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The Reestablishment of American Ginseng (Panax quinquefolius)

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Abstract: Conservation biology and restoration ecology are concerned not only with protecting fragile ecosystems but also with intervening in an attempt to repair what has been damaged largely through anthropogenic activities. As a result of high demand as a medicinal herb and the failure of harvesters to conserve, the federal government has placed American ginseng (*Panax quinquefolius*) on the list of plants that may be in danger of extinction. Ginseng favors a habitat ranging from 30 to 50 degrees north latitude and minimum cold cycles of 45 days with temperatures below 2 degrees Celsius. Other specific criteria include 20 inches of annual precipitation, adequate shade, and slightly acidic, well-drained soil that is high in organic material content. Remote sensing, ground truthing, and an analysis of local climate data helped determine whether the study areas met these requirements. The role of remote sensing and the use of GIS in preserving forests and biodiversity are discussed. Although it could take from eight to ten years before harvest, the wild simulated ginseng roots command a price that is approximately the same as that of wild ginseng. The present body of knowledge concerning the optimal growing conditions of ginseng should be enhanced as a result of this research and could serve as a model for a viable economic alternative to clear cutting deciduous forests, which is among the long term goals of this project.

Key-Words: Conservation biology, Restoration ecology, Endangered species, American Ginseng, Remote sensing, GIS

1 Introduction

Since the settlement of Indiana, the species of ginseng indigenous to the state, *Panax quinquefolius*, has become increasingly rare due to overharvesting and poor harvesting practices. As a result of high demand and the failure of harvesters to conserve, the federal government has placed *Panax quinquefolius* on the list of plants that may be in danger of extinction. Due to the heightened awareness of the importance of environmental protection [1] and in an effort to further the investigation of the optimal growing conditions for ginseng, ecosystems that could support *Panax quinquefolius* populations were identified and mapped through the use of remote sensing. Once this was accomplished, cultivated ginseng roots were planted at selected sites in an attempt to reintroduce the species to a portion of its native habitat. The restoration areas are located at the Indiana State University (ISU) Field Campus in Brazil, Indiana, which is a reclaimed strip mine, and on land formerly held in agriculture at Landsbaum Woods near Terre Haute, Indiana. Both properties are owned by ISU. The use of remote sensing techniques complements and reduces the fieldwork in this ginseng re-establishment effort.

Reports indicate that American ginseng was abundant in the region before the arrival of the Europeans. Therefore, the purpose of this project is the successful reintroduction of *Panax quinquefolius* to Landsbaum Woods and the ISU Field Campus. Based on the existing literature, this species of ginseng favors a habitat ranging from 30 degrees north latitude to 50 degrees north latitude. Favorable conditions include minimum cold cycles of either 45 days with temperatures below 2 degrees Celsius or 60 days with temperatures below 9 degrees Celsius. Other criteria include 20 to 60 inches of precipitation annually, slightly acidic, well-drained soil with organic material, and adequate shade [2].

Numerous variables were considered at the study areas including soil characteristics, slope, orientation, air temperature, and dominant tree species. Several hypotheses will be tested to determine the strength of association between reintroduction success rates and the variables. The present body of knowledge concerning ginseng's optimal growing conditions should be enhanced as a result of this study. If the project is successful, it might serve as a model for a viable economic and renewable alternative to logging forests for timber since wild ginseng can garner as much as $360 per pound on the current market [3].

2 Forest Conservation

The importance of conserving forests cannot be overstated. Effective forest management includes maintaining environmental stability, providing sanctuary for wildlife, and protecting biodiversity [4]. Because forests exert such a strong influence on the environment, they are a critical element in mitigating climatic change due to their ability to slow the rate of greenhouse gas emissions. Several options for reducing carbon dioxide through the use of trees are available which include curbing deforestation, establishing reforestation projects, enhancing management and harvesting techniques, and maximizing urban forests. It is widely accepted that protecting existing forests and planting new forests can help reduce the greenhouse effect, and a number of multi-disciplinary mitigation options revolving around forests are surfacing as researchers collectively consider the threat of global warming.

Many groups have proposed forest management as a simple way to restrain the increase of atmospheric carbon dioxide and offset global warming. To examine whether forest management is a suitable means of controlling global warming, a decade-long study of carbon exchange between the atmosphere and a 60 year-old northern red oak forest by measuring how much carbon the trees and soils stored and how much they released was conducted [5]. The types of tree species in the forest, their growth rate, and the age of the forest all affect carbon uptake. For example, mature trees store less carbon and remove less carbon dioxide from the atmosphere. The number of dead trees also affects carbon balance because as a tree decays, it releases some of its stored carbon back into the air. The researchers suggest that forest management can help mitigate global warming by controlling carbon exchange, but it is a complex process with numerous factors to be considered.

Many of the deforested areas of the world could once again support vegetation under proper management techniques such as the creation of tree plantations or by allowing natural vegetation to regenerate through techniques such as wildfire suppression. One of the main reasons for preserving forests is their role in regulating climate and hydrological cycles because forests are involved in the constant exchange of large quantities of energy that takes place between the biosphere and the atmosphere. Forests can have rapid growth rates and yield substantial benefits including an economic return for local people. Small-scale reforestation with mixtures of native species, such as ginseng, can be financially profitable both for investors and farmers [6].

The rapid growth and expansion of tree management projects in China, which in addition to sequestering carbon dioxide emissions have an important impact on the mental and physical well-being of local residents [7]. China's forest cover increased from 9 percent in 1949 to 18 percent in 2003 [8]. An examination of 50 years of forestry data found that beginning with the 1970s, the average carbon density of planted forests in China increased from 15 to 31 megagrams per hectare [9].

Likewise, analysis of vegetation structure with forest functions and value in Chicago, Illinois, reveal that local urban forests remove 5575 metric tons of air pollutants and sequester approximately 315,800 metric tons of carbon annually [10]. In short, forest conservation and restoration appear to be a means of improving ecosystem functioning, ecological and economic resilience, and human livelihoods [11].

3 The History of Ginseng

The influence of Chinese healing methods such as acupuncture and natural herb remedies has become widespread. This may be a matter of necessity as many people in China are too poor and isolated to rely on physicians and pharmaceuticals [12]. With a population of over one billion people and an average patient to physician ratio of 1000:1, it is understandable that herbal remedies are relied upon in China [13].

The two opposing forces known as yin and yang are critical elements in the Chinese philosophy of ginseng which is considered a yang or heating herb. As humans go about their daily lives, they tend to become cool. Ginseng acts not so much as a stimulant, but rather as a balancing mechanism adding heat to the body which leads to increased endurance and stamina [14].

Westerners slowly began to discover the healing properties of the ginseng root. As Jesuit missionaries traveled to the Orient, they were amazed at the advanced medical knowledge of the Chinese physicians. One of the earliest documents written on the beneficial effects of ginseng was written by William Simpson, a Yorkshire naturopath. Naturopaths are the Western version of Oriental herbalists advocating the use of "natural foods, food supplements, sunshine, exercise, and water to help sick people return to normal functioning" [15].

Stories of the many uses of ginseng spread to the Americas as trade began to be established between the colonies and the rest of the world. However, ginseng soon met the fate of other biotic species in the New World, which were exploited by trading companies funded in part by various European governments. Advertisements from the period reveal the high demand placed upon ginseng by big business in the form of exporting houses, which shipped the root to the Orient.

In a short time, ginseng in much of America was threatened with extinction. Since the turn of the century, ginseng has been hunted on a smaller scale due to its rarity and the prominence of institutionalized healthcare. However, with the recent resurgence of interest in Oriental traditions and philosophy, demand for the ginseng root is once again growing. Also, because the Chinese have tended to overharvest their own ginseng resources, the Orient is turning to growers in the West to help supply their need for the root. Over 95 percent of wild ginseng is sold to the Chinese and shipped to Hong Kong. Research in British Columbia estimates that a ginseng crop planted on 365 hectares could be worth $60 million in five years [16].

It appears that ginseng is once again becoming big business which could lead to a decline in wild ginseng populations if care is not taken in harvesting the root. Lee Allen Peterson cautions that "over-collection for sale as a medicinal herb has made this once common plant quite rare; it should not be used unless absolutely necessary" [17]. The following section examines the reasons behind the high demand for ginseng.

4 Medicinal Properties

Researchers interested in learning more about the properties of healing herbs have discovered that the root of the ginseng plant contains numerous beneficial constituents. An analysis of a typical ginseng root reveals monosaccharides, disaccharides, trisaccharides, polysaccharides, amino acids, peptides, proteins, alkaloids, lipids, fatty acids, phytosterols, ginseng oils, organic acids, polyacetylenes, flavinoids, terpenes, and ginsenosides.

Ginsenosides are the major active component of the ginseng plant. There are from 13 to 23 to ginsenoside sugars in wild ginseng which are classified with an R value. The two main ginsenosides are Rg and Rb. Ginsenosides with an Rg designation are considered stimulants and are found primarily in Asian ginseng.

Ginseng found in America tends to have an Rb rating signifying that the root is a relaxant, which provides a calming effect. This helps explain the use of ginseng "for treatment of heart failure and to protect tissues from damage when an organism is in stress," according to Wagner and Liu [18]. North American ginseng also has a bitter-sweet taste while the Asian variety has a more herbal flavor [19]. The Rg and Rb ginsenosides represent the two opposing characteristics of the eastern and western species of ginseng, or the yin and yang philosophy referred to earlier. Chinese traditional healers use the ginseng root in combination with other herbs in an attempt to balance the body.

The root is reported to be capable of facilitating the formation of red blood cells. It is known to have been used as an antidote or detoxifying agent in cases of accidental poisoning. The use of ginseng can return pulmonary functions to normal. And the root has been shown to aid in the treatment of diabetes. Researchers at the University of Oula in Finland suggest that ginseng can help control blood sugar and insulin sensitivity [20].

According to Drs. James and Phyllis Balch, the root of the ginseng plant contains chemical and nutrient components such as calcium, camphor, iron, resin, starch, saponin, arabinose, and vitamins A, B, and E. They also report that ginseng can be used for impotence, stress, cocaine withdrawal, energy, diabetes, radiation protection, colds and chest problems and that the root promotes lung function, enhances immune function, stimulates appetite, and normalizes blood pressure [21].

5 Ginseng Restoration

Conservation biology and restoration ecology are fields of science concerned not only with protecting fragile ecosystems but also with humans intervening in an attempt to repair what has been damaged largely through anthropogenic activities. Following the lead of other ecological restorationists, the goal of this project is to reintroduce a depleted species to its native habitat. Due to the special requirements regarding shade and soil moisture, many of the deciduous forests of the eastern United States are suitable for ginseng cultivation. A high concentration of organic matter and well-drained yet moist soil is necessary if the plants are to thrive. Where soils are heavy or poorly-drained, the plants often fall victim to diseases which are spread by wind, water, or direct contact. Such diseases are more likely to occur during humid or wet weather.

Shade is an equally important component of ginseng cultivation. At least 80 percent shade is required for healthy plants. Too much sun is harmful to the leaves and can eventually destroy the plant. On the other hand, excessive shade often results in reduced seed and root yields. It is generally accepted that the best sites in the deciduous forests are those which are hilly and have a north or east orientation. South facing slopes receive too much sunshine causing the soil to dry out and damage the plant [22].

Certain tree species are thought to be beneficial to the growth of ginseng although scientific evidence to support such claims is sketchy. Many diggers of the root believe the best canopy trees are hickory, beech, and oak. Others believe that oak is not a good indicator species due to its ability to grow in poorer soils than that required by ginseng. Other trees typical of deciduous forests such as maples, poplars, and ash tend to be shallow-rooted which can make ginseng harvesting more difficult as the roots become intertwined.

There are three types of ginseng cultivation in the United States. The most intensive is field cultivation under artificial shade which requires large amounts of time, machinery, and capital. The roots produced by this method are of lower quality than the wild variety and generally sell for less than $50 per pound. However, such operations do produce an enormous quantity of seed, and the roots can be transplanted into a more natural setting such as a deciduous forest. Woods grown ginseng requires much attention and care as well. The seeds or roots are grown in seed beds under a natural canopy. After five years, the roots are ready for harvest. Woods grown roots are of a higher quality than those grown under artificial shade conditions.

The most sought after of the cultivated types of ginseng is wild simulated which is nearly identical to ginseng which occurs naturally. Wild simulated ginseng is sown in or transplanted to the deciduous forest and left to fend for itself. As a result, maintenance costs such as fungicides, pesticides, herbicides, and fertilizers in most cases are nonexistent. Although it may take from eight to ten years before the plants are ready to be harvested, the roots command a price which is approximately the same as that of wild ginseng.

Planting ginseng seeds in a wild simulated context is quite simple. One common method is to hand-cast the seeds and rake them in before covering with a layer of mulch or leaf litter. The litter is abundant in the deciduous forest during the normal planting times of September through December. Seeds should not be planted deeper than one inch, which makes the task less burdensome. The bottom line concerning seed planting is to remember wide spacing reduces the chances for disease, produces bigger and more valuable roots, and requires less work. Successful seedlings will break the ground for the first time 18 to 24 months after planting because germination will not occur until the seed receives a cycle of moist cool and moist warm temperatures [23].

Transplanting ginseng roots is more labor intensive since each root must be handled individually, but once the roots are in the ground the idea behind the wild simulated method is to let nature take its course. The root is said to resemble a man as seen in Fig. 1. Traditionally, the man-image has been important to the value of the root. The more the root looked like a man, the higher price the buyer was willing to pay. However, the two "arms" and two "legs" shape is waning in importance.

Fig. 1 The man-image of the ginseng root

Fig. 2 Fruiting structure of American ginseng

Also, older roots are more valuable. The presence of many bud scars on the rhizome as well as numerous rings at the top of the root allow the trained eye to determine the age of the root. A series of well-defined rings is considered to indicate a superior root as opposed to rings that are vague in appearance. Color and weight are other considerations of the buyer. A tan or light brown root is deemed to be of higher quality than the white root, and lightweight roots are preferable to heavier ginseng roots.

Roots that are three years old and older will produce plants that fruit in the fall of the year (Fig. 2). Each of the two to four berries usually will hold two seeds as verified by Stoltz and Garland who found in their study of 10,499 fruit that 16.3 percent were one-seeded and 77.0 percent were two-seeded [24]. If the purpose of the planting of ginseng is the re-establishment of the species, there is no need to pick the berries as the creatures of the forest will handle the seed distribution. However, if one intends to sell the seed, it is best to pick the berries before the mice, birds, and chipmunks have a chance to do so. In order to ensure the species' survival, some of the seeds must remain on-site.

The best time to harvest the ginseng roots is in the fall when the leaves are wilting and gold and the full potency of the plant still is in the root. It is essential that the roots remain intact during the digging process because any damage to the root will result in a loss of retail value. The harvested roots are then carefully rinsed, dried, and stored in fiberboard containers at room temperature until they are sold, which is usually between October and December.

Efforts are now underway to help reduce the odds of ginseng extermination in the United States. Thirty-one states consider wild ginseng to be an endangered species and have prohibited its harvest. Among those states where it is still gathered, all ginseng must have certification papers issued by the state of origin before it can be shipped out of state. Additionally, before any exportation to foreign countries is allowed, a state must have a ginseng certification program in place along with a monitoring process.

Regulations concerning the sale of wild ginseng dictate when the roots can be bought and sold. For example, Pennsylvania stipulates regulations concerning the shipping of ginseng roots beyond the borders of the state. Other requirements of the Pennsylvania code are specifications concerning the replanting of ginseng seeds at the time of harvest. Such laws contribute to the prevention of ginseng depletion.

Once the roots arrive overseas, they are auctioned to expert ginseng graders who in turn sell the roots to stores and dealers throughout the Orient. The harvesting of wild ginseng in the United States has been monitored only over the last few years. The U.S. Fish and Wildlife Service reports that there are still substantial patches of wild ginseng, but the supply fluctuates yearly.

Wild ginseng populations can still be found in parts of Indiana. With continued careful monitoring, additional research, certification of all roots taken from the wild, and successful reintroduction of the plant into depleted areas, ginseng should remain a part of the deciduous forest landscape in Indiana for years to come.

6 Methods

A grant proposal was submitted to the Indiana Academy of Science for the purpose of obtaining funding for a ginseng restoration project. Included in the proposal was a request for funds to purchase 500 four-year old ginseng roots, two external temperature data loggers plus the appropriate software, and to obtain a chemical analysis of soil samples.

In order to maintain control over the project for the extended period of time required to monitor ginseng success rates, it was decided that study areas under the jurisdiction of Indiana State University would be appropriate. Fortunately, ISU owns two properties that appear suitable for ginseng reintroduction at Landsbaum Woods and at the Brazil Field Campus (Fig. 3). Permission to use these facilities was requested of the ISU Natural Lands Committee. With permission and funding secured, the next step in the restoration process was the selection of the most suitable sites.

6.1 Remote Sensing Applications

The conservation biologist of today is likely to use GPS, computer mapping, and remote sensing in management decision making to monitor environmental conditions [25]. Through the use of large-scale aerial photographs and digital imagery, it is possible to recognize and classify various types of vegetation and to actually identify plant species in some instances.

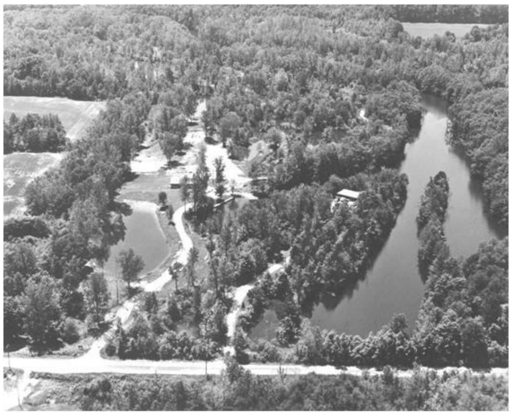

Fig. 3 The ISU Brazil Field Campus

Native vegetation occurrence and distribution is largely determined by a number of elements such as latitude, elevation, annual precipitation, temperature and solar radiation regimes, growing season, topography, slope, drainage, soil type, and prevailing winds.

If the conservation biologist is equipped with an understanding of the ecology of the particular plant under investigation, it is often possible to anticipate the types of native vegetation that might exist in a particular area based on these physical elements. Remote sensing techniques are an invaluable aid in such ecosystem predictions.

Remote sensing is being used increasingly for gathering information on archeological, geological, geographical, and botanical features of the Earth. Thirty-three universities with programs in forestry and environmental science now have access to Louisiana-Pacific Corporation's Terra Vision satellite imaging software which uses Landsat data with overlays of soil, watershed, vegetation, and other topographical information [26]. The education and training acquired as a result of such remote sensing technology will allow future land managers to examine the interrelationships that exist among Earth's various ecosystems [27].

Growth in the use of remote sensing is not only occurring in science and education, but in other areas of the economy as well. High-technology agribusiness often relies on remote sensing systems capable of measuring biomass accumulation and chlorophyll content to determine crop condition [28]. IBM began marketing Spot Image Corporation's satellite image data in 1992 due to an increase in the use of Geographic Information Systems (GIS) across the country [29]. The unprecedented use of remote sensing data, techniques, and technology offers the trained individual an opportunity to view Earth and its ecosystems from a totally different perspective. This new perspective will make an enormous contribution to the body of knowledge concerning the biosphere, and it may ultimately enhance our environmental perception of the planet just as the Apollo photos from space did in the sixties.

Despite remote sensing and the other available tools, much of the work done by restorationists is proceeding without national guidelines for endangered plant reintroduction. Many projects also lack a truly scientific approach and as a result, much baseline data is not being recorded. Therefore, it is imperative "to design experiments as thoughtfully as possible and then to watch the results carefully with an eye for learning what the plants are saying" [30]. The following portion of the study defines the parameters and outlines the methodology of this particular restoration project.

6.2 Developing a GIS

While ecological restoration projects tend to focus on relatively small areas, one should not lose sight of the fact that these reintroduced microsystems are a part of the total environment. The emphasis may appear to be on the individual ginseng beds, however, community and ecosystem function and integrity within the larger biological context should not be ignored. Although the techniques and ecology associated with the specific sites and populations are important, no organism can be successfully reintroduced and no community can be successfully restored unless these individual efforts are part of a healthy, intact, functioning, and diverse large-scale ecosystem. Through the use of aerial photographs, an inventory was conducted of the larger ecosystems which contain Landsbaum Woods and the ISU Field Campus. Included in this assessment were land cover and land use maps made from aerial photographs covering an area of approximately five miles by five miles at each study area.

These data were used to develop a geographic information system (GSI) of both study areas. The principal advantage of a GIS is its ability to allow the user to perform a spatial analysis, which can be described as the investigation of the locations and shapes of geographic attributes and the interactions between these features. Spatial analysis is essential for determining site suitability and potential, for approximating and calculating geographic relationships, and for deducing and comprehending the problems of place. In short, spatial analysis allows one to address those issues associated with location. The generic questions that can be answered with GIS include where specific features are located, the geographical patterns that exist, where and what changes have occurred over time, where certain conditions apply, and the implications of human action [31]. When one considers that all ecological questions exist in a spatial context, the environmental education and research potential for GIS applications is substantial.

The first modern GIS, the Canadian Geographic Information System (CGIS), was developed in the early 1960s to inventory Canada’s natural resources and is acknowledged as a milestone in the development of GIS. The CGIS classified land according to its capability for forestry, agriculture, recreation, and wildlife, and many of the GIS terms and concepts used today originated with the CGIS [32]. The Canadians understood that in order for the CGIS to be an effective environmental tool, accurate and relevant data must be incorporated into the system. The success of the CGIS is evidenced by its continued operation today in mitigating pollution, managing resources, and in land-use planning [33].

The establishment of the CGIS in the 1960s was the pioneering age of GIS, which led to the age of experimentation and practice in the 1970s and 1980s followed by the age of commercial dominance in the 1990s and the current age of user dominance in the 2000s [34]. This recent ascendancy of multiple users has enabled GIS to evolve from a mere computerized tool into the interdisciplinary field of Geographic Information Science. Originally an instrument used only by geographers, multiple academic disciplines are implementing degree programs explaining GIS theory and educating students in the composition, design, and application of database administration systems. The science of GIS arises from the need to study the issues involved in creating, storing, and manipulating spatial data [35]. The effect of GIS on society as well as the effect of society on GIS qualifies GIS as a science involving users as diverse as cartographers, computer scientists, engineers, statisticians, and even lawyers [36].

6.3 Ecological GIS Examples

The following three brief case studies outline the potential of GIS in conservation biology [37]. The Forest Issues Group (FIG) of Nevada is concerned with threats facing the Tahoe National Forest. Using maps of the region created with GIS, the members of FIG have convinced administrators that several proposed timber sales were unsustainable. When government officials planned to apply herbicide on 20,000 acres within a burned area of the forest, FIG turned to GIS to analyze and model the success of regenerating seedlings without the use of chemicals. The latest undertaking by FIG involves the creation of a GIS to track long term changes in forest vegetation using data from the Landsat Thematic Mapper. The project will allow researchers to determine the overall health of the forest ecosystem over time and make recommendations for sustainable management.

The Oregon Natural Resources Council (ONRC) was founded in 1974 and is currently protecting some 3.5 million acres. Prior the formation of the ONRC, much of Oregon's national forests had been subjected to road construction and subsequent clear-cutting resulting in major sedimentation damage to hundreds of miles of salmon streams, which cost millions in tax dollars for recovery efforts. The main goal of the ONRC is to raise awareness of the threats to the wilderness and wildlife of Oregon. GIS maps are used extensively in the ONRC's advocacy and outreach program at press conferences, in public meetings, and other forms of the mainstream media. The ONRC anticipates eventually mapping all of Oregon's wilderness boundaries and ultimately passing a bill to permanently protect these areas.

Will Allen is a GIS Analyst for the Conservation Fund and reports that the New River watershed of North Carolina, Virginia, and West Virginia covers over 4 million acres and requires environmental managers to have a full understanding of the region's geography in order to recognize the potential hazards and develop ways to counter these threats. Prior to the development of a GIS for the watershed, the quality and fitness of the existing data were rigidly assessed. The appropriate data then were integrated into the GIS, and numerous spatial analyses were conducted to determine the best means for coordinating land and water protection efforts with hazard mitigation strategies. The result is the creation of local communities that are less prone to disaster and more likely to receive greater protection for natural resources within the watershed.

6.4 Site Selection Assessment

The GIS was used to conduct classify the land use and land cover at the two study areas. The system developed by Anderson and used by the USGS offers several categories, which were useful for this process. Among those categories applicable to an assessment of the study areas is urban or built-up land, agricultural land, rangeland, forest land, water, wetland, and barren land. These general categories serve as the first level in the hierarchy for expressing land cover and land use in the study areas. The second level is a bit more complicated as it attempts to define vegetation cover types such as deciduous trees, which indicate ginseng habitat. In some instances, certain cover types have to be deduced based on association rather than actual recognition. This is accomplished through a general understanding of the types of vegetation that should or should not be present in the study areas. Texture, tone, site, and crown size images are among the principles of object recognition used to identify vegetation cover types [38].

Once the land cover and land use classifications were made, the sites within the study areas that seem to have the densest vegetation and the most shade, slope toward the north, and located near a stream bed were delineated on topographic maps of Landsbaum Woods and the ISU Field Campus. The sites were ground truthed for verification of the observed features.

Fig. 4 A commercial ginseng farm

After the ginseng reintroduction sites were selected, the planting of the roots began. One of the six major seed and rootlet suppliers in North America is approximately a five-hour drive from the study areas. The ginseng farm is a large commercial venture with the plants grown under artificial shade (Fig. 4). The price of four-year old ginseng roots is currently $50 per hundred. A pound of stratified seed cost $65. For this project, 500 four-year old roots were pulled and ready for planting in early November.

6.5 Transplanting

Transplanting ginseng roots is labor intensive because each root must be handled individually. A narrow trench eight inches deep and three inches wide is dug. The root is laid in the trench at an angle with the bud end upward and approximately one inch below the soil surface while the tendril end trails downward. Once the roots are in the ground, they are covered with soil and a layer of leaf litter and will remain dormant until the following spring. The study sites were prepared and planted with minimal disturbance to the forest floor. The soil is not mechanically tilled and as a result, wild ginseng tends to be a hardier, more potent plant than cultivated ginseng grown under artificial conditions with the aid of fertilizers, herbicides, and pesticides.

This research is modeled to some degree after a previous study conducted in Illinois [39]. That particular statewide study counted the number of ginseng plants growing in the wild across Illinois. Relevant data collected included tree and soil inventories, slope orientation and steepness as well as exposure to the sun. Seeds from the wild ginseng plants were distributed at the appropriate time with a 66 percent germination rate occurring some 18 months after planting. The hypotheses formulated for the study in Indiana involve an examination of similar data.

7 Hypothesis Testing

For the project, a total of 500 four-year old ginseng roots were planted at the two study areas (Fig. 5). Each area includes five small sites totaling approximately 100 square meters with 50 roots at each site. Sites were selected based on their potential for ginseng reintroduction and the emphasis of a particular variable under investigation. The first hypothesis suggests that the study area with the lowest mean temperatures will have higher success rates because *Panax quinquefolius* seems to favor colder climates.

The second hypothesis proposes that those sites oriented toward the north will have higher success rates due to an increase in the amount of cold air and a decrease in the amount of sunlight received. Again, the literature indicates that ginseng prefers shade and cold temperatures. The Brunton compass is adequate for determining the orientation of individual sites in the initial planting phase of the project. While aerial photography will facilitate the mapping of the larger ecosystems' land use and land cover, GPS was used for mapping the individual sites within the study areas.

Ginseng is a very slow growing plant. The first seedlings do not break the ground for at least 18 months (Fig. 6). Ginseng roots have been reported to live as long as 23 years [40]. Because of the many changes that can take place in a forest environment over such a long period of time, it is necessary to accurately map the ginseng plots so that they will not be lost among the other vegetation of the forest floor. Merely marking the perimeter of the sites with surveyor's tape or some other such means is insufficient in the long term. Therefore, creation of accurate maps of the individual sites was imperative.

Fig. 5 Four-year old ginseng roots

Fig. 6 American ginseng seedling

A final hypothesis considers the soil pH at the two study areas. Because it was formerly a strip mine, it was suspected that the soil at the ISU Field Campus is more acidic than that at Landsbaum Woods. This was verified through soil analyses. The third hypothesis states that the study area with the higher acidity will have lower success rates. While ginseng prefers a slightly acidic soil, it may be that the former strip mine is too acidic.

Other research questions which might present themselves during the course of the study will also be considered with the purpose of successful reintroduction and increasing the knowledge of ginseng's optimal growing conditions. The plants should sprout in 18 months allowing the initial quantification of success rates and comparisons between the two study sites to begin. When the data have been gathered, statistical analyses will be conducted to determine the strength of any associations that might exist between the variables and ginseng success rates. Graphs depicting any such correlations will be created.

8 Conclusion

If any information concerning the optimal growing conditions for *Panax quinquefolius* can be added to the existing body of knowledge as a result of this project, then progress will have been made. If any of the 500 roots that are planted survive and propagate over the years, then it is likely that the species will become re-established in and around the study areas. Additionally, the research might conclude that the roots grown in these Indiana woodlands are marketable. Forest owners may be encouraged to find out whether their forests are suitable habitat for ginseng. In the long-term view, planting and harvesting ginseng may prove to be a viable economic alternative to cutting forests for the sale of timber. This alternative relates to the nation's growing interest in naturopathy, homeopathy, and other forms of alternative health care. Forests provide the natural shade environment, means of seed dispersal, and nutrient rich leaf litter that are necessary for the highest quality roots. While ginseng is slow growing, it is not as slow growing as a tree and once it has been established ginseng can be harvested on an annual basis. As a result, Indiana's forests can continue to serve as wildlife habitat while providing a sustainable means of income for the owners as the forests are converted to working wilderness areas.

Leaving forests intact also coincides with the concern over biodiversity and the complex interactions within and the interconnectedness of that web of life, which includes humans and all other living organisms. When the fecundity of a forest is reduced to land used for monoculture, numerous species are displaced. It is widely accepted that habitat destruction is the predominant cause of the loss of species. To slow this process by any degree would be a worthwhile endeavor and is among the long-term goals of this project.

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