer specific niche environments.[3]

Throughout its geographical range however, populations of American ginseng are never abundant. Ginseng populations are locally uncommon and are typically composed of less than 200 individual plants.[3] The distribution of individuals within populations are highly clumped in both adult and juvenile plants, suggesting that the typical range of seed dispersal is relatively

small and dependent on gravity.[17] On the other hand, the red, fleshy drupes are characteristic of fruit that is distributed by birds, but the correlation between animal consumption rates and dispersal are not currently known.[3] This clumping tendency could also suggest that ginseng congregates around certain microclimates which are themselves clumped, but given that they are a habitat generalist, there is no evidence to support this theory.

Ginseng is a relatively long-lived perennial herbaceous plant that can live to over 50 years, however in most natural populations, plants rarely survive over 25 years.[3 18] There are a few ways to estimate the age of the plant. The most accurate way is to examine the subterranean stem of the plant, also known as the rhizome. In American ginseng, the rhizome forms well-defined scars every year, so the age of the plant can be determined by counting the rhizome scars.[19] Another, less invasive method of estimating age is by counting the number of palmately compound leaves, commonly referred to as "prongs," on the plant and the number of leaflets on these prongs. Although this cannot provide information of exact age, prong and leaflet number are directly correlated with age and can be a relatively good indicator of if the plant has reached maturation, as one-pronged ginseng plants are always juveniles.[18]

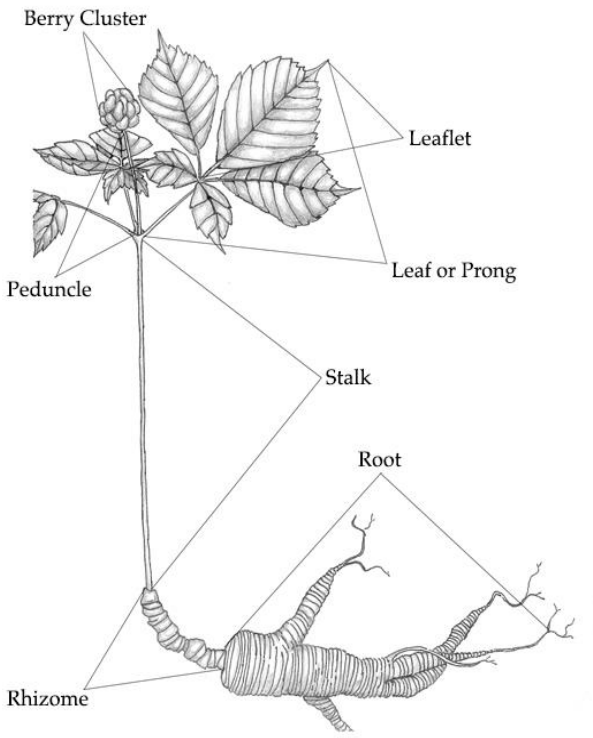

Figure 2 Anatomy of a three-pronged ginseng plant[16]

Plants begin to attain maturation when they reach the two-pronged stage and the majority of them are mature by the time they have three prongs. Because of this, most state laws require that plants have three prongs in order to guarantee the ginseng is at least five years old and has reached maturity. Compared to older plants though, the reproductive output of plants with less leaf area is relatively small. In a population dynamic study of American ginseng conducted by Lewis and Zenger, they found that even though almost one half of fruiting ginseng were composed of two-pronged plants, they only accounted for 24% of the matured fruit.[18] It is hard for new ginseng plants to become established and takes quite some time when pre-germination time and maturation time are accounted for. After ginseng fruits ripen, it takes 18 to 20 months before seeds begin to germinate. However, the number of seeds that make it to the germination

stage is very small, suggesting that ginseng has a high seed mortality rate.[18] Flowers are white with five sepals, petals and stamens and one inferior ovary with one to three ovules.[3] Small bees (Halictidae) and flies (Syrphidae) are common visitors of the plant. As ginseng increases in size, both its fecundity and its survival rate increases.[20] Smaller plants have a much higher annual mortality rate of 69-92%, compared to the relatively low mortality rate of less than 10% in larger plants.[20] This makes becoming established relatively difficult for ginseng, but once it actually is established, it is likely to survive for quite a long time.

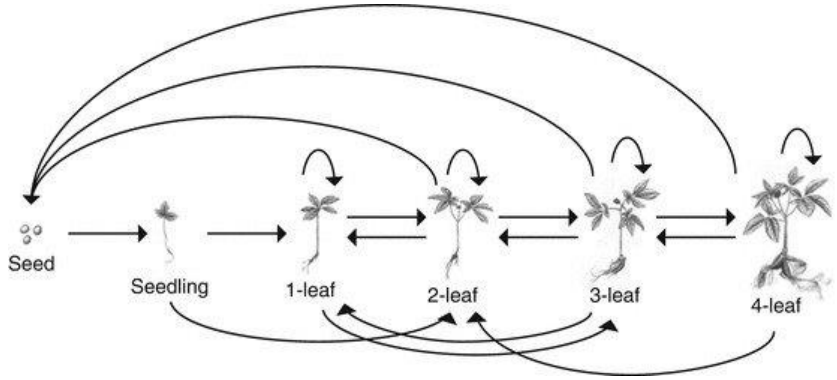

Figure 3 The life cycle of American ginseng[3]

Given the long life cycle of American ginseng and its ability to survive much longer than the typical herbaceous plant, the harvesting threats ginseng faces can be compared to that of large animals when facing hunting pressures. Although hunters do not typically seek out juveniles, through overexploiting the older mature individuals, they reduce the number of reproductive species in the population. Due to the long life cycle and the low output of individuals that will make it all the way to maturity, it can take a very long time for a population to recover to the size before being exploited.

Threats to American Ginseng

Although overharvesting is the biggest, and most well-studied threat facing American ginseng, there are several other environmental factors affecting ginseng populations. While ginseng can inhabit a significantly large range, it is still facing habitat fragmentation. Some of this is caused by industries such as coal mining and logging. The development of suburban sprawl is another factor. Other species have implications on the survival of ginseng as well. The white-tailed deer is a predator of ginseng, and although instances of browsing will not often kill the plant, it will reduce its fitness. This may lead to a population decline since smaller plants produce fewer viable seeds. If the same plant is grazed year after year, this may eventually cause it to die. Grazing reduces the majority of ginseng's photosynthetic functions, causing it to rely on stored underground resources which eventually become depleted. Invasive plant species threaten ginseng as well, adding new fierce competition into the landscape that did not exist previously. Finally, global climate change poses a new threat to ginseng by altering the environment that ginseng has adapted to. All of these factors are directly or indirectly caused by humans. Although some factors may be very difficult to change or reverse, others have the potential to be managed practically.

Harvesting Intensity

To understand the effects of harvesting on ginseng, it is important to understand how harvest is being conducted. A study by McGraw, Souther and Lubbers in 2010 investigated the rates of harvest of ginseng as well as the rates of compliance with harvesting regulations.[15] They monitored 30 populations of wild ginseng across different states and different types of land, including state and national parks and forests, private land, nongovernmental nature preserves and military bases, which was used as a control for harvesting due to being well-guarded. They

found that harvesting occurred most frequently on nature preserves and state parks and forests, accounting for over 40% of the populations they surveyed. This study also suggested that the likelihood of harvest increases with the size of the population. Overall, the annual rate of harvest was relatively low at 1.3% of the population annually, but this number alone does not account for the age or size of the plant.

To measure the intensity of the harvest, they also accounted for the proportion of plants harvested that were not reproductive or were under the size limits specified by most State governments. They found that 69% of the harvested plants did not have seeds the year they were harvested and 37% of plants harvested were only one or two-pronged plants. McGraw et al. also accounted for other forms of non-compliance with the law when harvesting. Twenty one percent of harvests occurred outside of legal harvesting season and 65% of harvests occurred on open-access land where harvesting was not allowed. Accounting for this along with non-compliance with plant-size regulations, 94.1% of harvests were illegal in at least one respect.

Effect on Evolution

The most obvious consequence of the overexploitation of ginseng is extinction from natural populations when they are unable to replace themselves after harvest takes place. But another easily overlooked consequence is the effect harvesting has on ginseng's evolution. In order for evolution to occur, a population must have traits that are heritable, variable, and lead to different outcomes in fitness. The difference in fitness outcomes is what drives natural selection. Organisms with traits that make them less likely to survive and reproduce will not pass on their genetic information to the next generation, while organisms with traits that make them more likely to survive will pass down more genetic information. In the process of evolution, traits that lead to lower levels of fitness are gradually eliminated from a population, leading to a gene pool

where these traits are rare or non-existent. There is a large range of environmental factors that can select against certain plant traits, and humans are an important agent of selection.

A famous example of humans as drivers of trait selection can be found in the decrease in horn size in big-horned sheep. Because big-horned sheep were game animals hunted for their impressive trophy, hunters prioritized sheep with the biggest horns[21]. This created a new selection pressure against large horns. Sheep with larger horns now had reduced fitness because they were more likely to be killed by hunters, and big-horned sheep populations slowly selected for smaller horns. The result of hunting by humans was so strong that the average horn size of big-horned sheep decreased.

Ginseng faces a similar situation. The oldest, largest plants are the most highly sought after, and younger plants are not only less valuable, but also illegal to harvest. These larger plants are also easier to spot, whereas small plants may go unnoticed to hunters. A study by Mooney and McGraw in 2009 investigated how different harvesting pressures affect the relationship between size, age and reproduction.[19] The study included 12 populations with a range of different harvest intensity indexes. Plants in populations with higher harvest indexes had significantly smaller leaf area, than those in lower harvest indexes. In higher harvest indexes, the ginseng stem was also found to be significantly shorter. A ten year-old plant would be 15cm in a population with a low harvest index, whereas a ten year-old in a high harvest index population would be 12cm.

To test whether the differences in size characteristics were due to the environment, Mooney and McGraw set up a common garden experiment.[19] Plants from eight of the populations in the study were transplanted and lived in one common environment. Three to four years after the transplant, these plants maintained different leaf areas. Although this does not

account for the time the plant spent in its original environment, if it is assumed that three years is enough time for carryover effects to diminish, this data suggests that the difference in leaf area is due to difference in genotype rather than differences in environment. Mooney and McGraw also found evidence that harvesting pressures may have implications for ginseng reproduction (i.e. fitness). In populations with high harvest indexes, they found that the likelihood that a flowering plant would produce fruits was significantly less than in the low indexes. In the high harvest index populations, they also found that the number of seeds produced was significantly less. This study has some serious implications for the future of wild ginseng if harvesting continues. If ginseng continues to evolve to become smaller and smaller, harvesting ginseng in the wild may eventually become an unprofitable endeavor. Plants will become more and more difficult to spot and those that are found will not sell for as much, since the size will be smaller. On the other hand, the reduced reproduction ability of plants experiencing intense levels of harvesting may increase ginseng's rate of decline in the wild. It adds another challenge to all the threats American ginseng faces today.

Climate Change

Temperature fluctuation due to climate change could have a significant effect on the survival of American ginseng. Ginseng is found in habitats in Canada all the way down to Georgia, so at first it might seem as if the plant might be able to withstand a large variation in temperature. After all, there is about a10°C temperature gradient between these two habitats.[22] Global temperature changes are projected to increase 6°C at the most, so with this information alone, it could be easy to think that ginseng will not face significant consequences from climate change. However, this fails to account for regional adaption to temperature. If ginseng sub-

populations have evolved to thrive best in local climate conditions, when faced with climate change these plants may be much more temperature sensitive that it would initially seem.

To test for this adaptive differentiation, in 2012 Souther, Lechowicz and McGraw investigated the response of different ginseng sub-populations to the same environmental and climactic conditions.[22] Plants from environments with different elevations and different overall temperatures were transplanted so that temperature and climate could be controlled. They found that there was a significant difference in the growth and reproduction responses to temperature among different ginseng sub-populations. This would suggest that these populations have some form of adapted differentiation and different genes. However, these results do not suggest that different populations experience a "home temperature" advantage. In other words, populations exposed to conditions more similar to the area they came from did not show higher levels of fitness. Souther et al. suggest that this may be because response to climate variation is much more complex than just temperature. There are many other factors to consider, such as the interaction between temperature, soil moisture, light, herbivory and disease.

Fluctuation in temperature is important to consider when looking at the implications of climate change. Even if a plant can withstand a different set of temperature conditions, it may not be able to withstand the increased variability and increased frequency of extreme events that come with climate change. In another study by Souther and McGraw in 2011, the impact of irregular weather associated with climate change was investigated in more detail.[23] In 2007, in the eastern U.S. there was a spring freeze that occurred after a period of warm weather. Since the research team already had a long-term demographic dataset for American ginseng, they were able to analyze the effects of this spring freeze on survival and fitness. They found that when there were higher temperatures before the freeze, the damage to the plants was greater. This

included tissue damage along with cellular dehydration. Smaller plants were also affected significantly more than larger plants. This is one of many types of irregular and extreme weather that can occur with climate change, but it suggests that as general weather patterns change, it will have an effect on American ginseng.

On its own, climate change may not be enough to lead to ginseng's extinction in the wild. With large enough populations, ginseng may be able to evolve and adapt to new conditions. However, since ginseng has a very short seed-dispersal range, population might not have the chance to establish in areas farther north that will be more suitable in the future.[24] In addition, the small, widely-dispersed population clusters reduce the genetic diversity among sub-populations. This mean that there may not be enough variation for individual populations to adapt fast enough. The harvesting pressure ginseng faces makes this problem even worse. The population and genetic diversity is reduced even further, reducing the ability for sub-populations to adapt in the future.

Deer Browsing

Although American ginseng and white-tailed deer have co-existed in the same environment since before the arrival of European settlers, the dynamics between these two species have changed so that deer pose a greater threat to ginseng survival than before. Deer populations are at an historic all-time high. Loss of predators and management policies have led to this increase, as well as forest fragmentation which creates an edge habitat which deer thrive in[16]. Since ginseng is one of the many plants deer consume, it is likely that the browsing pressure on ginseng has increased with this deer population flux.

When deer browse ginseng, it does not typically kill the plant, however it has other consequences for the long-term survival of ginseng populations. A study by Furedi and McGraw

in 2004 measured the rate at which fruit-bearing ginseng plants were browsed by deer.[25] There was a large range of herbivory frequencies ranging from 13% to 100%, but these results indicate that deer browsing is a frequent occurrence in natural communities. They also found evidence that when deer consume ginseng fruit, the seeds are destroyed in the digestive process. This indicates that deer browsing may significantly reduce the seed bank, impacting the viability and growth of ginseng populations.

Other studies on deer and American ginseng population dynamics also indicate that high levels of deer browsing negatively impact ginseng populations. In one study analyzing the population viability of ginseng, they found that when the rate of deer browsing was decreased by 50% or more, there was a serious increase in the local ginseng population viability.[26] They estimated that the minimum viable population was around 800 species, but when browsing rates were decreased by 50%, the minimum viable population was less than 400 species.

Another study investigating the interactive effects between deer browsing and harvesting on ginseng found that in unharvested populations, deer browsing had a significant impact on the growth rate of ginseng populations, however in areas that were harvested (responsibly or otherwise) the impact of deer browsing on ginseng growth rate was negligible.[27] One explanation for this is that after deer browse ginseng populations, the plants are much more difficult for harvesters to spot, leading to a reduced harvesting rate.

Invasive plants

With the arrival of European settlers to the Americas, new plants were introduced to American environments. Some of these plants only thrived well under the care of humans, others co-existed relatively well with the local ecosystem, without taking over. However, some took over the landscapes they were introduced to, becoming invasive species. Invasive species are

much more aggressive in their introduced environment compared with their native habitat. In introduced habitats, invasive species may not have natural predators that keep their population in check, and the other native species they are surrounded by have not co-evolved with them. This means that native species do not have any special adaptations to specifically compete with the introduced invasive species. One example of this is increased susceptibility to allelopathy. This occurs when a plant releases chemicals that affect the survival and reproduction of other organisms, often negatively. Because native plants have not evolved adaptions to the allelochemicals of invasive species, they can face reduced fitness, resulting in being taken over by the invasive species or the inability to colonize an area inhabited by the invasive species.

Like many other native plants, American ginseng faces the increasing threat of invasive species. A survey of 30 different ginseng sub-populations revealed found that 63-70% of populations contained at least one invasive species.[28] This survey also found that the presence of invasive species increased with the presence of harvesting. Some possible explanations for this suggest that human disturbance in these areas could facilitate invasive colonization more easily or that humans act as vectors for these invasive species. In 2010 Wixted and McGraw conducted an experiment specifically on the effects of the invasive and allelopathic plant garlic mustard on ginseng.[29] The results indicated that while garlic mustard did not affect ginseng seedling growth, as its presence increased, ginseng mortality increased likely due to a combination of increased competition and allelopathic effects. This suggests that recently invaded ginseng populations may be able to tolerate a low density of garlic mustard, but as invasion continues and that density increases, it will cause ginseng populations to decline.

Habitat Disruption

The habitat of American ginseng can be disrupted in several ways that impact its viability. Basic development is one concern. Suburban sprawl is expanding into the natural habitat of ginseng and fragmenting populations. This can affect the general environment along the forest edges, changing the amount of light, the temperature and the moisture levels.[16] These changes can limit the area where ginseng can grow even further. A fragmented forest system also has a different species composition. At the edges of forests, there are different pollinators, which do a less effective job at pollenating ginseng.[16] As mentioned earlier, since deer thrive in fragmented forest environments, these areas may also see an increase in deer browsing rates. Fragmentation can turn some ginseng populations into islands as well. Because of this, gene flow between different ginseng populations is significantly reduced and as a result, sub-population genetic diversity may decline.[30] This means that when ginseng faces other survival challenges, it will be less able to evolve and adapt to them. With fragmentation, invasive species also have an increased potential to enter the local ecosystem. They often enter through roadways or housing developments.[28] Landscaping ornamental plants that are non-native have the potential to become established and invasive in wild areas, providing ginseng with new competition.

Changes in the forest canopy have implications for the survivability of American ginseng that have not been fully explored. These changes, like suburban development, can alter the local ecosystem, changing temperature, humidity and soil moisture.[16] The consequences these environmental changes have for ginseng have not yet been examined, but when combined with the effects of global climate change, it is questionable whether such an altered environment would be optimal for the plant. Ginseng is well-adapted for relatively low levels of light so if the thickness of the forest canopy is reduced, this can lead to a less than optimal environment for

ginseng.[31] American ginseng is adapted for the occasional canopy disturbances that occur in old-growth forests, but further research is needed to understand how more dramatic disturbances such as logging affect this understory plant.[31]

The central Appalachian Mountains overlap with the natural habitat range of American ginseng. This area is very rich in coal, and surface coal mining is a common practice.[16] This practice can totally change a landscape. Not only are all the trees and understory plants taken out of the mining area leaving a rocky, unvegetated landscape behind, but the process of surface mining can also change the patterns of hydrology as well as seriously alter the area's soil profiles, soil chemistry and nutrient cycling patterns.[3] Not only does surface mining reduce ginseng's natural habitat, but like suburban development, it creates habitat fragmentation, the detrimental effect of which have been previously discussed.

The culmination of overharvest and these other anthropogenic factors have led to ginseng's decline. One factor by itself may have a smaller impact, but when combined with everything else, it has a much more devastating effect. If harvesting and development continue, American ginseng will suffer the same fate as Asian ginseng and all but vanish from the wild.

An Overview of Chinese Medicinal Theory

To understand how ginseng is consumed today, it is necessary to understand its role in the Chinese medical system. Traditional Chinese medicine is formulated around a set of concepts that may be difficult to understand with only a biomedical background. Ted Kaptchuck, an authority on Chinese medicine in the West provides a comprehensive guide to the theory of Chinese medicine in *The Web That Has No Weaver*.[32] In this section I will summarize some of the ideas laid out in this book in order to provide a better understanding of the system in which

ginseng is integrated. Since many Chinese medical terms do not contain the same exact meaning as their English translations, I capitalize terminology to indicate this difference.

One of the fundamental concepts that Chinese medicine is built upon is Yin-Yang theory. Yin and Yang are opposites that complement one another. They are not particular forces or physical things, but rather philosophical qualities that provide a framework to help people understand how things relate and function with each other in the world. Yin and Yang do not exist on their own, but rather are two sides of the same coin. The character for Yin, 陰 means "shady side of the mountain" and Yang, 陽 means "sunny side of the mountain". Thus, anything with Yang must have Yin, and vice versa. Because Yin and Yang balance and interplay with one another, they create, control and transform one another. Yin and Yang can also be further be broken down into Yin and Yang subcategories; the sunny side of the mountain has trees with sunny sides and shady sides. In Chinese medicine, illness results from an imbalance between Yin and Yang.

Treatment, whether herbal remedies, acupuncture, moxibustion, massage, lifestyle advice or some combination, seeks to restore the natural balance of Yin and Yang in an individual. Because everyone has a different constitution and natural balance, Chinese medicine interprets measurements differently from biomedicine. In biomedicine, pulse rate and blood pressure as often contrasted with a range with what is healthy, but in Chinese medicine, measurements like pulse can only be considered in the context of the individual. Another example is how some peoples' temperatures run on the cold side, while others run on the hot side. A temperature that could indicate a fever in one person, might not in another.

In the system of Chinese medicine, there are different "fundamental textures" in the body that flow in the body and manifest transformations in the body. These textures have different

relationships with each other and the Organs in the body, and can be classified as more Yin or Yang in relation to one another. Disharmonies in the body can result from deficiency or stagnation in one of these textures. The rate at which their functions are manifested in the body manifest can also differ significantly. For instance, Qi (氣) which among other things functions as the source of movement in the body, can fluctuate on a minute to minute basis. On the other hand, Essence (*Jing*, 精) which is the force that guides development and aging unfolds over the course of a lifetime. Spirit (*Shen* 神), unique to humans that defies time and space, is another fundamental texture in the body. It gives humans the capacity to appreciate art, pursue the goal of self-actualization or have a feeling of connectedness. In Chinese medicine, physical and psychological phenomena are understood to be fundamentally linked, so different elements of the Spirit are linked with different organs in the body which are associated with physical phenomena. Another fundamental texture is Blood (*Xue* 血), which helps nourish the body. It shares a strong connection with Qi and is Yin in relation to Qi.

In Chinese medicine, organs are not defined by physical form like in biomedicine, but rather by their function. Because of this, the definitions of organs in biomedicine and in TCM are not equivalent. Chinese medicine acknowledges organs that biomedicine does not and vice versa. Although the concept of Organs in TCM may seem abstract, they act as an internally consistent system that can be used to understand the relationships and functions of observable phenomena in the human body.

Meridians (*jingluo* 經絡), are pathways and channels that carry Qi and Blood throughout the body. They connect all fundamental textures and Organs, as well as link the interior part of the body with its exterior. There is a system of regular Meridians that correspond with the different Organs of the body as well as finer Meridians. A practitioner uses acupuncture or herbal

medicine to access these Meridians in order to restore the body to balance. When herbal medicine is used, individual herbs are typically not used on their own. Instead, formulas consisting of several different herbs are used to resonate with the different imbalances in the body.

Contemporary Use of Ginseng

Since Asian ginseng has been integrated into Chinese medicine for much longer than American ginseng, it formed the basis for how American ginseng is used now. Scientific studies have concluded that constituents of American and Chinese ginseng are basically equivalent and in Chinese herbal materia medicas, the two ginsengs both fall under the category of tonics.[9] This category covers herbs that strengthen, nourish and build elements including Qi, Blood, Yin and Yang.[7] [8] Tonics are typically used to treat deficiencies in these areas.

Asian ginseng is defined as a Qi-tonifying herb. It can be used to treat conditions where there has been a serious collapse of Qi, with symptoms such as shallow, short breath, cold limbs, excess sweating and extremely weak pulse.[9] It strengthens the Spleen and the Stomach, and in this area, it can be used to treat symptoms such as lack of energy, appetite and chronic diarrhea. Deficiency in Qi and Yin can lead to thirst and lack of body fluids, so Asian ginseng can be used to help promote the generation of body Fluids. As it tonifies the Lungs, it can be used to treat shortened or labored breathing, and its benefits to Heart Qi help calm the Spirit, allowing it to help treat insomnia, restlessness and anxiety caused because of Qi and Blood deficiency.

American ginseng is also recognized as an herb which tonifies Qi, but this function is weaker compared to Asian ginseng.[8] On the other hand, American ginseng nourishes Yin, and is good for treating people with a combination of Yin and Qi deficiency. This makes it more

suitable for treating relentless fever.[9] Since it nourishes Lung Yin, it can be used to treat loss of voice, long-term wheezing and coughing blood.

In the case of both Asian and American ginseng, the decision whether to use the herb is not determined by a single symptom. Only by analyzing the combination of the patient's different symptoms and characteristics, can a Chinese medicinal practitioner determine what herbs are appropriate in treatment. Usually a practitioner will choose a formula to treat illness, so next I will explore some formulas in which American ginseng is used in modern TCM.

The White Tiger formula (*Bai Hu Jia Ren Shen Tang* 白虎加人參湯) is used to reduce levels of Qi heat and Yin deficiency.[33] Although this formula was taken from a text from 220 CE, American ginseng can be used in this formula to further nourish Yin and lessen the harsh effects of other herbs in the formula.

The Lotus Nourishing Formula (*Qing Xin Lian Zi Yin* 清心蓮子飲) strengthens the Heart, nourishes deficient Qi and Yin and strengthens the Kidney and Spleen.[33] In this formula, American ginseng also nourishes Qi and Yin, and cools Fire associated with Yin deficiency.

The Jade Spring Nourishing Formula (*Yu Quan Wan* 玉泉丸) is a modern formula that is used to treat an illness pattern associated with dry mouth, excess thirst and frequent urination.[33] Among other imbalances, this pattern is notably associated with deficient Yin, so American ginseng is used.

Although ginseng has a complex system surrounding the process of how practitioners prescribe it, this is not the only context under which ginseng is consumed. A healthcare system can be broken down into different components, such as a professional sector, a folk sector and a popular sector.[34] While the popular sector of healthcare may have overlap with other sectors, it is mainly determined by the individual and the environment around them. Popular understanding

inform consumers of ginseng. While relying on the cultural background of Chinese medicine, ginseng is used in the home by people without any medical background.

At the International Ginseng Festival in Wausau Wisconsin, ginseng is advertised to American and Chinese consumers as a product people can consume on a regular basis to improve health. This festival, along with other resources directed at a general audience explain how American ginseng can be used in everyday life through a combination of science and TCM. An English website selling Chinese herbal medicine explains:

> …Research implies that American Ginseng can provide the strengthening and immune-enhancing effects of Asian ginseng without over-stimulation as it contains higher levels of ginsenoside Rb1, which has a sedative effect on the central nervous system. Therefore, it is more suitable for the young, middle-aged and stressed.
>
> In TCM, American Ginseng is considered a Yin-tonic that is cooling, Qi-tonifying, yet non-stimulating. These properties have made American Ginseng the most popular supplement for urban dwellers whose fast-paced and energetic lifestyles may call for more calming and balancing herbs.[35]

Basic Chinese medicinal theory is used in combination with scientific evidence to provide consumers with an understanding of how American ginseng should be used. In a Chinese guide book that outlines the regulations on American ginseng harvesting, a large section is dedicated to the uses of ginseng.[36] This section spends little time discussing TCM, instead citing scientific studies that investigate the applications of American ginseng.

It is important to consider how American ginseng may be framed to consumers. In the past, Asian ginseng was glorified as a cure-all panacea, and this perception may have led to its serious decline in the wild when alternative options existed. If consumers are not careful and

well-informed, their demand will further the decline of American ginseng in the wild. From the perspective of TCM and biomedicine, American ginseng has many health benefits, but to protect the future of this wonderful root, it must be consumed in a sustainable manner.

The Ginseng Trade

One of the most important areas to look into when examining the ginseng issue is the trading system. Ginseng is not simply sold from the harvester straight to the Chinese consumer. Like many other international trade systems, ginseng goes through a series of intermediaries before reaching its final market. Investigating the economic and cultural factors surrounding the ginseng trade can reveal much about the harvesting patterns that are occurring today.

The first link in the ginseng trade system are the harvesters. Some harvest from their own property while others harvest from other public and private properties, legally and illegally.[1 2] While not everyone shares the same motives to harvest ginseng, regional economics have a significant role to play. In Appalachia, a rocky economy encourages many to harvest ginseng to supplement low income. Harvesting ginseng on its own will not bring in enough for these people to make a living on by itself, but can provide a few extra hundred dollars to help a family get by or have Christmas gifts for their children.[1 2]

On a darker note, however, methamphetamine and heroine epidemics also promote poaching. Desperate drug addicts will harvest ginseng as a way to supplement their habit. Since addicts will steal anything they can quickly convert to cash when they need drug money, ginseng becomes a poaching target for these people.[1] The desperation of addict-harvesters can cause them to disregard the size of plant and pulling up whatever they can find, as well as encourage them to trespass onto lands where ginseng harvesting is illegal. Sometimes the ginseng trade is

even linked with the drug trade itself, as poached roots are sometimes exchanged in return for drug.[1] Some ginseng buyers who are not affiliated with the drug trade will still take the ginseng of people who clearly have addiction problems.

Tradition also plays an important role in the lives of the ginseng harvesters. Many harvesters today have learned how to spot this valuable plant from their fathers and grandfathers.[1 2] Some people who are not in desperate need for money simply enjoy the quest to find ginseng. The plant is elusive and tremendously difficult to spot in the woods, blending in easily with other plants like Virginia creeper. This difficulty makes the pursuit of ginseng all the more exciting for some.[2] Spending days out in the woods of Appalachia in search for the "forest gold" can be an adventure in itself, and continues on the legacy of people living off the land they were born in.

In this area of the country, people are mistrustful of the government, especially high government, leading to difficulties in enforcing law on ginseng poaching.[2] When the CITES laws were enacted in 1975, it was met with much resistance from the people, and enforcers of poaching laws such as park rangers are seen as outsiders, due to being educated and from a different part of the country.[2] In addition, the media has romanticized ginseng poaching. In one History Channel program running in 2014 to 2015 poachers are featured as anti-authority personalities with big beards, camouflage and bandanas as they escape armed landowners.[1] Programs like these depict poaching as an adventure rather than a crime.

Despite the alluring get-rich promise of ginseng, harvesters often get the short end of the stick compared to the intermediaries who buy from harvesters. The intermediaries have a much better idea of what price ginseng sells for in China, and keep this price a secret from harvesters.[2] During the Qing dynasty, ginseng harvesters were not compensated well for their efforts, and this

pattern is repeated today in the U.S. While a higher price given to harvesters could encourage a higher rate of poaching, in a sense harvesters, many of whom come from a struggling socio-economic background, are exploited by these middlemen.

Although the age of the root can be determined by ginseng's rhizome scars, it is impossible for intermediates to determine whether the plant was harvested legally or illegally. All they can do is ask harvesters where their roots were harvested and take their word for it. Because of this, ginseng that was harvested illegally can still leave the country legally. There is no way for ginseng buyers to guarantee where harvesters acquired their roots. There has been an instance of park rangers dying the roots of ginseng on illegal harvesting grounds to make them unsellable, but this can only work on a small scale.[2]

The intermediaries help transfer ginseng to China where other individuals and large-scale companies distribute them in the market.[2] Due to China's growing middle class, more and more people can afford these expensive roots. Wild-harvested American ginseng is perceived as superior. Any ginseng from North America is perceived to be cleaner and safer than ginseng from China because the soil is perceived to be less polluted. Additionally, since China has made no effort to restore wild ginseng populations, the U.S. is one of the only sources of wild ginseng.[1] Although ginseng has an instrumental use as medicine, old, 20-year-old roots are a status symbol for the elite. These roots are valued for their aesthetic appearance, especially ones that are in the shape of people.[39] [40] Since ginseng can function as a symbol of wealth, some of those who purchase it may not be concerned with where it came from or if it was harvested legally or sustainably.

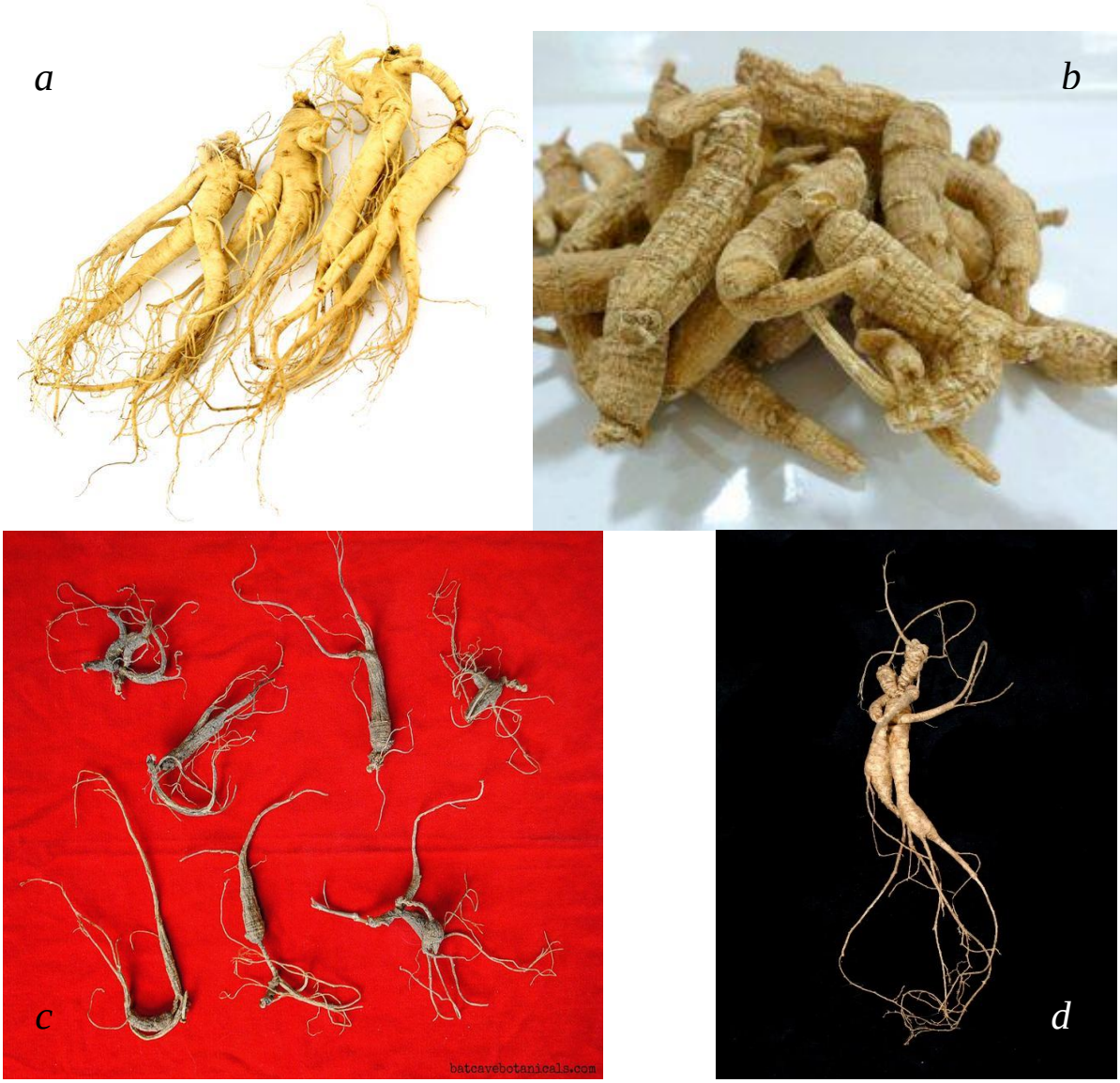

Figure 4 Cultivated and wild American ginseng. *4a* Fresh cultivated ginseng.[37] Note the thickness of the root. *4b* Dried cultivated ginseng.[38] Note the smoothness of the root in the final product. *4c* Dried wild ginseng.[39] This set was sold on Etsy, suggesting that ginseng is also valued for its aesthetics. *4d* Dried wild ginseng.[40] This root especially resembles a person and was sold on Ebay for $5,000.

One possible solution to ginseng poaching is to outlaw the trade of wild ginseng in the United States. However, this has the potential to massively backfire. Besides creating even more tensions with the government in localities where ginseng is harvested, ginseng has the potential to jump in price. Ginseng is already traded on the black market in Asia where roots from Siberia are smuggled across the border and sold for thousands of dollars per pound.[2] If American ginseng were to enter the black market, the price could double or triple. Not only that, but outlawing ginseng harvest would not encourage sustainable harvesting practices. Taylor suggest diggers may very well think

> "Since there's no legal stake in wild ginseng or its future, I might as well take what I can now. I can dig it secretly and get the bonus of whatever the black market will bear.[2]"

The actions that harvesters may take if harvesting is completely outlawed should not be overlooked.

What can be done?

A transition from truly wild ginseng to wild-simulated ginseng may be the most promising option to reduce the overharvesting. It is certainly not perfect. Wild-simulated ginseng requires years and years of time, which would not satisfy the needs of harvesters hurting for money right away. The act of harvesting wild-simulated ginseng is also less of an adventure than the hunt for truly wild ginseng. On the other hand, this practice still allows people to connect with the forests of Appalachia, even if the interaction is a little different. Wild-simulated ginseng would also address the Chinese demand for gnarly roots that the domestic ginseng industry does not. Additionally, educating and informing harvesters of the consequences of illegal harvesting may encourage some people to change their practices. Even if they do not switch to wild-

simulated ginseng, having a better understanding of ginseng may encourage some people to harvest in a more sustainable manner.

Addressing conservation issues that do not have to do with harvesting should not be overlooked. Harmful activities like surface mining and suburban development should be reduced to prevent the effects of habitat loss and fragmentation. Heavy logging in areas with known ginseng populations should also be reconsidered. In areas where deer populations are not kept in check by top predators, it should be considered whether or not to encourage hunting. While hunting could reduce the effects of deer browsing, encouraging hunters to enter a new area could lead to the introduction of invasive species that could be of detriment to ginseng populations. Although it is impossible to completely enforce the behavior of ginseng harvesters, informing harvesters of the consequences of illegal harvesting may encourage some people to change their practices.

Informing ginseng consumers is also crucial. Wild ginseng roots are prized over cultivated ginseng as they are perceived as more potent, but other alternatives should be considered. The consumption of wild-simulated ginseng should be encouraged by advertising it as a sustainable alternative to fully wild ginseng. The use of cultivated ginseng should also be supported as an alternative as well. Finally, the value of ginseng in the first place should be reconsidered. Other herbs such as *dangshen* have frequently been used as substitutes for ginseng in Chinese medicine. Ginseng has become something of a magical buzzword associated with health, but the true value of this herb needs to be looked at objectively with an eye to its historical and cultural contexts, rather than glorified by those who sell it.

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