Plugging the Leak on Wild Leeks: The Threat of Over-harvesting Wild Leek Populations in Northern New York

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Photograph by Kelsey Tuminelli, 29 April 2012

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Executive Summary

Over the past decade, pressure on wild leek populations from over-harvesting has dramatically increased throughout the plant's range. The species *Allium tricoccum* and *Allium tricoccum var. burdickii* are native to North America and thrived in the eastern United States and Canada before the first colonists even arrived. Wild leeks are slow to reproduce and populations take years to recover from any degree of harvesting. All harvested populations are at risk for depletion, which would reduce the total number of wild leek populations, as well as the genetic diversity of the species as a whole. In New York State, the *Allium tricoccum var. burdickii* species is listed as endangered and any harvesting of this plant is forbidden. The *Allium tricoccum* variation is not far behind, meaning that conservation efforts to ensure survival of the species must be quickly developed and enforced. A variety of groups hold stake in this issue, ranging from individual harvesters, to restaurant guests and owners and ramp festival participants, to all organisms sharing an ecosystem with the plants.

The New York State Department of Environmental Conservation (Proposed Part 2012) should monitor and protect wild leek populations, create guidelines developed for plant conservation practices, and fund initiatives to conserve New York's wild leeks. An appropriate solution to the wild leek conservation issue would ensure the protection of the species from over-harvesting, as well as the creation of a larger supply of the species that can be used in restaurants and during ramp festivals. After considering the feasibility of all possible solutions to the problem, we have come to the conclusion that the harvesting of wild ramps should be limited through a harvesting permit program, cultivation should be encouraged, and educational programs must be put in place to make people aware of the issues created by over-harvesting and to expose them to the basics of plant conservation. It is important to consider all costs associated

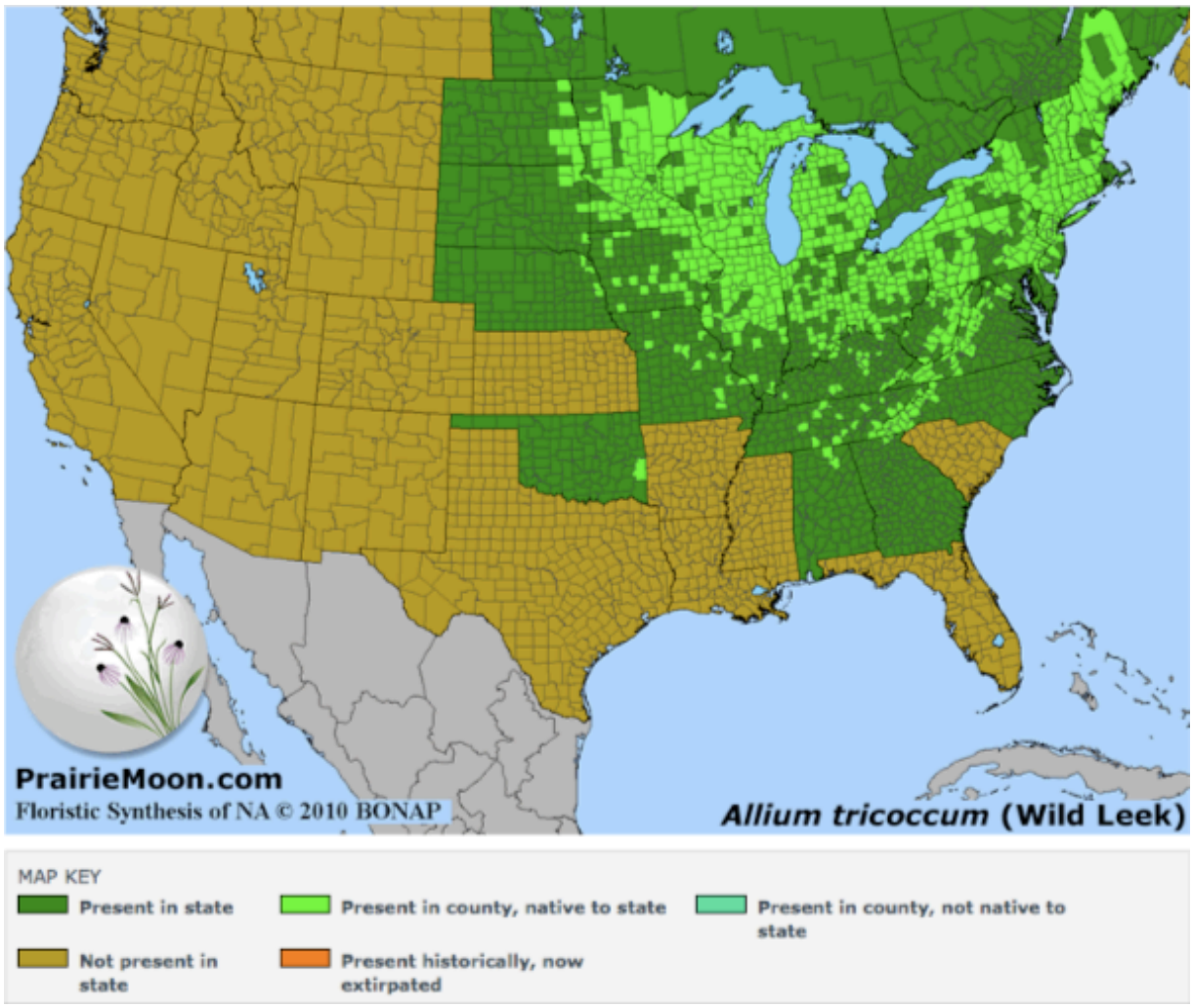
with the proposed solution and planned implementation, and to attempt to anticipate any opposition while developing ways to alleviate negative feelings and protest.

Problem Definition

In order to understand the conservation problem associated with wild leeks, one must first familiarize oneself with the history of the plant in the United States, as well as with the plant itself, and more specifically, the plant's life cycle. The main problem facing wild leek populations is the over-harvesting caused by increased harvesting pressures.

History of Wild Leeks in the United States

Wild leeks have a long history in the United States. The plant was already established when the first colonists arrived, and its range stretched throughout the eastern portion of the country. The plant was so common in some areas that Native Americans and colonists named locations based on its presence. In some regions, wild leeks were unwelcome, while in others they were allowed to flourish and were readily consumed.



(Prairie Moon Nursery 2012)

FIG 1. Distribution map of *Allium tricoccum* (wild leek) species in the United States and Canada. Note: this map does not include St. Lawrence County as part of the native distribution of *Allium tricoccum*. However, personal collection has confirmed the plant's existence in this area.

"Ramp", another term for "wild leek" has its origins in the British Isles. The term was most likely transported along with Scottish-Irish settlers who first used this word in their mother countries to delineate a similar looking plant that grows in Ireland and Scotland (Moyer 2008). Other theories on the origins of the word "ramp" suggest that British colonists associated the wild leeks of the United States with ramson, *Allium ursinum*, a relative of chives native to

Europe and Asia (Chapman 2005). The word "ramp" is clearly a variation of the English word "ramson", also known as the bear leek in Europe (Core 1945). Among other cultures, references are made to skunks when discussing ramps, due to their pungent smell and the odor emitted from a person who has consumed them in their raw form. For example, the Menomini Indians call the *Allium tricoccum* species of the wild leek by the name "pikwu'tc sikaku'shia", also translated as "the skunk" (Fernald and Kinsey 1943). The smell of wild leeks is so strong that school children used to eat the wild vegetable in large quantities in order to be excused from class as a way to free themselves for other more entertaining and leisurely activities (Moyer 2008).

Ramps were present in great abundance when the first European colonists arrived in North America. They were used as a source of food, due to their morphological and flavor similarities with the wild variants from Europe, which the colonists were familiar with (The Allegheny Leek Belt 1899). Wild leek references can be found throughout American history, speaking to their widespread abundance in the past. For example, within the travels of French Jesuit missionary Jacques Marquette, known as the founder of European settlements in Michigan, as well as for his mapping work of the upper Mississippi River, he and his party relied heavily on *Allium tricoccum* for sustenance during their journey from Green Bay, Wisconsin, to what is now present day Chicago, in 1674 (Fernald and Kinsey 1943). Wild leeks were so abundant around Chicago that native tribes referred to the area as "place of the skunk". The place name "Chicago" itself is derived from a word from the Miami and Illinois Native American groups' language that can be translated as "striped skunk", an ode to the historical presence of wild leeks and not to the presence of skunks (Fernald and Kinsey 1943).

Wild leeks are most prevalent in the so-called "Leek Belt" of New York, which stretches through the counties of Cattaraugus, Allegany, and Steuben in New York State, as well as the

counties in northern Pennsylvania bordering on these three counties. The first groups to live in this area made attempts to exterminate the wild leeks, probably because of their skunk-like smell and high abundance, but did not succeed (The Allegheny Leek Belt 1899). Those living outside of the Leek Belt incorrectly believed that the farmers of the Leek Belt walked about their land wearing shoes with "leek hook" bottoms that would extract the leeks from their soil as the farmers passed over them, as a way to rid their land of the plant (The Allegheny Leek Belt 1899). In the early days of colonization, there was also a stigma against the cultivation of wild leeks held by the upper class in this area. No one expected wild leeks to become a marketable commodity or to lend themselves to cultivation, although people did realize that if commodification were to occur, a great profit could be made off of the abundant plant (The Allegheny Leek Belt 1899).

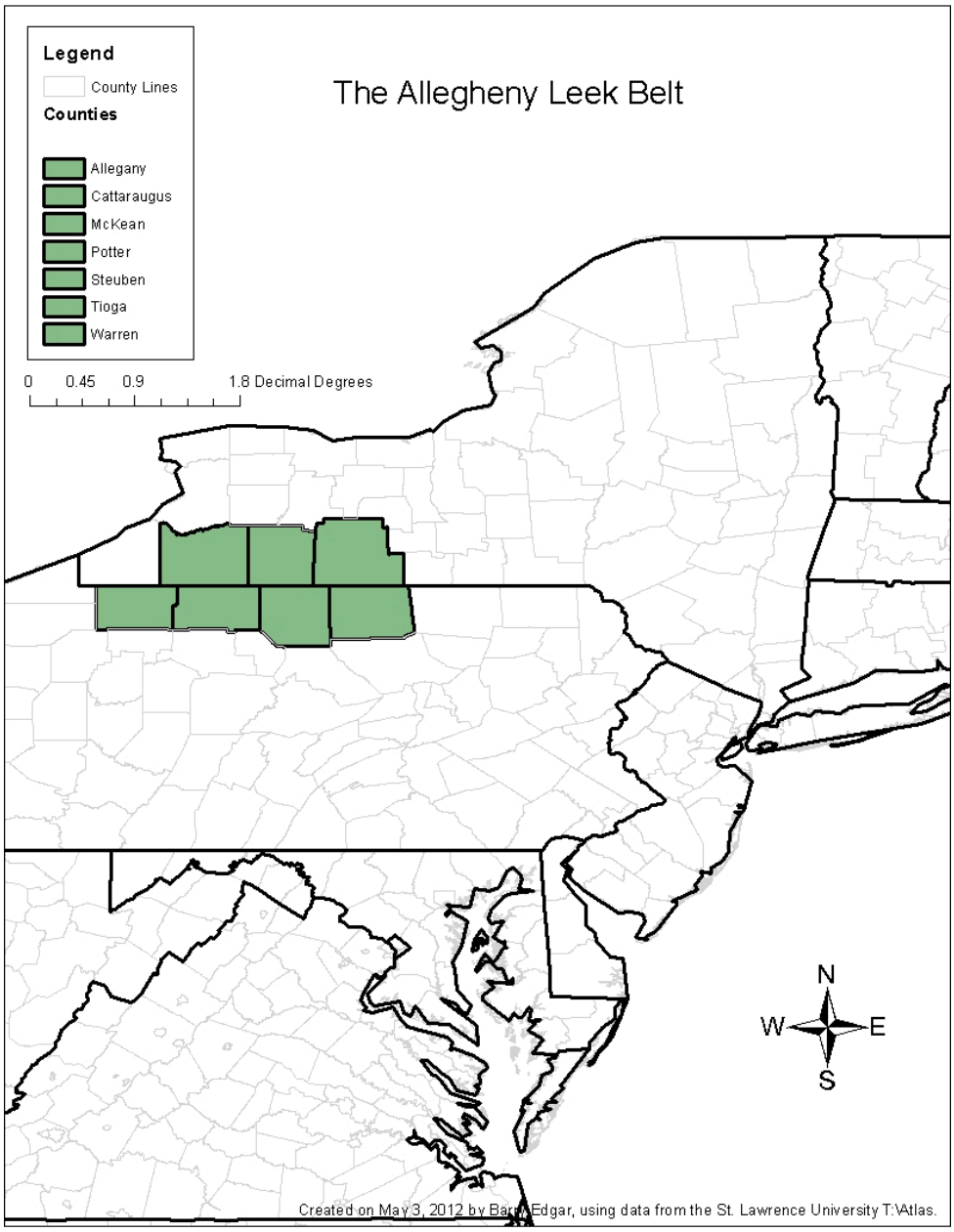


FIG 2. Map of the Mid-Atlantic States showing the location of The Allegheny Leek Belt, in counties of New York and Pennsylvania.

One of the first known references to the *Allium tricoccum* species of wild leeks exists within *Millspaugh's Flora of West Virginia*, appearing in 1896 (Core 1945). Since pre-colonial times, for reasons to be discussed below, wild leek populations have begun to dwindle in some

areas. In the southern part of their range, wild leek collecting has become an important part of mountain peoples' heritage (Blanchett 2002). With habitat connectivity, these southern populations may provide important genetic diversity for the wild leeks of the more limited northern distribution. Ramps were traditionally and are still today consumed as some of the spring season's first "greens" throughout their range, as ramps are among the first plants to emerge after the long winter months (Davis and Greenfield 2002).

Plant Description and Characteristics

Wild leeks are close relatives of onion and garlic plants as well as of the wider-known cultivated leek species, among other plants from the *Allium* genus (Moyer 2008 and Chapman 2005). They can be easily recognized and distinguished from most related species in the wild if one knows what to look for. There are two varieties of wild leeks to be considered for conservation, *Allium tricoccum* and *Allium tricoccum var. burdickii.* There is still some disagreement over whether or not the two varieties should be considered separate species or if *Allium burdickii* is actually a variation of *Allium tricoccum* (Jones 1979 and Proposed Part 2012). Currently, the NYSDEC is in the process of changing the conservation status of wild leeks to indicate that *Allium tricoccum var. burdickii* is an endangered species within the state of New York. In alignment with this classification, we will consider *A. burdickii* to be a variation of *A. tricoccum* from this point forward. Regardless of legal classification, a number of characteristics separate the two varieties of wild leeks.

The first clue of being in the vicinity of wild leeks is the unmistakably strong odor emitted from the raw form of the plant (Gibbons 1962). All *Allium* species have a strong scent, but the smell of wild leeks is the most powerful of them all. Wild leeks not only have a stronger scent

than their commercially grown relatives, but also possess a stronger flavor. Consumers of wild leeks have described the taste as being a cross between garlic and scallions (Hoyle 2003). Other descriptions place the taste of the wild leek as a cross between a mild onion and garlic (Gibbons 1962). In connection with the current local food movement, the distinctive flavor of the plant has made wild leeks a desirable ingredient in restaurants and homemade meals (Davis-Hollander 2011).

Wild leeks are spring ephemerals, a term referring to their short growth period lasting only from early spring until the tree canopy closes and enough light is no longer available for sustainable growth. The plant is a perennial; the herbaceous part of the plant emerges during the spring, but the underground basal bulb persists throughout the year. In undisturbed wild growing populations, wild leeks can be found in large clumps or colonies. In some cases, these leeks are so closely packed that all other understory plant life is excluded from the area (Greenfield and Davis 2001).

The plant's bulb is about two inches in length and can be as thick as a thumb, although the size may vary depending on the stage of vegetative propagation the plant is in at the time of observation (Gibbons 1962). Vegetative propagation refers to the growth of a new plant from a rhizome or from the splitting of a bulb of a parent plant (Hoyle 2003). When the leaves emerge in the early spring, they may be rolled tightly into small cylindrical packages. As they expand throughout their short life, they become tubular and flat with a characteristic lanceolate shape, similar to the leaves of an onion plant.

(Natural and Agricultural Observations 2011)

FIG 3. Wild leeks emerging in the early spring, before their leaves are fully open.

(Flickriver 2012)

FIG 4. Fully emerged wild leeks, with characteristically lanceolate shaped leaves.

The leaves may be from five to nine inches long and have a width of one to three inches across (Gibbons 1962). At the stage where leaves have emerged and expanded, the wild leek has an appearance similar to the foliage of the lily-of-the-valley plant, which is a distant relative. Confusing the two could lead to devastating consequences, as all parts of the lily-of-the-valley are poisonous (Chapman 2005). Flowers of the leek plant are arranged in a terminal umbel, emerging only after the leaves have receded, and are white/green in color (Gibbons 1962). The average wild leek will grow to be from eight to twelve inches tall; this is much smaller than the cultivated variety, which grows to be between two and three feet (Gabris 2000).

A few key features of wild leeks can be reliably used to distinguish between the *Allium*

tricoccum and *Allium tricoccum var. burdickii* varieties. *Allium tricoccum* is the larger of the two and has a slightly different coloration; the plant has a red or purple pigmentation from anthocyannis, a sugar pigment synthesized within the plant (Jones 1979). This pigment will be expressed as red or purple depending on the pH of the soil. The pigment appears mostly at the edge of the bulbs, which are otherwise a white color, or at the bottom of the leafy stocks (Feiring 2006). *Allium tricoccum var. burdickii* prefers a somewhat drier growing environment than *Allium tricoccum*. The final difference between the two species has to do with the timing of the plants' onset of anthesis, or the period during which the flowers of the plant are open and fully functional. In Funks Grove, of McLean County, Illinois, Jones (1979) reports that the anthesis period for *Allium tricoccum var. burdickii* lasts from June 6 through June 19, whereas the anthesis for *Allium tricoccum* occurs during the month of July. Another study in Kalamazoo County, Michigan, suggested a wider range of anthesis dates for the two species, as they cover a larger geographical area. This study showed that *Allium tricoccum var. burdickii* has an anthesis period from June 2 through June 24, and *Allium tricoccum* from June 29 through August 31 (Jones 1979). With reference to either study, the anthesis periods of the two species do not overlap. This suggests that the varieties are reproductively isolated from one another, limiting the chances for hybridization.

Habitat and Environmental Conditions Necessary for Plant Growth

Wild leeks are a wide-ranging species native to North America. Their preferred habitat differs between the northern and southern extent of their range. The plant is known to grow throughout the Appalachian Mountains. The northern limits of its range reach parts of Canada, such as Montreal and Ottawa, and the southern limits stretch through South Carolina, and even

northern Georgia (Legault 2003). They have also been reported to grow as far west as Minnesota and Iowa (Gibbons 1962). Both *Allium tricoccum* and *Allium tricoccum var. burdickii* grow within New York State, but their population distributions have not recently been mapped and have not been updated on the NYSDEC website (Proposed Part 2012).

The understory plant prefers a damp, mineral rich soil, slightly acidic in pH (approximately 5.5), such as that normally found within hardwood forests (Gabris 2000). Hardwood forests composed mostly of sugar maples (*Acer saccharum*) make an excellent home for wild leeks; the plant can also live among beech trees (*Fagus* genus), hemlock (*Tsuga* genus), and other hardwoods (Legault 2003). Wild leeks are often seen growing in association with plant species such as mayapple (*Podophyllum peltatum*), trillium (of the *Trillium* genus), bloodroot (*Sanguinaria canadensis*), black cohosh (*Actaea racemosa*), and other forest herbs (Hoyle 2003). In the north, wild leeks are most likely to be found growing in forest depressions, along streamside bluffs, or in moist, marshy, forested areas. Another prominent location within its northern range limits is in upland maple-rich woods. As for wild leeks growing in the warmer more southern habitat, the plant prefers mountain slopes of loosely packed soil at elevations of 1000 to 3000 meters (Jones 1979). Along with the threat wild leeks face from increasing harvesting pressures, they are also negatively impacted by habitat loss. For example, the maple forests wild leeks thrive in are slowly disappearing for a range of reasons including increasing urbanization and deforestation (Legault 2003).

Wild Leek Life History

As previously discussed, wild leeks are among the first signs of spring in many areas. They are some of the first vegetation to emerge after the cold winter months. Beginning

in April, the plant leaves break through the recently thawed soil. It is at this early time that wild leeks have the mildest flavor (Chapman 2005). Throughout the month of May and into June, the plants' leaves grow and broaden, soaking in the sunlight and transforming it into energy for further growth and reproduction. Once surrounding vegetation begins to block off sunlight from reaching the wild leeks and the forest canopy closes, the wild leeks' leaves die back. After the leaves have disappeared, the greenish-white flowers begin to emerge; the flowering period in ramps' life cycle lasts from June through August, depending on the species (Gibbons 1962 and Core 1945).

(Fowler 2012)

FIG 5. Flower of the *Allium tricoccum* species.

Wild leeks can reproduce in two ways. Sexual reproduction in wild leeks results in the formation of seeds and has the added benefits of increasing distance of dispersal as well as increasing genetic variation among and between populations (Nault and Gagnon 1993). In the past, scientists were unable to observe a biotic seed dispersal agent and believed that the most common method of dispersal was through rain and other water movement (Jones 1979). However, those studying the species have now identified a variety of animal pollinators and dispersal agents. Once a seed is produced and planted, it will take at least one year to germinate. It takes another three to five years from germination for a wild leek plant to become reproductively mature, which is one reason why it takes so long for a population to recover from harvesting (Hoyle 2003).

The second way that wild leeks reproduce is asexually, through vegetative propagation. Leeks produced this way are essentially clones of the plant they originated from. This type of reproduction can occur when ramps are reproduced from rhizomes, or underground root-like stems, or when a large bulb is split into two or more smaller ones, creating new plants (Hoyle 2003). In order for a bulb to split in this way, it must be relatively large, and therefore must have been growing for at least a few years in order to reach reproductive age.

These two types of reproduction are not equally as important to each of varieties of wild leeks. *Allium tricoccum* tends to reproduce mostly by vegetative propagation, whereas both methods of reproduction are equally as prevalent among plants of the *Allium tricoccum var. burdickii* variety (Jones 1979). This difference in reproductive strategy is another characteristic working toward the reproductive isolation of the two varieties. The reason that *A. tricoccum* relies on vegetative propagation is because the plants tend to grow in such close vicinity to one another. They are so tightly compacted that not only is there not enough room for a plant of any

other species to establish itself within the colonized area, but the adult wild leek plants also prevent seeds of their own kind from germinating, due to lack of space and resources. The plants create a barrier between the seed and the sun, and the extensive underground system of roots and rhizomes outcompete the seeds in their ability to absorb nutrients from the soil. Usually, any seeds that are produced only become established around the edges of a large cluster of adult ramps (Jones 1979). Seeds of *Allium tricoccum var. burdickii* have a better chance of germinating and becoming established when dropped from a parent plant, since this variety of wild leeks does not grow as close together as the *Allium tricoccum* variety does. *Allium tricoccum var. burdickii* tends to grow in scattered groups of only three to twelve, and seedlings are observed to be closer to mature plants since there is less intraspecies competition and more space to grow (Jones 1979). The fact that *Allium tricoccum* survives better than *Allium burdickii* when transplanted and potted and when planted in a garden may be attributed to the species' reliance on vegetative propagation (Jones 1979).

Harvesting of Wild Leeks

Wild leeks are harvested throughout their range for a variety of purposes, including personal use, commercial sales in both roadside markets and on a larger scale, use in restaurants, and use during wild leek celebrations and festivals. Harvesting at any scale puts a population at risk, and the impacts are clearly visible among studied populations (Rock et al. 2004). However, it is possible to harvest sustainably if harvests are controlled and limited, and focus remains on creating as few negative impacts as possible.

Normally, wild leeks are harvested in their entirety; the whole plant is pulled from the ground, including its leaves, bulbs, and any rhizomes connecting the plants (Rock et al.

2004). All parts of the plant are edible, but the outer layer of the bulb must be disposed of, as it serves as a protective layer for the bulb (Feiring 2006). Since the wild leeks' growth season is so short, harvesters take advantage of their presence quickly once they emerge. The main harvesting season lasts from April through May and the plant tastes different depending on the time of harvest. Some prefer those harvested earlier in the season because they believe that as time passes the leaves develop a tougher texture or wilt (Gabris 2000).

Most parties involved are well aware of the increasing demand for wild leeks over the last few years (Davis-Hollander 2011). In line with basic economic theory, as demand increases so do prices. In the case of ramps, sales have reached a high of 25 dollars per pound in upstate New York; a pound includes around 50 ramps (Pickowicz 2011). Closer to New York City and around major cities in the province of Ontario, Canada, the same pound of ramps can be purchased for 15 dollars (Pickowicz 2011). However, not all ramps that are harvested are sold, and the market is mostly informal, making it difficult to gather an accurate count of the number of ramps harvested for each purpose per year. Furthermore, those harvesting populations on their own private lands do not report their take.

Since ramp harvesting for personal use remains unregulated in most locations and the numbers of ramps harvested by and for individuals remains largely undocumented, the number of ramps harvested per year is most likely much higher than estimates would suggest, as is the pressure on ramp populations created by this harvesting (Rock et al. 2004). One estimate only focusing on use of ramps during ramp festivals suggests that a total of around 3,200 pounds of ramps are consumed during these festivals every spring. As festivals' popularity increases, so will the amount of ramps needed. At the time of the study, individual festivals were reported as using between 500 and 600 pounds of ramps. Each pound is composed of 40 to 80 ramps (leaves

and bulbs included), depending on the size of the plants harvested (Hoyle 2004). A later estimate of the number of ramps consumed within a season was made by Davis-Hollander (2011). He attempted to include all sources of harvesting and determined that at least two million wild leeks are harvested each spring in the United States for consumption of some kind.

Even before local food movements became increasingly popular beginning in the 90s, over-harvesting was creating a lasting impact on wild leek populations. Beginning in 1988, the Great Smoky Mountain National Park began monitoring their wild leek populations and found that easily accessible areas contained populations of *Allium tricoccum* that were less dense and generally smaller in size than populations in more secluded or difficult to access areas. It was assumed that easily accessible populations were more likely to be harvested from, and this harvesting resulted in a lasting decrease in population size. Since the time of the Great Smoky Mountain National Park study, harvesting pressure on wild leeks had only been increasing in the area, until harvesting limits and a regulation system were put in place (Rock et al. 2004).

Many other examples exist nationwide showing the destruction caused by over-harvesting (Legault 2003; Rock et al. 2003; Pickowicz 2011; Sen 2011). Harvesting effects can even be seen in the northern limits of the plant's range; populations in Canada have also noticeably decreased in size after over-harvesting (Rock et al. 2004). Sufficient harvesting research allows for the generalization that all harvesting, even at low levels, can have a lasting impact on wild leek populations. All wild populations are vulnerable to these harvesting effects, and may need years to recover, even from a one-time harvest (Rock et al. 2004; Davis and Greenfield 2002). Wild leeks can only recover from such a harvest when left undisturbed for an extended period of time. A population will increase with this added stability (Davis-Hollander 2011).

It is not only the harvesting itself that damages colonies of wild leeks; the indirect effects of harvesting, such as trampling of plants, also increase with rising harvesting efforts and higher numbers of harvesters traveling through an area (Davis-Hollander 2011). Wild leek clusters, especially those of *Allium tricoccum*, naturally exclude competitor plants from living amongst them. However, when individual ramps are removed from a cluster, the population density is decreased and space opens up for plant species that would otherwise be unable to establish themselves in the midst of the ramps. Decreased density due to harvesting leaves ramp populations particularly susceptible to invasive species. The invasive plant species Amur Honeysuckle (*Lonicera maackii*), for example, has been seen to outgrow and outcompete *Allium tricoccum var. burdickii* and other spring ephemerals once it has established itself in an area. The plant grows up and then branches out quickly, shading all other forest floor growth (Miller and Gorchov 2004). Garlic mustard (*Alliaria petiolata)* also takes advantage of the opening of space within a wild leek colony and then continues to negatively affect the surrounding plants. Non-native species can outcompete the wild leeks or have an allelopathic effect when they release chemicals into the environment that inhibit the growth of ramps and other native plants along with the symbiotic mycorrhizal fungi (Davis-Hollander 2011).

Medicinal Uses

Ramps first became a marketable commodity in 1966, when the USDA began to promote wildcrafting as a means of improving the local economies of south-central Appalachia. The area is still known today for its focus on traditional uses of plant foods and medicines (Cavender 2006). Wild leeks have a variety of traditional medical uses and have properties that lend them to potentially be developed into modern medicines to treat more serious diseases.

As some of the first greens to emerge in the spring, wild leeks are an integral part of a vitamin and mineral tonic many use to promote health after the long winter months (Davis and Greenfield 2002). They have also been used as a preventative measure against colds and the flu, as well as for part of a cure for scurvy (Legault 2003; Feiring 2006). For these uses, the plant is best consumed whole, and is eaten either raw or fried. Also, the plant is used as a purging tool for disease prevention and treatment to clean both the blood and the digestive system (Cavender 2006).

Some evidence points toward the ability of wild leeks to lower cholesterol and lipid counts in the blood (Cavender 2006). Even more promising is the plants' potential use as a cancer-treating agent. For example, rats treated with selenium-enriched ramps experienced lessened effects of cancer (Davis and Greenfield 2002). Further research on relatives of wild leek species has shown the existence of an antibacterial component in *Allium sativum*, common garlic, and *Allium ursinum*, the bear leek of Europe. It is possible that *Allium tricoccum* shares some of these properties with its relatives, but no studies have been conducted to confirm this suspicion (Core 1945).

Public Thoughts and Comments

All human stakeholders can agree upon the culinary, cultural, and overall value of wild leeks, but do not always treat the plant with the respect it deserves. Some are unaware of the damages their harvesting practices are causing on ramp populations. Others are noticing the population declines but do not know how to help the problem. St. Lawrence University student Ellie Brown[1], for example, has been harvesting wild leeks for years and has noticed a rise in the

[1] Email interview, May 4, 2012

popularity of wild leek harvesting and does realize that this added harvesting pressure could lead to declining populations. Unfortunately, only a small number are aware of the issue and are working to prevent it from worsening or to reverse the trend of declining population size.

Harvesting of ramps at the beginning of spring becomes a cultural celebration for many people. These early spring harvesters see the activity as a way of reconnecting with the land. Where some associate Groundhog Day with the beginning of spring, others, such as Chef Walt Danna, who uses ramps as an ingredient in many of his dishes, believe in ramps as the ultimate weather predictor and true indicator of the changing of the seasons (Moyer 2008). Harvesters use ramps in their cooking to enjoy the distinctive taste, but are also aware of the ingredient's cleansing and purging properties, among other suggested health benefits (Feiring 2006).

Ramps are such an integral part of the culture of some regions that the plant has even made its way into popular literature. Author Jeff Mann (2002) writes within his poem, "RAMPS", about how the rarity and seasonality of ramps is one reason why many people enjoy them and is a contributing factor to their popularity. His poem mentions environmental problems, such as industrialization and fresh water shortages, but does not view over-harvesting associated with wild leeks in the same light as these more obvious issues. The disconnect in many peoples' minds between the harvesting of wild leeks and its associated problems serves as evidence for the need to make more people aware of the environmental effects of their actions. We must change the public's opinion on the status of wild leeks and make stakeholders aware of associated issues in order to better conserve the species.

Information on the decline of wild leek populations in individual states and provinces is available in varying amounts on a state-by-state basis. Direct studies and other types of evidence

from within New York State speaking toward a decline in populations is lacking compared to that emanating from some other areas, such as Quebec and North Carolina. That being said, when ethnobotanist and plant ecologist Dr. Aswini Pai[2] was asked whether or not ramp populations in New York State face a substantial threat from over harvesting, she responded affirmatively. She feels that with the recent popularization of esoteric foods over the past ten or so years, ramps are, "bound to be over-harvested." She would agree with Legault's (2003) assessment that "…this bounty of the earth has become a victim of its own popularity."

3. Identification of Stakeholders

A wide range of stakeholders are involved in the issue of wild leek conservation. These groups include restaurant owners and patrons, wild leek cultivators, harvesters of ramps for personal food or medicinal use, scientists experimenting with medical uses, future patients to be treated with ramps and ramp products, people who use ramps as part of their folk medical cures, Native American groups practicing traditional use of the species, participants in ramp festivals, communities that benefit economically from nearby ramp festivals, conservation biologists, and, of course, the environment. "The environment" as a stakeholder can be further broken down into more specific groups, such as ecosystems containing ramps, organisms that make use of the nitrogen fixing properties of ramps, and organisms that consume ramps or ramp products. The place of each stakeholder within the larger system is not fully understood, according to United States Forest Service technologist, Jim Chamberlain. He believes that more research is needed to understand how social and economic aspects affect wild leek harvesting (Hoyle 2003). The insights and perspectives of various stakeholders, including a conservation biologist, a botanist,

[2] Personal interview, April 4, 2012

and a harvester of wild leeks for personal use, were obtained through personal and email interviews for the purpose of this study. Attempts at contact with festival planners, the NYSDEC, and a restaurant owner were also made, but to no avail.

Personal and Restaurant Consumption

Ramps can be prepared for consumption in a variety of ways; some people choose to fry the vegetable, while others enjoy them pickled or dried (Davis and Greenfield 2002). The vegetable can be eaten raw, although the smell of the plant is often transferred to the consumer, where it remains for an extended time period. It is often prepared alongside potatoes and eggs, and sometimes fish or another type of meat (Hoyle 2004). All parts of the plant can be consumed, according to taste preferences; the flavor of the bulb is much stronger than that of the leaf (Davis-Hollander 2011). Individuals often consume ramps that they themselves or someone from their family harvested for personal use. Ramp derivative products, such as leek-flavored butter, are also produced, sometimes accidentally. Ramps often grow in meadows where cows are kept to feed. When cows consume the ramps, their milk will carry the strong, distinct taste of the plant, making it unsellable at market. The farmers will drink this ramp-flavored milk so it does not go to waste (The Allegheny Leek Belt 1899).

Before the 1990s, only two small groups were known to harvest ramps for culinary use. One of these groups was made up of wild plant foragers of the southeast, who used the ramps for personal use, festivals, or sale at small roadside stands (Davis-Hollander 2011). This group had a sustainable way of harvesting ramps by only taking some from each clump. The second group known to harvest ramps was composed of "knowledgeable individual wild food foragers gathering a small amount of plants for personal and family consumption" (Davis-

Hollander 2011). It has only been since the 1990s that more people have found out about the culinary uses of ramps, with the popular movement to incorporate more local harvested foods into our diets (Davis-Hollander 2011).

Wild leek harvester, Ellie Brown[3], practices sustainable harvesting techniques by taking mostly only wild leek leaves and leaving the underground bulbs intact. She is well aware of suggested sustainable harvest limits and takes care to abide by these suggestions on harvesting trips. Brown is part of a minority group, as most people harvesting ramps are likely unaware of the environmental damage they may be causing, although they may be observing the results while just not attributing them to their own practices. Also, it could be that commercial harvesters are not thinking about long-term sustainability of their harvesting practices and are trying to make a quick profit off of the plant during its short growth period. Resulting problems are due in part to a lack of knowledge and education.

Only recently have more expensive, fancy, "white table" restaurants shown an interest in the preparation of wild leeks for their customers (Greenfield et al. 2001). These restaurants have realized that a market for locally grown products has been expanding and is worth acting upon to satisfy customers of a wider demographic. The resulting increase in demand and need for a consistent supply of the forest-grown plant has caused wild populations to decline in size (Greenfield et al. 2001). If harvesting regulations were imposed on wild leeks, fewer ramps would be available for restaurants. The wholesale price would rise, if enough were even available for sale, necessitating a rise in restaurant meal prices. Restaurants would be forced to remove the items containing ramps from their menus if the costs grew too high or the marked-up prices were above that which the average restaurant customer was willing to pay. These

[3] Email interview, May 4, 2012

predicted economic consequences for the regulation of wild leek harvesting suggests that restaurant owners and patrons would initially be against all such regulations.

Native Americans

Well before European colonists arrived in North America, Native Americans were using wild leeks as a food and medicinal resource, harvesting sustainably in an environmentally responsible way. These Native Americans most likely taught early settlers how to look for and to harvest wild leeks early in the spring as a food source and for their medicinal value (Hoyle 2003). Wild leeks have been ingrained within the Native American culture for centuries. As previously mentioned, the various groups named geographical locations based on the presence of wild leeks. Native Americans use the plant as a spring tonic to clean the blood at the start of the spring season, ridding the body of all unhealthy materials accumulated during the winter months from a less varied diet (Chapman 2005). Like those of southern Appalachia, Native Americans also use the plant to cure colds and as a source of vitamin C (Chapman 2005). The Iroquois and the Mohawk utilize wild leeks as a pediatric aid along with the aforementioned uses[4].

Festivals

Throughout the range of wild leeks, ramp enthusiasts celebrate the spring and the arrival of ramps by taking part in ramp themed festivals and cultural celebrations. The plant is said to have achieved "cult status", as ramp lovers meet year after year around the prime harvesting period of the vegetable (Chapman 2005). These festivals take place in locations as varied as the Mason-Dixon Historical State Park in Pennsylvania, Hudson, New York, and Harlan County,

[4] Personal interview with Aswini Pai, April 4, 2012

Kentucky (Moyer 2008). The central activity at these festivals is always eating. Ramps are prepared in a variety of ways, like ramp burgers, ramp soup, and ramp wine, for all to enjoy (Moyer 2008). Ramp festivals place a great demand on wild populations. A large number of ramps is needed to supply the festival, taken within a very short time period at the beginning of the season, before the ramps have had time to reproduce. Thousands of ramps are harvested each year for their use in festivals; one estimate suggests the use of 3,200 pounds per spring for festivals alone, which places a great strain on populations (Hoyle 2003).

Some festivals also take advantage of the opportunity to go on harvesting trips and appreciate ramps in their natural state within the forest. Most festivals include music, games, and even activities such as petting zoos in addition to just eating, in order to create a major tourist attraction for the surrounding region and for guests from further away (Davis and Greenfield 2002). People arrive from far and wide to celebrate the ramps and spend generous amounts of money while passing through or staying in the town hosting a ramp festival. The influx of people helps to stimulate the economy of some of these more isolated mountain towns. In some locations, locals take advantage of the potential fundraising opportunity for organizations, such as local firehouses and 4H clubs. A festival in North Carolina generates 30 percent of the local firehouse's budget annually (Hoyle 2004). Limits on wild leek harvesting would severely alter the spirit and events scheduled for ramp festivals. Therefore, festival-goers and members of host communities would view any regulations negatively.

Wild Leek Environmental Benefits

Scientists have proposed the idea that wild leeks play an important role in nitrogen mineralization in some environments. This idea is known as the vernal dam hypothesis, which

credits spring ephemerals with being nitrogen sinks during the early spring, when trees are dormant and very few other plants have begun to show signs of life. These plants then release this stored nitrogen later in the season when other plants are active and need the nutrients. The hypothesis suggests that this temporary uptake of nitrogen increases nutrient stability within the environment. If nitrogen were not taken up by the wild leeks in the early spring, it would be lost to leaching (Rothestein 2000). The vernal dam hypothesis is widely accepted, but is lacking associated research to validate its claims. Rothestein (2000) suggests that if this hypothesis were viable, summertime rates of net nitrogen mineralization would be greater in plots with spring ephemerals than in those without. He studied nitrogen uptake by spring ephemerals and found that they made a contribution of 0.446 grams of nitrogen per square meter. This amount was nowhere near as large as the amount absorbed by the microbial community of 3.2 grams per square meter (Rothestein 2000). Rothestein's study is evidence that nitrogen uptake by spring ephemerals, such as *Allium tricoccum* is not as important as the vernal dam hypothesis suggests; however, the plant does play a role in nitrogen cycling and the consequences of eliminating that ecosystem process remain undetermined.

Connections to Other Species

The place of ramps within the larger ecosystems lends the plant to a range of interactions with other organisms sharing its environment, such as pollinator species, seed eaters, and less desirable organisms, like those causing disease and resulting in damages to the wild leek plants. Seed production in wild leeks is resource limited. The plant uses environmental resources for bulb and herbaceous growth, only managing to produce seeds during times of plenty. Reproduction can also occur through vegetative propagation, and growth of the

underground bulb is conducive to this type of reproduction. The number of seeds produced by wild leeks also depends on the activity of pollinators (Nault and Gagnon 1993). Pollinators are more likely to focus on a group of plants with a high density of inflorescences that have a high caloric component to their flower products. Pollinators of wild leeks are mostly flying insect species, including the solitary *Halictus* bee, sweat bees from the *Dialictus* genus, *Augochlora pura*, and occasionally bumble bees (Jones 1979). Another more recent study on wild leeks by Nault and Gagnon (1993) reported a more diverse range of pollinators, including the bee *Bombus terricola*, and the flies *Minettia lupilina*, *Simulium parnassum*, *Chloropidae*, and *Drosophilidae*. One biotic seed dispersal agent is spoken of within wild leek literature. The deer mouse, *Peromyscus maniculatus*, was observed collecting the seeds of ramps (Nault and Gagnon 1993). If ramps were to disappear, these pollinators and seed-feeders would have to rely on other plants to meet their nutritional needs.

4. Governmental Issues

The issue of wild leeks pertains to areas in northern New York State containing wild leek populations and should be the responsibility of the New York State government, specifically the New York State Department of Environmental Conservation (NYSDEC). *Allium burdickii* is currently listed as endangered in the state of New York under Part 193.3 Protected Native Plants of the Environmental Conservation Law (ECL). However, Part 193.3 is currently being updated to Proposed Part 193.3, which includes *Allium tricoccum var. burdickii*, Burdick's Wild Leek, as an endangered species of New York State instead of *Allium burdickii*. Since the NYSDEC controls the protection status of the species, it should also regulate any form of interaction between humans and wild leeks (i.e. harvesting, cultivation).

There are no local and regional conflicts of laws since NYSDEC regulates all native plants under the ECL. However, a conflict may arise when considering wild leek populations located in Native American reservations, such as the Saint Regis Mohawk Tribe in Akwesasne, NY. Because Native American groups are considered sovereign nations, they have their own set of laws and government to oversee them and are therefore not under the jurisdiction of departments such as NYSDEC. It is unlikely that a large majority of wild ramp populations exist in reservations, so any conflicts with Native American tribes will not be of significant concern.

Governments are expected to promote plant conservation through:

- Passing favorable laws and regulations, as well as enforcing them
- The beneficial management of state-owned assets, including land, plant resources, and industries' use of plant resources
- Setting favorable financial incentives as well as disincentives
- Providing advisory services to promote conservation practices
- Support for scientific research
- Accreditation of educational courses
- Raising public awareness
- Setting a moral tone (Hamilton and Hamilton 2006)

Hamilton and Hamilton state that "...the ideologies and economic policies of governments have significant impacts upon conservation" (2006). Thus, the NYSDEC must set the standard for efforts toward the conservation of wild leek populations. The NYSDEC should oversee local town governances, making sure they are carrying out proper conservation steps.

5. Development of solutions to the problem

a. Parameterizing solutions:

An ideal solution to the decline in wild leek populations must have the ability to protect populations from further decline while still allowing for human stakeholders to continue their traditional use of wild leeks. If wild leek harvesting continues, harvesting limits must be put in place. Rock et al. suggest that only ten percent of the wild leek populations can be harvested every ten years (2004). These strict regulations must be enforced by DEC rangers or volunteer officials. Education for all those coming in contact with wild leek populations is also vital to the prevention of over-harvesting. Educational programs that explain the importance of conservation efforts as well as proper harvesting techniques are crucial in preventing over-harvesting of wild leek populations. Only when wild leek populations are sustainable and healthy and are no longer threatened by over-harvesting, and when the public is educated, will we be satisfied that the problem is solved.

b. Identification and evaluation of potential solutions:

Ban Harvesting

One potential solution to the over-harvesting of wild leeks is to completely ban all harvesting. Completely banning wild leek harvesting in northern New York will eliminate the potential threat for over-harvesting of populations. There have been successful harvesting bans practiced outside of New York State. For example, in Gatineau Park, located in Montreal, Quebec, no harvesting is permitted. Gatineau Park has offered legal protection of wild leeks from harvesting since 1980 (Nault and Gagnon 1993). Wild leek population growth rates are

closer to equilibrium when their habitat is stable, thus concluding that overharvesting was a probable reason for population extinction in Quebec (Nault and Gagnon 1993). If one is found picking leeks in Gatineau Park, a National Capital Commission (NCC) officer can issue a minimum fine of $500 (Spears 1990). However, fines vary from $500-$20,000 for individuals and from $1,000-$40,000 for companies for a first infraction (Legault 2003). In Quebec, anyone wishing to report illegal cultivation of wild leeks can contact the provincial anti-poaching (S.O.S. Braconnage) through a toll-free line or contact their local wildlife office (Legault 2003). The ban on wild leek harvesting within the protected area of Gatineau Park is seen as a first step toward protecting wild leek species in Quebec, but for the species to be fully protected, efforts must be made elsewhere as well (Hamilton and Hamilton 2006).

A complete ban of wild leek harvesting has also been initiated in Great Smoky Mountains National Park (GSMNP). In spring 2002, GSMNP banned the collection of ramps after a five-year study indicated a decline in the park's ramp populations (Hoyle 2004). The five year study found that once a ramp patch was extensively harvested the population may take up to 20 years or more to recover (Blanchett 2002). Field observations of the five-year study concluded that ramp harvesters collect their quotas from within one patch, leaving few individuals to provide seeds to regenerate the patch (Blanchett 2002).

Jim Chamberlin, an advocate for sustainable wild leek populations, remarked that "while we cannot scientifically predict when the current rate of harvesting of ramps will have a bigger effect on the species, every knowledgeable authority I spoke with agreed now is the time to put on the brakes" (Davis-Hollander 2011). With prohibiting the harvesting of wild leek populations, the threat of over-harvesting is eliminated.

Limit Harvesting

A second solution to the over-harvesting of wild leeks would be to limit harvests with permits and the imposition of fines when limits are disregarded. Harvesting of wild leek populations has been shown to be unsustainable, unless at very modest levels (Rock et al. 2004). Rock et al. experimented with wild leek populations and found that growth rates of these plants were higher in years immediately following harvest, but declined as populations recovered (2004). The mean recovery time for a 25% harvest was 22 years, and population recovery may be density dependent (Rock et al. 2004). The results of these studies prompted Rock et al. to recommend improved monitoring of harvests and greater enforcement of harvest limits (2004). Another study in agreement with these results found that a decline in population is predicted with a simulated harvest of as low as 15% (Nault and Gagnon 1993).

Another conservation strategy recommends harvesting 20 percent of wild leek leaves every five years (Davis-Hollander 2011). This conservation strategy also encourages the harvest of older individuals that have already had a chance to reproduce. If plants are allowed to reach maturity before they are harvested, their genes could be passed down prior to their removal from a population, thus increasing the genetic diversity and overall size of a population (Davis-Hollander 2011).

Taking only the leaves of a wild leek plant and leaving the root and bulb is a more responsible way to harvest, as this method leaves ramp clusters intact and does not kill the plant (Pickowicz 2011). Native American groups such as the Cherokee have utilized this method of harvesting for centuries (Davis-Hollander 2011). The method of only taking the leaves and the petiole of the plant is also used in Europe for harvesting of the ramson species, *Allium ursinum*,

utilized for its culinary value (Davis-Hollander 2011). Perhaps if all harvesters only took the leaves and the petiole, and not the underground bulb, wild leek populations would not be threatened by over-harvesting. Educating the public and harvesters is key in implementing this sustainable harvesting technique.

In the province of Quebec, there are wild leek harvest limits. Since 1995 the sale of wild leeks has been strictly prohibited; there are strict controls on harvesting populations under Quebec's Loi sur les especes menacees ou vulnerables act (Legault 2003). These harvesting limits were put in place after wild leeks were designated as vulnerable species by the Ministere de l'Agriculture, des Pecheries et de l'Alimentation du Quebec (MAPAQ) (Pickowicz 2011). Wild leeks were among the nine plants that were the first to be protected under the Endangered Species Act of Quebec (Hamilton 1994). Daniel Gagnon, a prominent ecological researcher with focus on wild leeks, remarked that new regulations on wild leeks would help save colonies that are threatened by commercial harvesters (Hamilton 1994). However, Gagnon does believe that there is still enough of the plant in Quebec to provide for personal harvest (Hamilton 1994). The annual limit in Quebec is set at 200 grams per person, which is the equivalent of about 50 tiny bulbs (Legault 2003). Quebec is serious about conserving wild leek populations. Fines, harvest bans, law enforcement and education all have been beneficial to limiting the threat of over-harvesting of wild leek populations.

Commercialization

Commercialization of wild leeks could be a possible third solution to the problem. In the national forests of North Carolina, commercial permits are distributed at the rate of fifty cents per pound for up to 500 pounds of wild leeks (As ramps sprout 2005). In the North

Carolina's Nantahala National Forest, the government enacted regulations in 2005 to tell people where they could harvest the plants and how, and to charge collectors 50 cents per pound for their harvest. One pound is equivalent to 40-80 plants (As ramps sprout 2005). With the new harvest limits, harvesters would only be allowed to "...harvest half the plants in every square foot of a ramp patch." (As ramps sprout 2005) In Nantahala National Forest, the number of commercial collection permits for *Allium tricoccum* increased from one permit in 1996, with a single bushel collected, to 16 permits in 2001 with 46 bushels reported collected, showing the rise in popularity of leek harvesting (Rock et al. 2004). A bushel can hold as many as 650 *Allium tricoccum* plants (Rock et al. 2004). By standardizing the size of a bushel, harvesting of wild leek populations can be more easily estimated.

Another way to regulate the sales of wild leeks on a commercial market could be to consider the certification of wild leeks as a non-timber forest product (NTFP), also known as a secondary, minor, special, or specialty non-wood, non-traditional product (Chamberlain et al. 1998). NTFP certification is a recent development in forestry management, used as a means of developing responsible stewardship of the land and associated resources with the promise of consumer product labeling (Shanley et al. 2002). NTFP labeling is done in the hopes that educated, and environmentally responsible consumers will be more likely to purchase products labeled as originating from a well-managed forest. The system develops products that are appealing to a small niche in the market (Shanley et al. 2002). With any luck, this niche market could be the same niche market interested in wild leeks in the first place. The locavore food movement, concentrating on eating locally produced goods, and the natural foods movements, with focus on consuming organic, non-genetically modified plant and animal products, might

also be interested in purchasing leeks from certified growers who exhibit the same environmental and social values as they do.

The possibility of increasing sales will make producers more likely to seek out certification, which calls for environmentally and socially friendly management policies. In this way, the program is creating economic incentives for responsible stewardship and sustainable management practices (Shanley et al. 2002). The demand for NTFPs has been increasing since the 1990s. There are four categories of NTFPs currently recognized, including edibles, specialty wood products, floral greens, and medicinal and dietary supplements, all of which contribute to local economies. Wild leeks could be placed under the category of edibles or of medicinal and dietary supplements, or both. It is often difficult to keep track of sales of NTFPs and their exact contributions to local economies because they are often based on informal markets, such as roadside vendors or farmers' markets (Chamberlain et al. 1998).

There are three systems in place to regulate NTFP certification. If wild leeks were to be officially regulated as an NTFP, they should be labeled under the Forest Stewardship Council (FSC) system. Label status is giving on a case-by-case basis, as decided by third party members of the FSC after careful research and observation. The mission of the FSC fits best with problems relevant to wild leek management. The organization concentrates on maintaining biodiversity, productivity, and ecological processes of the forest in which the NTFPs are grown. The FSC also considers how their focal products relate to social aspects of the surrounding society, promising their attention to creating benefits for local communities within management practices. Products cannot be certified unless farmers can prove that their crops are grown sustainably, with stewardship practices that will provide for the long-term viability of the product and the industry (Shanley et al. 2002).

The growth of the NTFP market and the possible inclusion of wild leeks under NTFP guidelines may create further issues of resource management. Since the classification of products as NTFPs is a relatively new phenomenon, information on how to manage a forest to promote the growth of these NTFPs and then also advertise for their sales is lacking. A lack of regulation could lead to increased over-harvesting, degradation of the resources, and increased tensions among stakeholders. Suggested regulations based on NTFPs include long-term leases of land suitable for wild leek growth or the implementation of a program around harvesting permits (Chamberlain et al. 1998). A further suggestion was made to allow stakeholders to participate in the development and implementation of regulations so they would feel involved in the process, to make their ideas heard and seriously considered, and to relieve potential tensions between the numerous stakeholder groups (Chamberlain et al. 1998).

In the United States, American ginseng, *Panax quinquefolius*, faces some of the same conservation problems as wild leeks. Like wild leeks, ginseng has medicinal value and has been collected historically, for a long period of time. There are now four types grown, including wild, simulated wild, woods grown, and artificial-shade cultivated ginseng. Similar cultivation types could be attempted in the case of wild leeks, as the plants share some of the same requirements, both being forest herbs. Also similar to wild leeks, over-harvesting decimates ginseng populations and inhibits population recovery. The two species have similar maximum harvest suggestions, at somewhere between zero and ten percent of the total population of an area (Nantel et al. 1996; Shanley et al. 2002). Based on these similarities, it is reasonable to assume that any potential problems related to the recognition of American ginseng as a NTFP and its further commercialization would also be problems in the case of wild leeks.

The challenges in certifying ginseng are mainly a result of the type of people that tend to harvest it and their need for the economic benefit of selling the plant. American ginseng is relatively popular as an herbal supplement and families rely on the sale of their harvests for monetary support. Challenges also result from the difficulties in verifying the plant's NTFP status throughout its chain-of-custody. Questions arise as to how a certified product can be kept track of when it passes through so many hands before being ultimately sold for use on the market, and how to keep non-certified growers from selling their products as certified. NTFP certification also begs the need for forest access enforcement, to prevent non-affiliated harvesters from taking advantage of wild populations. Finally, for the certification program to be successful, officials must evaluate how receptive consumers will be to the newly certified product and whether or not a big enough niche exists for the product on the market (Shanley et al. 2002).

Reintroduction Program

Another solution to the problem of the over-harvesting of wild leeks would be to implement a reintroduction program. Following the model created by the Montreal Biodome would be beneficial in alleviating pressure caused by over-harvesting of wild leek populations in New York State. The Montreal Biodome launched the SEM'AIL program in 1999 as an awareness, education and restoration program for wild leeks in Quebec. The SEM'AIL program is a wide-ranging operation designed to help protect efforts already in place to solve the wild leek over-harvesting problem (SEM'AIL).

Under the SEM'AIL program, in March 2000, 2001, 2003 and 2004, one million wild leek seeds were distributed to owners of maple stands who were interested in the preservation of

wild leeks. The program also called for the re-planting of over 440,000 bulbs seized by wildlife officers from illegal harvesters. These bulbs were planted in forests owned by SEM'AIL supporters and participants. As of 2010, a total of 1,117 landowners have planted wild leeks on their land. These landowners agreed to monitor their plantations for five years under the conservation program. The conservation operation implemented by the Montreal Biodome has been very successful. In over 80 percent of the reintroduction cases, wild leeks have become established. Several hundred new wild leek colonies have become established due to the SEM'AIL program (SEM'AIL). The reintroduction program created by the Montreal Biodome shows how successful a reintroduction program can be.

Cultivation

Encouraging personal or commercial cultivation to alleviate pressure on wild ramp populations could also be a solution. We asked Professor Aswini Pai, "do you believe the cultivation of ramps should be regulated in New York State?" Pai[5] believed ramps can and should be cultivated, as well as regulated. Many others in the scientific community and in the general public believe wild leeks should be cultivated and would be interested in learning more about the process[6] (Greenfield and Davis 2001; Davis and Greenfield 2002; Land 2010). Some have gone to the extent of researching proper cultivation practices of wild leeks (Davis and Greenfield 2002). Cultivating these plants would benefit festival participants, chefs, and consumers, and would create a new, marketable product for the commercial grower (Davis and Greenfield 2002).

[5] Personal interview, April 4, 2012
[6] Email interview with Ellie Brown, May 4, 2012

It is important to note that cultivating wild leeks is different from cultivating domesticated plants such as broccoli or lettuce. Because wild leeks are able to sustain themselves without human assistance, it is possible to keep "half-wild" populations within the plant's native distribution. While transplanted or seeded ramp populations can survive on their own, human husbandry will increase the growth of these populations, leading to more productive harvests.

The first step towards successful cultivation is careful site selection. Choosing a well-drained site with rich, moist soil that is high in organic matter is very important. Studies have shown that soil moisture is a crucial environmental variable that influences seed germination, seedling emergence rates, survival, and growth rates of wild leeks. Thus, a sufficient amount of moisture must be maintained throughout all seasons, not just during the growing season (Greenfield and Davis 2001). Ramps typically grow in environments with a high calcium to magnesium ratio along with a soil pH of approximately 5.5 (Greenfield and Davis 2001). Studies have shown that it is vital to maintain high levels of calcium and a proper pH of 5.5 to ensure healthy population growth (Greenfield and Davis 2001).

Another important factor in site selection is proper shading, which can be provided by either a natural forest canopy or an artificial shade structure. Wild leeks grown under 30 percent shade in forests were found to have the highest seedling emergence rates, while ramps grown in open fields showed the poorest emergence and seedling survival rates (Greenfield and Davis 2001). Forests canopies of beech (*Fagus*), birch (*Betula*), sugar maple (*Acer saccharum*), poplar (*populus*), buckeye (*Aesculus*), linden (*Tilia*), hickory (*Carya*), and oak (*Quercus*) were all found to be suitable for growing ramps. Areas that host trillium (*Trillium*), toothwort (*Lathraea*), nettle (*Urtica*), black cohosh (*Actaea racemosa*), ginseng (*Panax quinquefolius*), bloodroot (*Sanguinaria canadensis*), trout lily (*Erythronium americanum*), bellwort (*Uvularia*), and

mayapple (*Podophyllum peltatum*) are suitable for growing wild leeks as well, since these plants share growing requirements with ramps.

Choosing the right variety of wild leek is essential to the success of your "half-wild" population. Studies have shown that when transplanted, *Allium tricoccum* survives far better than *Allium tricoccum var. burdickii* (Jones 1979). Thus, *Allium tricoccum* should always be the variety used in cultivated populations. Besides surviving transplantation better, *Allium tricoccum* almost always reproduces through vegetative propagation, ensuring that all reproductive effort will result in growth of your cultivated population, not dispersal to other areas. Another advantage is that *Allium tricoccum* is not listed as endangered or threatened by human exploitation, like *Allium tricoccum var. burdickii* is. Throughout the rest of this cultivation subsection we will use the terms wild leek and ramp to refer to the *Allium tricoccum* variety only.

There are two ways to start a "half-wild" population of wild leeks: transplantation or seeding. Transplanting ramps is a good alternative for novice gardeners since the alternative method of seeding requires more time and patience. Wild leek bulbs can be purchased from online stores or can be dug from wild populations in spring when the ground has thawed. However, when removing bulbs from wild populations, keep sustainability in mind to ensure the persistence of the wild population. The best time to plant purchased or wild bulbs is in mid-March after the ground has thawed. In a prepared planting bed, transplant the bulbs approximately 3 inches deep, and 4 to 6 inches apart, allowing all the roots to be buried, keeping just the very tip of the bulb above the surface. Planting the bulbs at the proper depth is very important for the survival of the wild leek bulb (Greenfield and Davis 2001). The time it takes to reach a harvestable ramp population depends on the size of the bulbs when they were

planted. For example, planting large bulbs that are greater than a half-inch in diameter can provide harvestable wild leek population within two to three years (Greenfield and Davis 2001). When transplanting, one should note that transplanted ramps do not compete successfully with weeds. Thus, weeds should be controlled until the leeks are well established (Greenfield and Davis 2001).

For the more advanced gardener, seeding is the better route to a "half-wild" population of wild leeks. Direct seeding is also beneficial because it does not negatively affect wild populations by removing individual bulbs, like transplantation does. To begin the seeding process, one must purchase seeds from a store, online or not. Although seeds can be sown at any time of year during which the ground in thawed, sowing in the late summer to early fall proves the most success due to seed requirements. Fresh ramp seeds have a dormant, under-developed embryo that requires a warm, moist period to break root dormancy followed by a cold period to break shoot dormancy. Germination of ramp seeds can take upwards of 18 months, depending on the season the seed was planted in. Thus, it is vital to sow seeds early enough in the summer to ensure that the seeds undergo a warm, moist period before the cold winter months to break root and shoot dormancies, and begin germination by the following spring.

After selecting the proper site based on prior information in this subsection, begin by raking back debris such as leaves and sticks on the forest floor, removing unwanted weeds, tree sprouts or roots. If the soil is not naturally high in organic matter, incorporate organic materials, such as composted hardwood leaves and other decaying plant material from the forest. Loosen the soil and rake it to prepare a fine seed bed; sow seeds thinly on top of the ground, pressing them gently into the soil. Lastly, cover the seeds with several inches of hardwood leaves to retain moisture in the soil and to protect the seeds from wildlife (Greenfield and Davis 2001).

Once germination is complete, it will take roughly three to five years for seedlings to mature fully (Davis-Hollander 2011). Finally, wild leeks will begin to undergo vegetative propagation, which was found to be the most important pathway for increasing population growth, since recruitment from seeds is highly unlikely in *Allium tricoccum* (Nault and Gagnon 1993). Mature plants dominate 40 to 70 percent of the population and daughter ramets, or clones, become independent between five and eight years of age. However, juvenile ramp mortality is high and annual growth rates are low, leading to a slow-growing younger population. Maintaining large individuals in your population is pivotal because size is the most important factor for surviving adverse environmental conditions, and bulb division rates increase as ramet size increases (Nault and Gagnon 2002).

Throughout the cultivation of your population, it is important to facilitate growth through proper husbandry, which includes regular weeding and mulching. As mentioned before, regular weeding is especially important in the early stages of cultivated populations, as pre-established ramps do not compete well with weeds. Mulching can provide numerous benefits for wild leek cultivation throughout the seasons. Studies have shown that hardwood leaves provide the best mulch, while poor results were obtained with pine bark and commercial mulches. Mulching benefits wild leeks by suppressing weeds, retaining moisture, providing essential nutrients in detritus such as nitrogen, insulating during subzero temperatures, and protecting new seeds and seedlings from wildlife (Greenfield and Davis 2001).

Do not harvest your "half-wild" population of ramps until the whole site is filled, the plants have large bulbs, and have flowered and produced seeds. There are a few methods to harvest wild leeks, including digging whole patches, harvesting a portion of a patch, or thinning out and harvesting just the largest plants. If you plan to harvest whole patches, it is

recommended to have enough plots to allow for a five to seven year rotation to assure a continuous harvest each year. In other words, only harvest one-fifth or one-seventh of your production area each year. When harvesting a portion of a plot, no more than 15 percent of the wild leeks should be removed. If you use the thinning method, great care should be taken not to damage bulbs not being harvested, and a total of only five to 10 percent of the plants should be collected (Nault and Gagnon 2002). Some harvesters recommend using tools such as a garden hoe, pick, or soil knife to collect ramps, while others use their bare hands by "snapping" the bulb free of the clump it was attached to. When you complete your harvest, it is important to wash collected wild leeks thoroughly, trim off the rootlets, pack them in waxed, non-airtight cardboard boxes, and store them in a cool place (Greenfield and Davis 2001).

Land Preservation

Finally, preservation of land containing wild leek populations could be a solution to over-harvesting. Poachers profit from the illegal harvesting of ramps, and their methods often destroy the areas where ramps once occurred, making it difficult for wild leek populations to become re-established in the area (Pickowicz 2011). Thus, preserving whole areas of land and forbidding harvesting within these areas would be beneficial in decreasing the threat of over-harvesting of wild leek populations. Even within protected populations, illegal harvesting has continued to be a problem, and the number of illegal harvesters caught has not declined over the years[7]. A prime example of wild leek land preservation exists in Gatineau Park, Quebec.

c. Identification of feasible solutions

[7] Email interview with Patrick Nantel, April 15, 2012

Placing a complete ban on all wild leek harvesting would be infeasible. Controversy would arise among stakeholder groups who rely on wild leeks for their medicinal uses, their culinary appeal, and their ties to cultural practices. Also, if a complete ban were put in place, it is likely that illegal harvesting would occur, as it did in Gatineau Park[8]. The National Capital Commission (NCC) is already having trouble with people picking wild leeks in this area, where harvest is strictly prohibited (Spears 1990). Furthermore, there is already a problem with illegal harvesting in areas with harvest limits, so completely banning the practice would only exacerbate the problem (Davis-Hollander 2011). Completely banning wild leek harvesting would also call for an increase in government spending and monitoring officials.

Although further commercialization of wild leeks would be possible, this would not be helpful in solving the problem facing the species and does not meet our parameters defining a successful solution. Markets for wild leeks currently exist, as the plant is sold by roadside vendors and is available for sale online. The recent movements for eating local, sustainable, and foraged foods, has caused market demand for wild leeks to greatly increase. Additional commercialization along with associated advertisement would further expose ramps to the local and global market and increase the number of consumers interested in purchasing wild leeks. This would inevitably put a greater stress on leek populations. Demand would quickly exceed supply with the expansion of markets in Northern New York. Botanist Aswini Pai and conservationist Patrick Nantel agreed that the commercialization of wild leeks and the creation of a more formal market would not be an acceptable solution to the wild leek problem[9].

[8] Email interview with Patrick Nantel, April 15, 2012
[9] Personal interview with Aswini Pai, April 4, 2012, and email interview with Patrick Nantel, April 15, 2012

Limiting harvests with permits and imposing fines when limits are disregarded is more feasible than placing a complete ban on the resource. As seen in Quebec and national forests of North Carolina, limited harvests are implemented and fines are given to those that do not follow harvest limits. This solution would not completely put an end to cultural practices centered around wild leek harvesting, and would therefore be seen as more acceptable to those interested in preserving their cultural traditions. It would also allow for continued harvesting for personal use, but to a lesser extent.

A reintroduction program of wild leek populations in northern New York is another feasible solution. The previously mentioned SEM'AIL program has proven to be very successful as a reintroduction program. However, cooperation of landowners was essential since public and private lands are required for the program. The educational component of the program was also very important for raising public awareness. This potential solution would call for a large amount of time and organizational measures, as well as a sufficient number of dedicated managers and volunteers. A source of funding for the project would also need to be determined. Without these aspects in place, a reintroduction program would not be feasible in northern New York.

Suggesting personal or commercial cultivation to alleviate pressure on wild leeks is another feasible solution. Cultivation would help prevent wild ramp populations from being over-harvested by providing cultivated wild leeks to meet the market's demand. This solution does not take the place of the implementation of proper harvesting techniques and harvesting limits. It would still be necessary to harvest at sustainable rates within both fully wild and cultivated wild leek populations. Once again, proper education is a vital aspect of this solution and would to ensure that cultivation is practiced in a responsible, sustainable way.

Lastly, the preservation of land containing wild leeks is a feasible solution. Preserving land that contains wild leeks is beneficial to wild leek populations within these protected areas. However, this could result in greater harvesting pressures elsewhere, to make up for the demand no longer served by populations on protected lands. Also, preserving land requires law enforcement, money, and continuous, non-patchy land areas. Local communities surrounding the preserved land must also cooperate with the rules and regulations put in place with regard to the preserved area. Conflicts could arise over the preserved land.

d. Identification of best solutions

The best solution for the problem facing wild leeks in New York State is a multifaceted one, incorporating the imposition of harvesting limits along with fines for disregarding these limits, the encouragement of sustainable wild leek cultivation for personal and commercial use, and the implementation of a public education aspect on plant conservation and cultivation practices for all those interested in harvesting or protecting the plant.

6. Ease of Implementation

To consider the ease of implementation of our solution, we will address any conflicts that may arise when our best solution is put into effect. Before any part of the solution can be implemented, it is vital that stakeholders understand why we need to regulate the harvesting of wild leek populations. Once people understand the detrimental effects of their unsustainable harvesting practices on wild leek populations and the resulting situation wild leeks are faced with,

they will be more likely to cooperate and to change their practices to be more in line with conservation efforts[10].

A major factor weighing into the success of any solution is the ability to meet the cost needed to implement it. Our best solution requires funding to issue harvesting permits, for public education, and to pay and support personnel who carry out various jobs, such as monitoring wild leek populations or working with government officials to pass legislation. Funding for education, personnel, and permit costs will initially have to come from the NYSDEC. As demand for wild leeks continues to grow, we anticipate a large number of permits to be requested, resulting in an influx of capital from permit fees. Income from harvesting fees can be used to support personnel and educational programs. However, further government funding will likely still be needed. We also see the need for educational programs diminishing over time as informed citizens reiterate the information they have learned to others.

With any kind of change, some form of opposition will follow. Thus, the greatest barrier to the implementation of our solution will be changing the mindset of stakeholders, especially wild leek harvesters. Many people grew up harvesting ramps from local wild populations without learning or seeing the negative impacts that over-harvesting can have. Educating those who consume wild leeks at roadside vendors or markets as well as restaurant owners and patrons will also be an important step to overcome opposition to our solution. The education component of our solution is aimed at teaching stakeholders that wild leeks are not infinite; they are a finite natural resource that requires management to maintain populations for future use. Through this education component we need to make sure that people understand that the policy is not aimed to

[10] Personal interview with Aswini Pai, May 4, 2012

eliminate the harvest of wild leek populations, but seeks to limit harvest to guarantee the persistence of populations.

Even with the knowledge that over-harvesting threatens wild leek populations, some harvesters feel that harvesting from wild populations is an important aspect of their traditional spring activities. Personal testaments from harvesters have revealed that many people see the activity of foraging in the woods as part of the 'allure' of harvesting wild leeks (Sen 2011). Some harvesters feel a sense of connectedness to their American ancestors when they enter the woods to collect their wild leek bounty. Foragers from well known wild leek areas feel that collecting wild ramps is a part of their mountain heritage (Blanchett 2002). For many, regulating harvests would dampen these feelings and cause this antique activity to feel more controlled and contemporary.

Another related group of people who may be opposed to our solution are those who attend annual ramp festivals. Similar to the feelings of traditional harvesters, festival-goers may also feel that ramps from wild populations are an integral part of the festivals and cannot be replaced by cultivated ramps. We seek to alleviate these negative feelings through public education that details why regulation is necessary to ensure that these traditions can persist.

Many festivals require thousands of wild leeks, which are normally collected from wild populations for no cost. Under our proposed solution, harvesting any ramps will require a permit, which will cost money and limit the number of ramps you can harvest from a single population. This presents an issue for many festivals that help support local fire companies, 4H clubs, and other community programs. In order to gather the large volume of ramps needed for a festival, a lot more time and money will be required than in the past, which will limit the funding available for community programs that previously benefited from fundraising efforts. For these

reasons, festival participants will most likely be opposed to our solution of regulating harvests with permits. However, our solution also encourages and provides the educational tools necessary to begin a cultivated population of wild leeks. There is the potential for festivals to cultivate their own populations of wild leeks that they can manage. Incorporating the cultivation of wild leeks into festivals could lead to greater involvement of the community and indirect education of sustainable harvest.

After implementation of our solution, it is likely that the supply of wild leeks will fall because private and/or commercial cultivation has not yet taken off. The supply could also be adversely affected by annual wild leek harvesters choosing not to forage because of the solution's permit requirements. High demand for wild leeks coupled with a low supply would likely cause prices to increase dramatically. Inflated prices would make illegal harvest more attractive to some, leading to an increase in unregistered harvesters working against what our solution is trying to establish. However, after a few years, when private and/or commercial cultivation have had a chance to catch up, wild leek supply will be able to meet the demand causing illegal harvest to no longer be profitable.

7. Step-by-Step Implementation Plan

New York State Department of Environmental Conservation (NYSDEC) has listed *Allium tricoccum var. burckii* as an endangered species that requires remedial action to prevent extinction. Although *Allium tricoccum* is not listed in NYS, it is listed as a species of least concern in Maine, Rhode Island, and Tennessee where it is also commercially exploited (Plant Profile 2012). Because there is the potential for overexploitation of *Allium tricoccum*, immediate action must be taken by NYS to conserve the species. Funding for these conservation efforts

should come from NYSDEC, as part of their mission statement includes the protection of natural resources and the environment (About DEC 2012).

Before we begin implementing our solution, stakeholders and the general public have to be educated as to why there is an issue, what exactly the issue is, and why it needs to be resolved. The most general way to broadcast information is on the Internet. A government web page would be very useful to discuss the problem and our proposed solution. Since the NYSDEC already has a section of its website devoted to permit regulations and questions, a page for wild leek permits could easily be added. The webpage would detail permit requirements, restrictions and regulations, as well as supply comprehensive information on how to begin a personal or commercial cultivated population of wild leeks. Harvesting limits for wild populations and harvesting suggestions for cultivated populations along with harvesting techniques would be included in the information provided. For those who harvest wild leeks but do not have access to the NYSDEC website, it would also be helpful to provide informational classes on wild leek harvesting at local community events, such as ramp festivals. Efforts must be made to reach the widest audience possible. If the funds were available, it would even be advisable to produce informational flyers to be distributed through the mail in areas with high densities of wild leek populations or in areas particularly susceptible to over-harvesting. These flyers could also include information on how to cultivate wild leeks, in an effort to increase the number of participants working within this part of our solution.

Once stakeholders are knowledgeable on the issue and understand that management of wild populations is necessary for the persistence of wild leeks as a species, we can implement our plan to require permits for harvest from wild populations. By working with the NYSDEC we will be able to outline permit requirements and limitations, define a set harvesting season,

and develop guidelines for personal and/or commercial cultivation. Through the NYSDEC, our solution can be translated into a state law affecting all wild leek populations in the State of New York.

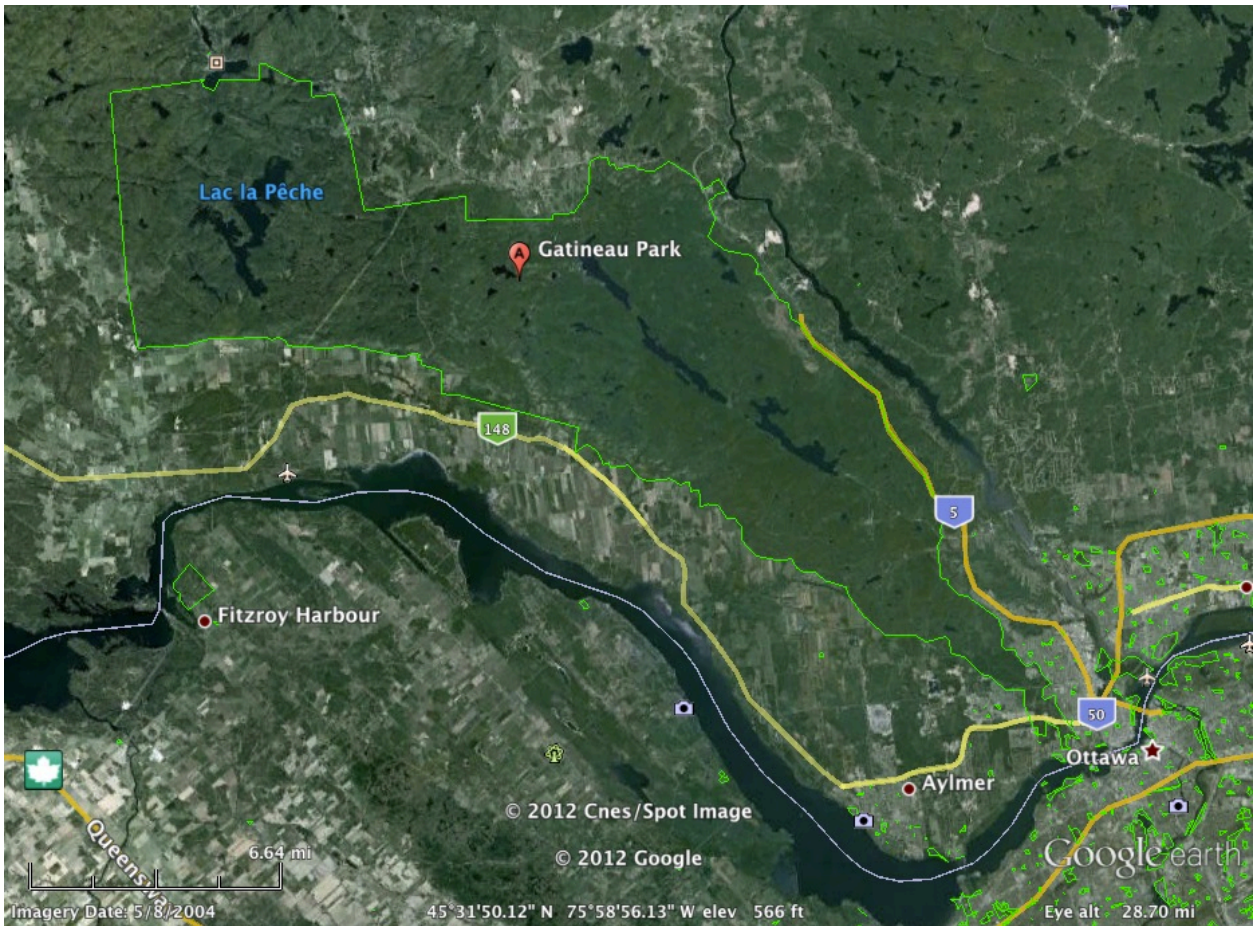
Monitoring wild populations of ramps will be a difficult task, but knowing where and what size populations are will help. Determining possible locations of wild ramp populations requires Geographical Information Systems (GIS) analysis of forest type, elevation, slope, and other habitat characteristics to find suitable habitats for wild leeks. Once a state-wide map of suitable habitat is created, it will be necessary for either paid personnel or volunteers to check each site for the presence or absence of wild leeks. If a population is present, surveyors must note characteristics such as the size and accessibility of the population. This information will be crucial to the monitoring of wild populations of ramps.

To monitor the permit and cultivation status, personnel such as rangers must be hired. The NYSDEC already employs Environmental Conservation Police Officers (ECOs) and park rangers whose jobs could be extended to include wild leek monitoring and permit issuing. Monitoring remote populations may require special gear and technologies that will have to be purchased with government funding. There is the potential for local volunteers to get involved and to help with monitoring of wild populations in their area, which would also cut costs to some degree. However, the majority of costs will have to be covered by government conservation funding. But, as stated before, once permits are implemented, the money raised can be used to supplement governmental funding.

The final step in the implementation of our solution would be to encourage personal and commercial cultivation in northern New York. Along with the NYSDEC's website, which will

detail cultivation regulations and practices, economic incentives or product certifications could be put into effect to boost the appeal of cultivation.

Appendix



(Google Earth 2012)

FIG 6. Google Earth image shot of Gatineau Park, located in the province of Quebec, Canada. Green lines indicate the park boundaries. Yellow lines are major roadways.

Citations

"About DEC." *New York State Department of Environmental Conservation*. New York State Department of Environmental Conservation, 2012. Web. 8 May 2012.

"Allegheny Leek Belt. The Nature of the "Wild Onion" and Its Relation to Cattaraugus County

Names." *The New York Times* 3 Sep. 1899. Archives.

"As the ramps sprout, so do new rules." *The Washington Post*. The Washington Post Company, 3 May 2005. Web 1 Apr. 2012. <http://www.washingtonpost.com/wp dyn/content/article/2005/05/02/AR2005050201310.html>

Blanchett, S. 2002. Park Service declines to revisit ban on harvesting ramps. [Internet]. 2002 May 3 [cited 2012 April 7]. The Newport Plain Talk. Available from http://newportplaintalk.com/story/4731.

Cavender, A. 2006. Folk medical uses of plant foods in southern Appalachia, United States. Journal of Ethnopharmacology 108:74-84.

Chamberlain, J; Bush, R.; and Hammett, A.L. 1998. Non-timber forest products. Forest Products Journal 48(10):10-19.

Chapman, Sasha. 2005. Quantum Leeks. Toronto Life 39(4):85-86.

Core, Earl L. 1945. Ramps. Castanea 10(4):110-112.

Davis-Hollander, Lawrence. Ramps (wild leeks): when is local not kosher? *Grit*. 1 Apr. 2011. Web. 1 Apr. 2012. <http://www.grit.com/from-the-ethnobotanist/ramps-wild-leeks.aspx.>

Davis, J.M. and J. Greenfield. 2002. Cultivating ramps: Wild leeks of Appalachia. p. 449-452. In: J. Janick and A. Whipkey (eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA.

Feiring, Alice. 2006. "Into the woods, on the trail of the wild leek." *New York Times.* New York Times, 14 Apr. 2006. Web. 1 Apr. 2012. <http://travel2.nytimes.com/2006/04/14/travel/escapes/14ramps.html

Fernald, M. L. and A.C., Kinsey. 1943. Edible Wild Plants of Eastern North America. Idlewild Press, NY, pp. 126-129.

Flickriver. 2012. "Gormet tags". Web. 8 May 2012. <http://www.flickriver.com/photos/tags/gormet/interesting/>

Fowler, John T. 2012. "Galleries". John Fowler, 2012. Web. 24 April 2012. <http://johnfowler.photoshelter.com/gallery-list>

Gabris, Linda. 2000. The leeks of summer. Ontario Out of Doors 32(7):22

Gibbons, E. 1962. Stalking the Wild Asparagus. David McKay Company, Inc., NY, pp. 157 -159.

Given, D. R. 1994. Principles and Practice of Plant Conservation. Timber Press, OR.

Google Earth. 2012. Google Earth image shot. Web. 8 May 2012.

Greenfield, J. and J. M. Davis. 2001. Cultivation of ramps (Allium tricoccum and A. burdickii). NC State University: Horticulture Information Leaflets. Web. 5 Apr. 2012. <http://www.ces.ncsu.edu/depts/hort/hil/hil-133.html>

Hamilton, A. and P. Hamilton. 2006. Plant Conservation: An Ecosystem Approach. Earthscan, VA.

Hamilton, Graeme. 1994. Wild leek, alpine fern first to make province's list of endangered species. *The Gazette* A1.

Hoyle, Z. 2003. How Many Ramps Do you Need for a Festival? United States Department of Agriculture - Forest Service Web 7 Apr. 2012 <www.srs.fs.usda.gov/news/97>

Hoyle, Z. 2004. Are ramp festivals sustainable? United States Department of Agriculture - Forest Service. Web 4 Apr. 2012. <http://www.srs.fs.usda.gov/news/65>

Jones, Almut G. 1979. A study of wild leek, and the recognition of *Allium burdickii* (Liliaceae). Systematic Botany 4(1):29-43.

Land, L. "Ramps - finding, picking, cooking (and planting!)" *Leslie Land in kitchen and garden and all around the house*. Leslie Land, 27 Apr. 2010. Web. 24 Apr. 2012.

Legault, Rita. 2003. Popularity threatens wild leeks: take a few, leave the rest, suggests conservationist. Record 1.

Mann, Jeff. 2002. RAMPS. Appalachian Journal 29(3):343.

Miller, KE., and D.L. Gorchov. 2004. The invasive shrub, *Lonicera maackii*, reduces growth and fecundity of perennial forest herbs. Oecologia 139:359-375.

Moyer, Ben. 2008. Ramps bring signs of spring throughout Appalachia; wild leek festivals signal the start of the season. Pittsburgh Post - Gazette B1.

Nantel, P., D. Gagnon, and A. Nault. 1996. Population Viability Analysis of American Ginseng and Wild Leek Harvested in Stochastic Environments. Conservation Biology 10:608-621.

Natural and Cultural Observations in and around Hawthorne Valley. 2011. "Monthly Archives: 2011". Web. 24 April 2012. <http://hvfarmscape.wordpress.com/2011/04/>

Nault, A. and Gagnon, D. 1993. Ramet demography of Allium tricoccum, a spring ephemeral, perennial forest herb. Journal of Ecology 81:101-119.

Pickowicz, Natasha. 2011. Precious and dwindling: Quebec's wild leeks. The Gazette.

"Plant Profile: *Allium tricoccum* Aiton ramp". *United States Department of Agriculture Natural Resources Conservation Service*. United States Department of Agriculture, 8 May 2012. Web. 8 May 2012.

Prairie Moon Nursery, Inc. "*Allium tricoccum* (wild leek)". Prairie Moon Nursery, 2012. Web. 24 April 2012. <http://www.prairiemoon.com/seeds/wildflowers-forbs/allium-tricoccum-wild leek/>

"Proposed Part 193.3, Protected Native Plants." *New York State Department of Environmental Conservation*. New York State Department of Environmental Conservation, 2012. Web. 4 Apr. 2012.

Robbins, C. 1997. U.S. medicinal plant trade studies. TRAFFIC Bulletin 16 (3), 121–124.

Rock, J., B. Beckage, and L.J. Gross. 2004. Population recovery following differential harvesting of Allium tricoccum Ait. in the southern Appalachians. Biological Conservation 116:227-235.

Rothstein, D.E. 2000. Spring ephemeral herbs and nitrogen cycling in a northern hardwood forest: an experimental test of the vernal dam hypothesis. Oecologia 124:446-453.

"SEM'AIL: public seeding program for wild leek in Quebec." *Montreal Biodome*. Ville De Montreal, 20 Apr. 2010. Web. 4 Apr. 2012.

Sen, I. "When digging for ramps goes too deep." *New York Times*. New York Times, 19 Apr. 2011. Web 23 Feb. 2012. <http://www.nytimes.com/2011/04/20/dining/20forage.html >

Shanley, P.; Pierce, A. R.; Laird, S. A. and G. Abraham, eds. 2002. Tapping the Green Market: Certification and Management of Non-Timber Forest Products. Sterling: Earthscan Publications Ltd.

Spears, Tom. 1990. "Threatened: NCC moves to plug leak of wild leeks". *The Ottawa Citizen* C4.