Forest Farming in Missouri

An Overview of the Production of Non-Timber Forest Products

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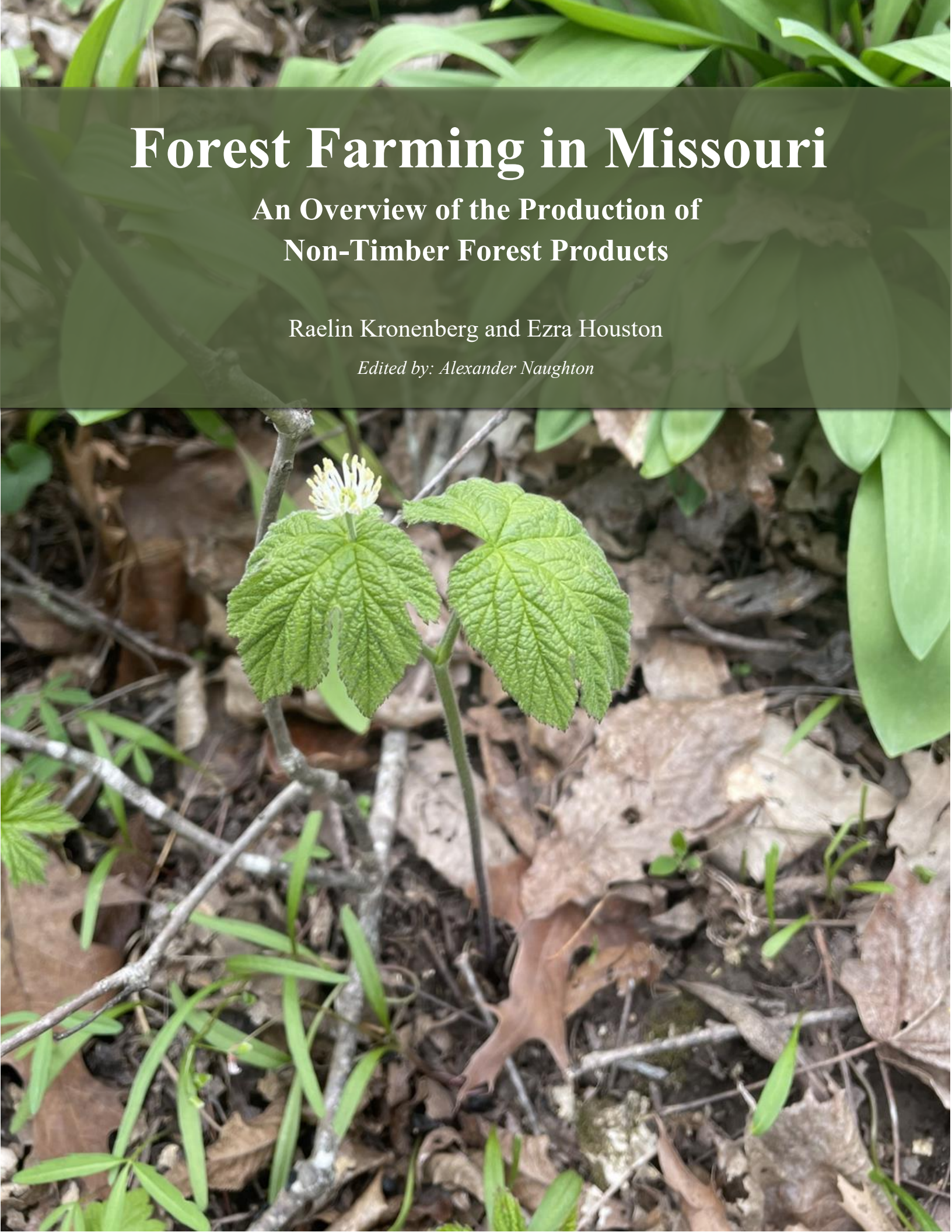

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*Cover image of goldenseal *(Hydrastis canadensis*) in flower among spring beauties, *Claytonia virignica* (foreground) surrounded by a patch of ramps (*Allium tricoccum*).

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Ramps (*Allium burdickii*)

Background of Agroforestry

Most modern approaches to land management divide land into distinct areas based on specific uses. A common example is zoning, which designates parcels of land for residential, commercial, or agricultural purposes. This separation of uses creates a patchwork landscape made up of urban development, agricultural production, and natural or undeveloped areas. Unfortunately, this separation of land use rarely allows landscapes to reach their full potential. In contrast, agroforestry is guided by the idea that "the whole is greater than the sum of its parts." Agroforestry is a suite of practices that intentionally integrate trees and shrubs into crop and livestock production systems. The overarching goal of agroforestry is to integrate land uses to provide multiple goods and services. Agroforestry has the potential to support farm income while also improving human well-being, wildlife habitats, and ecosystem services. Agroforestry refers to a range of practices that integrate trees with crops and/or livestock in perennial agricultural systems. The six main practices include riparian forest buffers, windbreaks, silvopasture, alley cropping, forest farming, and urban food forests. This guide focuses on the practice of forest farming as an approach to producing a variety of specialty products while supporting forest health.

What is Forest Farming?

Forest farming is an agroforestry practice that focuses on growing understory specialty crops, otherwise known as non-timber forest products (NTFPs), beneath a forest canopy (Chamberlain et al., 2009). These understory crops include culinary or medicinal herbs, woody plants, fungi, tree syrups, vines, and mosses (Jones & Lynch, 2007; Mudge and Gabriel, 2014). These crops make up a variety of products, including food, medicine, landscaping materials, and crafts, such as basket making or floral arrangements. Unlike foraging or wild crafting, forest farming involves the intentional cultivation of plants and the direct management of the forest canopy and understory to promote the growth of desired NTFPs. Interest in forest farming has steadily increased among landowners in both rural and urban settings due to its wide range of applications and ability to produce a variety of products. This guide will focus on the best practices for establishing a productive forest farm to provide farmers with additional income

Forest-grown goldenseal at the United Plant Savers Sanctuary (Top, Credit: Raelin Kronenberg) and shiitake mushroom logs resting in shady woods at the Lincoln University Alan T. Busby Research Farm (Bottom, Credit: Raelin Kronenberg)

while supporting forest health. It is important to note that forest farming is not a "get rich quick" scheme but a low-input production system that has the potential to generate income over the course of multiple growing seasons while encouraging active stewardship of forested land.

Non-Timber Forest Products

Non-timber forest products, commonly referred to as NTFPs, are high-value specialty products grown in a forest, including plants produced for food, medicine, landscaping, and crafts (USDA, 1997; Chamberlain & Predny, 2003). Examples of NTFPs grown for medicinal use include perennial herbs such as ginseng, goldenseal, and black cohosh. These species are sold as whole roots (fresh or dried) or made into "value added" products, such as medicinal and dietary supplements used for their therapeutic value. There are also several edible NTFPs that are sought after by restaurants, including a variety of mushrooms, ramps, ostrich fern, and pawpaw. NTFPs do not include dimensional lumber but can include specialty wood products for craft or ornamental use such as basket willow and red-stemmed dogwood. See table 1 below for a list of common NTFPs.

Benefits of Forest Farming

Box of assorted mushrooms
(Credit: Center for Agroforestry)

Forest farming can provide multiple benefits for the farmer, wildlife, forest health, and broader ecosystem. Active management of the forest can help to maintain and even enhance ecosystem function through nutrient cycling and increased diversity, improving wildlife habitats and boosting overall forest productivity (USDA, 1997; FAO, 2017). In turn, this provides opportunities for the provision of important goods including food, fuel, fibers, building materials, medicine, and raw craft supplies (Jones & Lynch, 2007). The production of NTFPs is a notable portion of the US forest economy, with their estimated value in the tens of billions (Vaughan et al., 2013). Growing a variety of non-timber forest products (NTFPs) allows landowners to diversify their income sources and potentially increase overall earnings, while also spreading out management efforts and revenue generation throughout the year. Additionally, landowners gain a greater appreciation for their forest through the process of stewardship. Beyond the benefits of producing consumable goods that can increase on-farm income, research studies have found evidence of the mental,

emotional, and spiritual benefits of spending time in forests and working closely with nature (Oh et al., 2017).

Table 1: Some NTFPs native to/commonly grown in Missouri.

Species	*Parts Used*	*Use Type*
American ginseng (*Panax quinquefolius*)	Rhizome, leaf	Med, Orn
American persimmon (*Diospyros virginiana*)	Fruit	Ed
Black cohosh (*Actaea racemosa*)	Rhizome	Med, Orn
Black walnut (*Juglans nigra*)	Fruit, sap, hulls	Ed, Med
Bloodroot (*Sanguinaria canadensis*)	Rhizome	Med, Orn
Blue cohosh (*Caulophyllum thalictroides*)	Rhizome	Med, Orn
Elderberry (*Sambucus canadensis*)	Fruit	Ed, Med, Orn
Goldenseal (*Hydrastis canadensis*)	Rhizome, leaf	Med, Orn
Mayapple (*Podophyllum peltatum*)	Root, leaf	Med, Orn
Ostrich fern (*Matteuccia struthiopteris*)	Crozier	Ed, Orn
Oyster mushroom (*Pleurotus spp.*)	Fruiting body	Ed
Pawpaw (*Asimina triloba*)	Fruit	Ed, Orn
Ramps (*Allium tricoccum*)	Whole plant	Ed
Sassafras (*Sassafras albidum*)	Bark, leaf	Ed, Med
Shiitake mushroom (*Lentinula edodes*)	Fruiting body	Ed
Slippery Elm (*Ulmus rubra*)	Bark	Med
Solomon's seal (*Polygonatum biflorum*)	Rhizome	Ed, Med, Orn
Stoneroot (*Collinsonia canadensis*)	Rhizome	Med, Orn
Sugar maple (*Acer saccharum*)	Sap	Ed, Orn
Trillium (*Trillium spp.*)	Rhizome	Med, Orn
Virginia snakeroot (*Aristolochia serpentaria*)	Root	Med
Wild geranium (*Geranium maculatum*)	Rhizome	Med, Orn
Wild ginger (*Asarum canadense*)	Rhizome	Med
Wild yam (*Dioscorea villosa*)	Tuber	Med, Orn
Witch-hazel (*Hamamelis virginiana*)	Bark	Med, Orn

Key: Ed=edible, Med=medicinal, Orn=Ornamental

A Brief History of Forest Farming

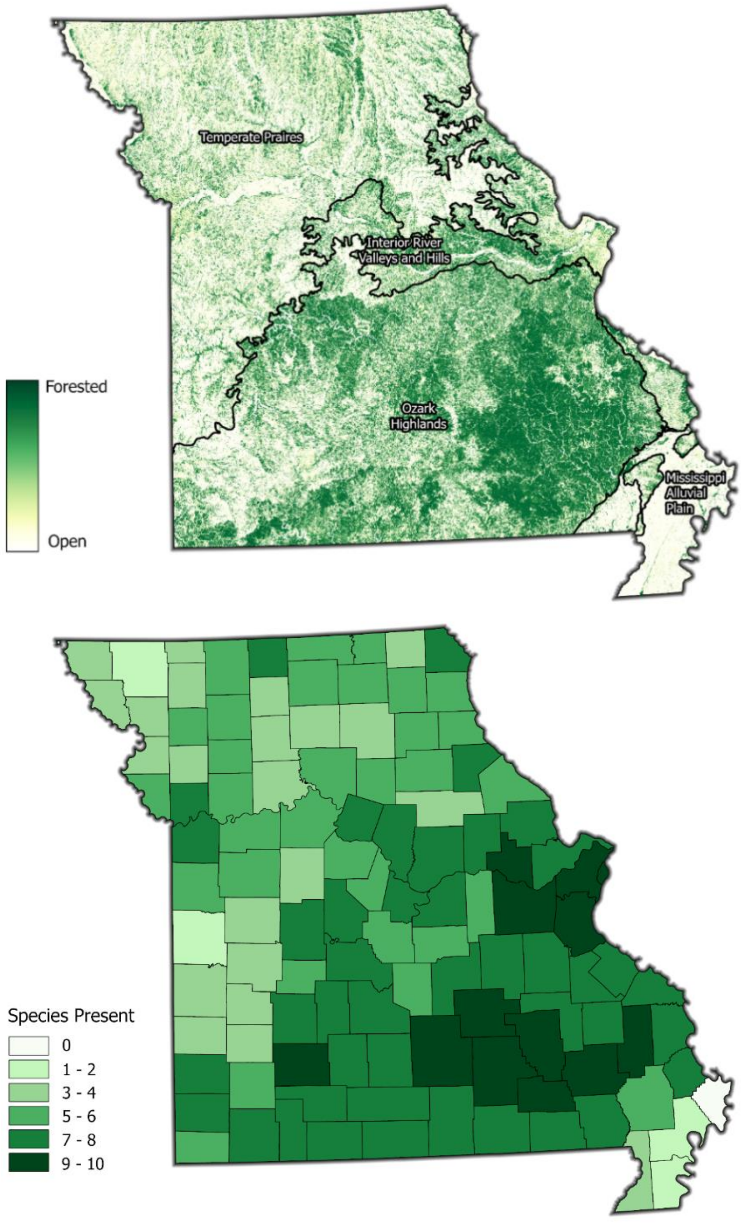
Agroforestry practices, including forest farming, have been used by many cultures to supply food, fuel, building materials, and medicine (Nair, 1993; Smith, 2010). Indigenous peoples have practiced versions of forest farming and forest management for centuries. They applied a variety

of cultural practices, such as burning, bark ringing, seed dispersal, and propagation to encourage the landscape to produce greater quantities of the plants and animals they relied upon for food, building, craft materials, and medicine (Wiersum, 1997). Throughout the 20th and 21st centuries, many species of NTFP are increasingly scarce in the wild due to a combination of overharvesting and habitat loss. This development has led to a resurgence in forest farming as part of a comprehensive approach to conservation ("conservation through cultivation"), as well as an opportunity to diversify farm economics among small specialty crop farmers.

Forest Farming in the Context of Missouri

In the United States, the practice of forest farming has traditionally been rooted in the Appalachian Mountains, where rugged landscapes limit the practicality of large-scale agriculture. However, many marketable species of NTFPs are also native to Missouri and the Midwestern US. In this region, fertile soils and gentle topography have resulted in the conversion of previously forested areas into open fields and pastures. In much of the Midwest, forested habitats, and consequently forest herbs, are confined to small patches of land that have been deemed "marginal" for agriculture. Fortunately, Missouri retains relatively large tracts of contiguous forested habitat in the rugged Ozark Highlands and in the hills along the Missouri and Mississippi rivers. These regions are ideal for forest farming.

That is not to say that NTFPs cannot be grown in other parts of the state in small, fragmented woodlots. These fragments are crucial to the health and connectivity of the overall



Forest cover in Missouri by ecoregion (Top) and the combined natural distributions of 10 NTFPs native to Missouri (Bottom)

landscape. Forest farming can be successful in woodlots as small as half an acre with active management, including invasive plant species control, re-introduction of native plant species, and, sometimes, even thinning and burning. For farmers with small woodlots, forest farming is a way to incorporate their forest into the overall farm operation, increasing productive land and the health of their farm ecosystem.

Approaches to Forest Farming

There are three main approaches to forest farming: wild-stewarded, wild simulated, and woods-cultivated. These methods differ in intensity of plantings, input levels, and management effort (Frey et al., 2021). Note that these approaches exist along a spectrum, and many farmers use intermediate approaches or combinations depending on their goals and situations.

Wild-stewarded forest farming is the lowest intensity approach and relies on species or products already present in a forest. It does not involve tilling or the addition of soil amendments. Generally, there is also no need to change the density of the forest canopy. This approach to forest farming focuses solely on the sustainable harvest and propagation of existing populations of non-timber forest products. Wild-stewarded forest farming is often practiced with ginseng, goldenseal, ramps, or other high value forest herbs. Successful wild stewardship requires knowledge of the crop plant's lifecycle and reproduction strategies to determine appropriate

A wild-stewarded population of ramps (Left, Credit: Ezra Houston), and wild-simulated planting of goldenseal (Right, Credit: Raelin Kronenberg)

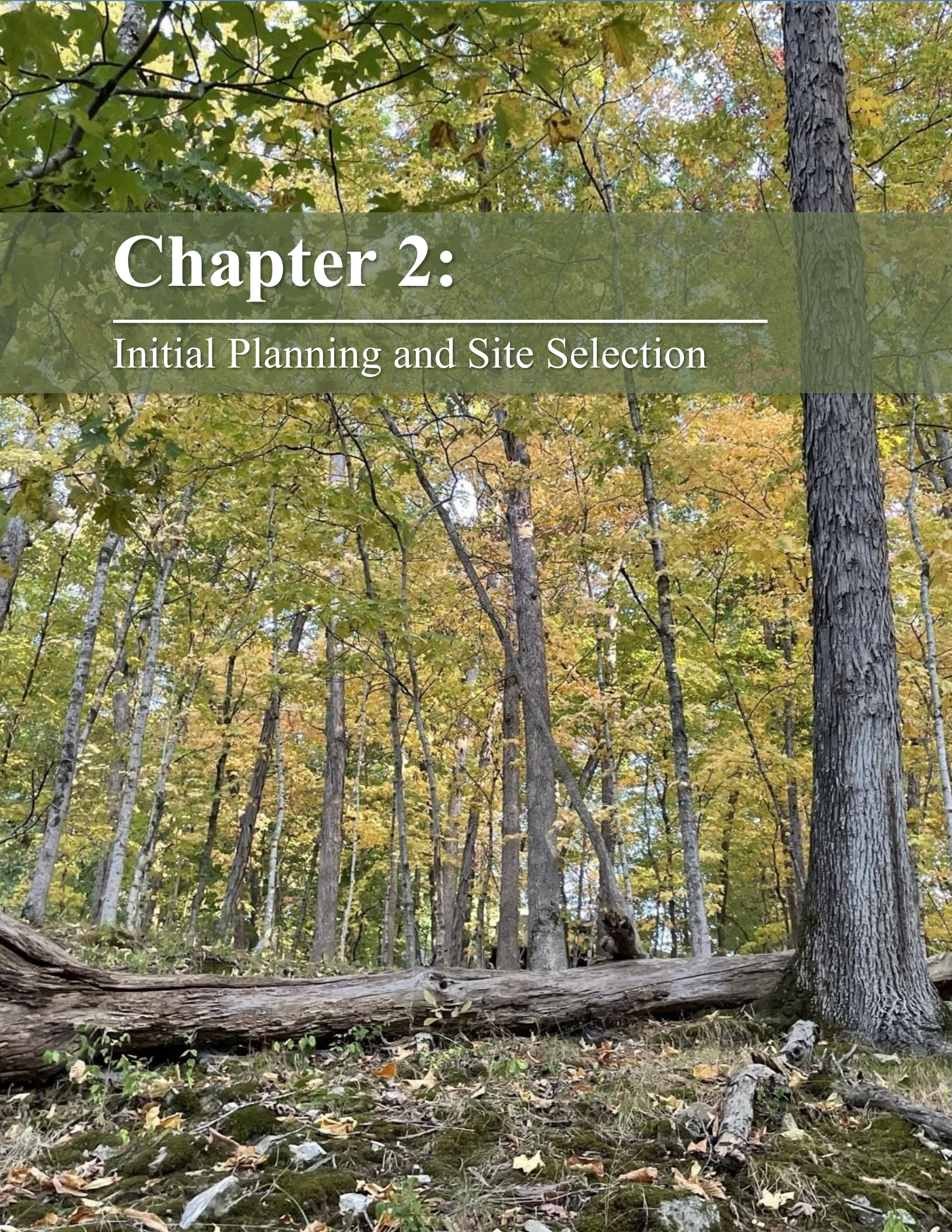
sustainable harvest levels. For example, wild ramps can be sustainably harvested down to a fixed density of 44-88 plants per square meter, or roughly 4-8 plants per square foot (Dion et al., 2016). Practitioners of wild-stewarded farming encourage reproduction through husbandry practices such as replanting seeds or dividing bulbs or rhizomes to augment populations of their desired crop species.

Wild-simulated forest farming is a slightly more intensive approach than wild-stewardship and involves the planting and establishment of NTFPs which are not already growing on a site. Plantings aim to mimic how the species would naturally propagate and grow in the wild. The wild-simulated approach can involve site preparation, particularly through thinning midstory shrubs and trees to reduce competition, but overstory thinning and inputs such as soil amendments are minimal. This approach is generally inexpensive; other than labor, the only initial cost comes with purchasing planting stock. Many farmers will start with this approach to experiment with forest farming as it carries fewer expenses than other, more intensive practices. Proper site selection is crucial in wild-simulated plantings because growing conditions are typically not optimized with soil additives, fertilizers, and tilling. However, one benefit of this production approach is that some wild-simulated NTFPs carry a price premium because they have similar characteristics to wild products. For example, wild-simulated American ginseng is highly prized in Asian markets and among some communities of Asian Americans for its quality and potency compared to that of woods-cultivated or field-grown American ginseng.

Woods-cultivated forest farming is the most production-oriented approach, requiring more intensive management and a larger initial investment than wild-simulated production. Generally, this approach involves building raised beds or lightly tilling the soil, adding soil amendments, active pest control, and closer plant spacing. The goal of more intensive management is to increase growth rates and optimize yields. It is best suited to sites where growing conditions are sub-optimal, or for producing NTFPs which do not carry price premiums for wild characteristics. Planting density is often higher in

Preparing simple woods-cultivated beds for forest farming (Credit: Raelin Kronenberg)

woods-cultivated production systems than in wild-simulated systems, leading to greater disease pressure and pest problems. Some forest farmers plant polycultures of complementary NTFPs (such as American ginseng and goldenseal) to reduce this pressure and increase the resilience of the system. If the forest farm is meant to produce a supplementary income, careful consideration of the management approach and the quantity and value of the resulting NTFPs should be given before planting.



Chapter 2:

Initial Planning and Site Selection

Walk, Don't Run

Establishing a forest farming operation takes time and experience. By going slow and being thorough in the planning and implementation phases, significant loss of time, money, and plants can be avoided. When experimenting with new crops, it is critical to keep careful records of dates, weather/climate, and the successes and failures of different species, techniques, and sites. Planning is especially crucial when working with plant species that are slow to germinate and produce. Some NTFP species can take upwards of 18 months from planting to germination and require several more years before they are ready to harvest. Tracking what works and what doesn't will help you develop successful techniques and determine which crops to focus on. For some protected species such as American ginseng, proper documentation is essential if the landowner wishes to eventually sell any of the plant material.

Site Selection Overview

Selecting a site that is appropriate for the NTFPs you want to grow is important for a successful operation, particularly if you plan to use a low input approach such as wild-simulated production. A poorly chosen site can cause even the most well-intentioned and managed plantings to fail. While growing sites can be evaluated at any time of the year, it is important to keep in mind sites can change significantly with the seasons. For example, some sites may be prone to flooding in the spring or become very dry in late summer. It is best to examine potential planting locations multiple times throughout the year to understand these seasonal fluctuations (Rural Action and United Plant Savers, 2019). There are several key factors to consider when selecting a site: slope position and aspect, soil characteristics, forest structure, and the presence of indicator species. These factors are interrelated; slope position and aspect influence soil characteristics, which in turn influence forest structure and what species are growing there. Lastly, it is important to consider the accessibility of your site from an operational standpoint.

Slope Position and Aspect

Slope position and aspect (the direction the slope faces) are often the first considerations in site selection. Interestingly, many commonly grown species of NTFPs have similar habitat preferences: cool sites with moist, but well-drained soil. Typically, lower topographic positions with gentle slopes are preferred because they tend to retain more moisture than steeply sloping uplands. Gentle slopes allow for some drainage, reducing the risk of fungal infection and root rot. Some species, such as ramps and ostrich ferns, can handle flatter bottomland areas with periodic inundation and more persistent moisture. When planting on a slope, north and east facing aspects are ideal because they are cooler and moister than south and west facing slopes, which receive more direct sunlight during the hottest part of the day.

Soils

Ideal soils for forest farming are deep, moist, loamy, and fertile, with slightly acidic pH and high levels of organic matter. These characteristics can be determined through careful observation, but soil texture and nutrient tests can be used to confirm observations and provide specific recommendations for soil amendments. Basic soil tests for pH and key soil nutrients such as calcium, magnesium, potassium, and phosphorous are relatively inexpensive and available from local NRCS offices or universities extension offices. Generally, soils for an optimal forest farming site have the following characteristics:

- At least 10% organic matter
- At least 95 lbs./ac available phosphorous
- At least 2500 lbs./ac available calcium, but optimally more than 3000 lbs./ac
- Calcium-to-Magnesium ratio of 5:1 or greater
- pH between 5.0 – 7.0

Loam soils are most likely to fall within these ranges of characteristics and have the added benefit of providing optimal water holding capacity. Loams consist of a roughly even mixture of sand, silt, and clay, which keeps them from drying out too quickly or from holding water for too long, allowing plants to access the resources they need to grow without harboring fungal pathogens. To quickly determine texture, take a handful of slightly moist soil and squeeze it into a ball. If it holds shape but crumbles easily when poked, it is a loamy soil. Sandy soil will not hold shape well, while clay soils will not crumble if moist.

A great place to start when assessing the soil of your forested site is the NRCS Web Soil Survey tool available online at https://websoilsurvey.nrcs.usda.gov/app/. With this tool, you can zoom into your property, delineate an area of interest, and view readouts of the soil characteristics within that area based on data collected by the National Cooperative Soil Survey over the last hundred years. This tool is not perfect, however, as this data focuses on describing agricultural sites rather than forested sites. Soil survey data is best used as a starting point or supplementary tool to inform field observations and soil testing.

Forest Structure

Forest structure has a strong influence on microclimate conditions present in the understory. It is often a product of successional status, a term which refers to the stages of a forest's growth and development through time. Young forests tend to be dominated by shade-intolerant tree species which grow fast, shed their lower branches quickly, and maintain a sparse, tall canopy. As the forest develops, shade-tolerant trees establish a foothold and grow slowly up through the midstory of the forest until finally reaching the canopy. Shade-tolerant species often retain their

lower branches for longer, casting a dense shade beneath them. Many NTFPs are herbaceous species adapted to these shady understory conditions. For example, American ginseng, blue cohosh, and Solomon's seal grow well in 70-80% shade. However, some NTFPs, such as black cohosh, will do well in slightly sunnier conditions of around 60-70% shade. Apsley and Carroll (2013) share a quick way to get a rough estimation of canopy shade using paper plates:

> "A quick method to approximate the amount of shade that is on a given site is to place 10 or more white paper plates at even distances on the ground at approximately noon on a sunny summer day. Count the number of plates that are at least half-shaded. Next, divide the number of shaded plates by the total number of plates placed on the ground. Multiply this number by 100."

Indicator Plants

Plant communities provide information about the characteristics of the site where they are growing. Tree species such as sugar maple (*Acer saccharum*), basswood (*Tilia americana*), walnut (*Juglans nigra*), bitternut hickory (*Carya cordiformis*), slippery elm (*Ulmus rubra*), and ash (*Fraxinus americana*), and shrub species such as spicebush (*Lindera benzoin*) and pawpaw (*Asimina triloba*) tend to grow in rich and mesic but well drained soils, which are ideal for forest farming. Species composition also influences microsite conditions on a site, including available light reaching the forest floor and characteristics of the leaf litter. The species listed above have thin leaves which decompose quickly, releasing calcium into the upper soil horizon and improving the soil quality (Rural Action and United Plant Savers, 2019).

The understory species composition can also serve as an indicator of site quality. The best indication that a site will support a particular NTFP is if the NTFP already grows there, however, other herbaceous understory plants can serve as indicators of high-quality forest farming sites. Useful understory indicators that are not commonly grown as NTFPs include: Jack-in-the-pulpit (*Arisaema triphyllum*), rattlesnake fern (*Botrypus virginianus*), maidenhair fern (*Adiantum pedatum*), Christmas fern (*Polystichum acrostichoides*), Dutchman's breeches (*Dicentra cucullaria*), cut-leaf toothwort (*Cardamine concatenata*), Virginia spring beauty (*Claytonia virginica*), white baneberry (*Actaea pachypoda*), sharp-lobed hepatica (*Hepatica acutiloba*) and others. Figure 1 provides an overview of different forests based on their overstory tree species and soil conditions along with some suggested NTFP species that would grow well within each forest type.

From left to right: Wild ginger (Asarum canadense) among sharp-lobed hepatica (Hepatica acutiloba); mayapple (Podophyllum peltatum) in flower; and goldenseal (Hydrastis canadensis) with berry (Credit: Raelin Kronenberg)

Table 2: Some indicator species for suitable NTFP growing locations in Missouri.

Overstory Trees	*Understory Herbaceous Perennials*
Sugar maple (*Acer saccharum*)	Jack-in-the-pulpit (*Arisaema triphyllum*)
American basswood (*Tilia americana*)	Rattlesnake fern (*Botrypus virginianus*)
White ash (*Fraxinus americana*)	Maidenhair fern (*Adiantum pedatum*)
Black walnut (*Juglans nigra*)	Dutchman's breeches (*Dicentra cucullaria*)
Bitternut hickory (*Carya cordiformis*)	Squirrel corn (*Dicentra canadensis*)
Slippery elm (*Ulmus rubra*)	Virginia spring beauty (*Claytonia virginica*)
Northern red oak (*Quercus rubra*)	Virginia bluebells (*Mertensia virginica*)
White oak *Quercus alba*)	Hairy sweet cicely (*Osmorhiza claytonii*)
Shagbark hickory (*Carya ovata*)	Christmas fern (*Polystichum acrostichoides)*
Midstory Shrubs	Cut-leaf toothwort (*Cardamine concatenata*)
Pawpaw (*Asimina triloba*)	White baneberry (*Actaea pachypoda*)
Spicebush (*Lindera benzoin*)	Sharp-lobed hepatica (*Hepatica acutiloba*)
American elderberry (*Sambucus canadensis*)	Trillium species (*Trillium spp*.)
Gooseberry (*Ribes spp.*)	Wood nettle (*Laportea canadensis*)

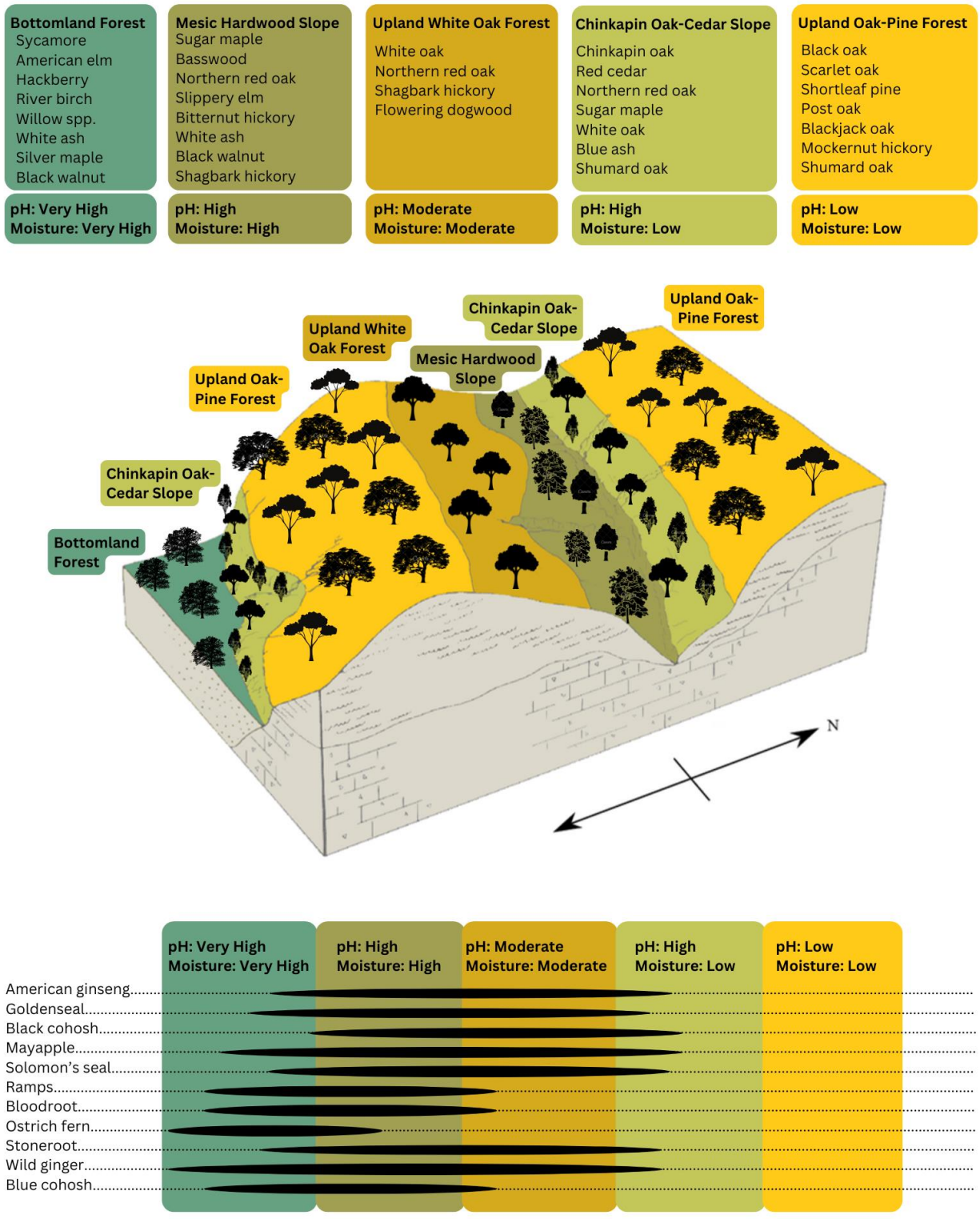


Figure 1. A generalized scheme of forest types and their positions throughout the landscape, along with habitat requirements for some common NTFPs in Missouri.

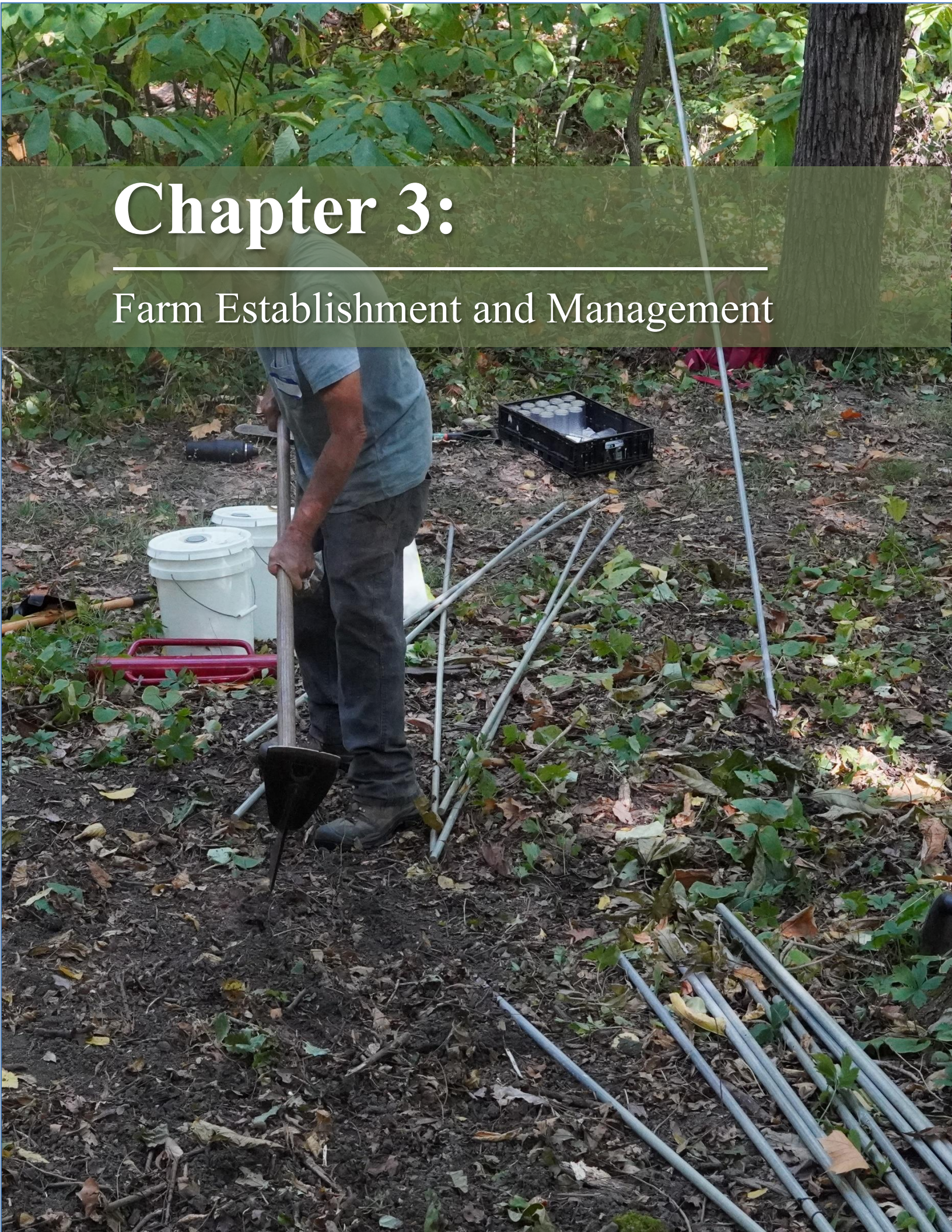
Accessibility Considerations

Accessibility is an important but sometimes overlooked factor when selecting appropriate planting sites. This is especially true when using a woods-cultivated approach with regular management. Being able to reach the planting site easily by foot or vehicle ensures plantings can be monitored for pest or disease problems, water and other supplies can be brought to the site, and harvested plants can be easily transported out. Depending on the size of the plantings, consideration should be given to spacing beds in a manner that allows an ATV or other vehicle to navigate through the area, making checking on and harvesting plants easier.

Unfortunately, forest farmers must also consider the potential threat of poaching, whether intentional or accidental. American ginseng and other forest herbs have a history of wild harvest from the "forest commons" that persists in some places today. Additionally, these plants can have high market value and take a long time to grow, which encourages foraging and wild harvesting. These traits make theft somewhat common, particularly for American ginseng. Some simple ways to reduce the potential of NTFPs being poached include installing fencing, keeping the location of plantings secret, or telling trusted neighbors who can watch for suspicious activity. Choosing a planting site away from main roads and publicly accessible land can greatly reduce the chance of poaching or accidental harvest by foragers.

Chapter 3:

Farm Establishment and Management



Site Preparation and Planting

Before planting can occur, some level of site preparation will be necessary. Depending on the approach used, site preparation intensity will differ. For wild-simulated plantings, there is generally very little preparation. Meanwhile, more intensive methods of site preparation are often necessary in woods-cultivated production approaches or where site characteristics are marginal for forest farming.

The first step when preparing a forest farming site is ensuring favorable light conditions for the desired NTFP species. This is typically accomplished by clearing competing vegetation in the midstory and understory but can sometimes involve thinning the overstory. Not all sites will require thinning depending on the current canopy structure and light levels at the forest floor. Many farmers engaged in wild-simulated production do minimal management, focusing on removing weedy or invasive plant species while leaving the overstory alone. Woods-cultivated producers often engage in more intensive management which includes clearing a large area of all the competing midstory vegetation and thinning some overstory trees to provide optimal light levels. Landowners who are interested in timber production may even consider compatible silvicultural treatments such as single tree or crop tree release. These types of select cut timber harvests can be an excellent way to produce supplementary income from the woods until NTFP production begins.

It may be necessary to amend soil on sites that lack certain nutrients. Calcium is the most common soil amendment used by forest farmers due to the high calcium requirements of many NTFPs (Persons and Davis, 2005; Davis and Greenfield, 2001). In soils with low pH and low calcium content, slaked lime can be used to increase both. In soils which have optimum pH levels, but which require more calcium, gypsum can be used instead. Overly basic soil can be amended with sulfur. Rather than using mineral fertilizers, many farmers prefer to amend their soil with organic materials that they can source themselves. For example, wood chips or composted leaves can be used to increase soil porosity and water capacity (Fontana et. al 2023).

Soil moisture management can be achieved through several methods. Many growers choose to form raised beds to help delineate production areas from the rest of the forest while improving drainage. If drainage is not an issue, raised beds are not necessary for successful wood-cultivated production, but they can still be useful for tracking and delineating plantings by species, year planted, etc. For drier sites, it may be necessary to add organic matter in the form of wood chips, leaf litter, biochar, or other types of natural mulch to conserve soil moisture. This organic matter

is especially important during Missouri's frequent hot summer droughts, as it reduces water and temperature fluctuations throughout the season and can provide additional benefits, such as reducing runoff and erosion and increasing soil fertility. Mulch is typically spread in a generous layer (approximately two inches deep) after planting to ensure that seeds or rootlets have good contact with mineral soil. Generally, straw should be avoided as it can hold onto too much moisture and encourage the development of molds and other fungal diseases. If using straw, ensure it is broken up well and spread in a thin layer.

Goldenseal plant surrounded by leaf mulch (Credit: Catherine Bukowski)

Planting

Unlike agricultural systems that focus on annual crops, planting a forest farm usually takes place in the fall since many of the perennial species grown as NTFPs have seeds which require cold stratification to germinate. Planting in the fall allows seeds to undergo this stratification in the ground and provides the added benefit of a protective leaf layer which will keep them moist. If establishing a forest farm with transplanted rootlets, it is also best to plant them in the fall after they have gone dormant. This reduces transplant shock and avoids desiccation.

A forest farmer plants ginseng seeds on a prepared site in the fall (Credit: Ezra Houston)

In Missouri, fall leaf drop can be a prolonged event, and hot dry periods are increasingly common through late October and early November. Planting too early could expose your seeds and rootlets to the risk of desiccation. To avoid this risk in a dry year, wait until after the leaf drop to plant. Many forest farmers will rake leaves away along 4-5' x 20-40' strips to ensure seeds have direct contact with mineral soil. The soil can be quite dry and hard after a hot Missouri summer and using a metal rake to roughen it up before planting is often a good idea.

Coexisting with Wildlife

When working in the woods, wildlife presence is to be expected. Although wildlife can damage forest farmed crops, coexistence should be the goal whenever possible. As is common in agriculture, high density monocrops are most susceptible to pests. Planting polycultures rather than focusing on one crop species will increase your forest farm's resilience. If you have the space, spreading your plants across multiple locations can help you avoid total loss of your crop in the case of a disease outbreak or pressure from pests.

The main pests that forest farmers contend with are deer, rodents, slugs, and insects. If deer are over-abundant on your property, it may be necessary to construct fencing. Wire fences are effective but can be costly. If you have time but do not have the capital to invest in a wire fence, creating a "slash wall" from forest debris is another option. A slash wall can also be a good way to use shrubs and small trees that were cleared from the midstory during site preparation. If neither of these fencing options are possible, hunting is another tool to reduce overabundant deer.

Farmers construct a slash wall from pawpaw stems cleared during site preparation (Top, Credit: Ezra Houston) and a high wire fence helps deter deer (Bottom, Credit: Katie Trozzo)

NTFPs are generally most susceptible to pests when they are young and not yet established. If you are using raised beds, screen covers can be a practical method of protecting seeds or seedlings during this vulnerable phase of their development. Some growers opt to germinate seeds in beds covered by screens, allowing them to become established before transplanting out into the main forest farm area. There are also various traps designed to catch insects, slugs and rodents that can help lower their populations and avoid significant loss of seedlings or plants due to predation.

Black cohosh showing insect and slug damage (Left, Credit: Raelin Kronenberg) and window screens protect young plants in nursery beds (Right, Credit: Catherine Bukowski)

A Note on Potential Diseases

Black cohosh plants with late-season leaf spot (Credit: Raelin Kronenberg)

In addition to damage done by wildlife, many forest species are susceptible to diseases and fungal pathogens, including leaf blights and root rot. Choosing an appropriate site with good soil drainage and avoiding high-density single-species plantings will go a long way in minimizing disease. Chemical fungicides are generally only used in high intensity woods-cultivated production systems, where disease pressure is much higher. The use of any fungicides in a forest must be done extremely carefully and thoughtfully due to the sensitivity of many organisms within the ecosystem. Michigan State University has developed a comprehensive bulletin detailing chemical control methods for diseases on American ginseng (Hausbeck, 2019), but these methods are costly and are incompatible with organic certification. Also, note that use of many of these chemicals is restricted to registered pesticide applicators.

If you are looking for an organic disease control method, the herbs themselves provide a solution. Medicinal plants get their beneficial properties from various bioactive compounds, known as “secondary metabolites.” Plants produce these secondary metabolites for defense against pests and diseases. Goldenseal, for example, produces antifungal alkaloids that effectively control *Alternaria, Fusarium*, and potentially other diseases on ginseng (Gao et al., 2024). A solution of goldenseal roots extracted in ethanol is the most effective treatment, but

leaves extracted in ethanol and roots extracted with water can also be used. Some farmers simply create a "compost tea" with goldenseal plants and apply it as part of their pest management strategy. Goldenseal is not the only plant that can be used to help control diseases on ginseng. In China, similar synergies between Korean wild ginger (*Asarum sieboldii*) and Asian ginseng (*Panax ginseng*) have been shown through growing trials (Zhang et al., 2024). This field of study is relatively new, but there are likely many other plant species that can provide disease-resistance support to one another.

Below is a table that lists some of the most common disease and pest issues a forest farmer may face, along with suggestions on how best to prevent, and in certain situations, treat the disease. Rember, prevention is the best strategy when it comes to diseases.

Table 3: Common pests and diseases encountered in forest farming operations.

Disease/Pest	*Symptoms*	*Prevention*	*Treatment*
Moles/Voles	Missing plants, seeds	Deterrents, plant in areas with no mole/vole sign	Trapping, deterrents
Deer	Missing leaves, portions of plant browsed	Fencing around planting areas, repellants	Install fencing and other deterrents. Some species can resprout after browsing if protected from further damage.
Slugs	Holes in leaves, often smooth edged, slime trails on and under the leaves	Keep mulch from piling up around the base of plant stems, keep planting area free from excess forest debris	Diatomaceous earth, beer traps, lime/wood ash mix, commercial slug bait
Insects (wireworms, cutworms, aphids)	Holes in leaves, cut leaves and stems, cupped leaves	Diversify plantings, plant extra to account for potential damage and loss	Neem oil, pesticides
Damping off	Sudden death of plant, blackening plant material	Plant in well-drained soil	None, prevention is important
Leaf spot/blights (*Alternaria*, *Phytophthora*, *Botrytis*, *Erysiphe*)	Dark spots on leaves, rotting leaves	Plant in well-drained, well-ventilated area, do not crowd plants, diversify plantings	Remove diseased foliage, fungicide, goldenseal extract
Root rot (*Rhizoctonia, Fusarium, Phytophthora*)	Plant dying back, mushy roots	Plant in well-drained soil	Goldenseal extract

Maintenance Activities

Several maintenance activities are recommended to improve the survival and success of a forest farming operation. Maintenance will vary throughout the year and will depend on the approach used.

Winter:

- Mechanically remove (cut or pull) invasive shrubs and other competing vegetation.
- Cut mushroom logs for inoculation.

Spring:

- Manual weeding or a spring burn can help to reduce competing vegetation.
- Some rhizomes can be transplanted in early spring while still dormant.
- Ramps can be divided and transplanted to grow your population.
- Mushroom logs should be inoculated before spring leaf-out.
- Harvest of ramp leaves and/or bulbs.

Summer:

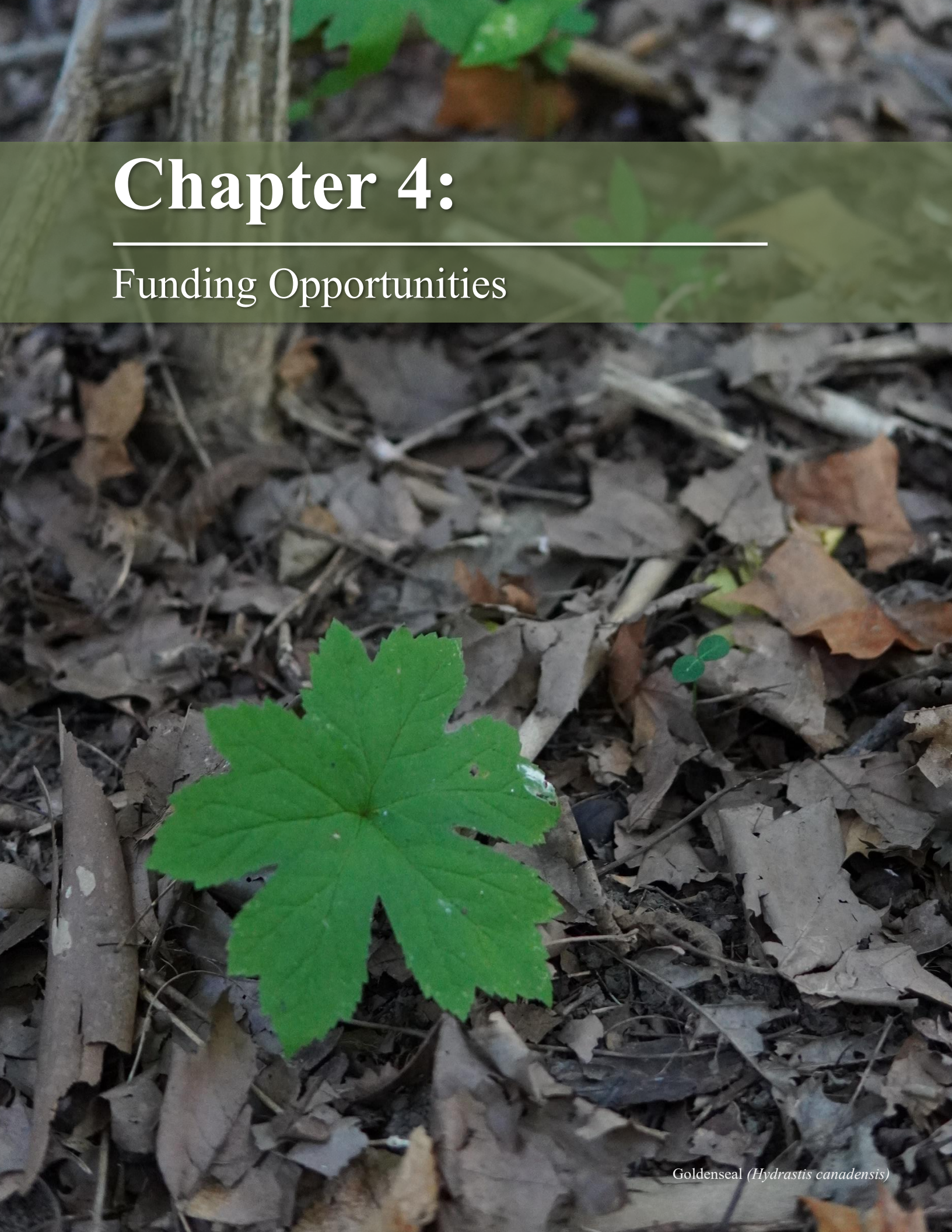
- Manual weeding around plants may be needed during summer, especially for newly established plantings.
- Monitor pest or disease issues and treat if appropriate.
- Clean up fallen trees and branches in and around the planting areas.
- Provide supplemental water during the first year or two after planting if rainfall is insufficient to maintain soil moisture.
- Collect and/or transplant seeds from summer-ripening species.
- Prepare planting areas for fall planting.

Fall:

- Collect and/or transplant seeds from fall-ripening species.
- Plant seeds/rhizomes in prepared locations.
- Harvest mature plant roots.

Chapter 4:

Funding Opportunities



Goldenseal *(Hydrastis canadensis)*

Due to the active forest management required to establish and maintain a healthy, productive forest farm, the practice fits nicely within a comprehensive natural resource management plan. There are several opportunities for landowners to receive financial support from both state and federal conservation programs to help offset the cost of forest management activities that can support the establishment and growth of a forest farm.

Federal Cost-Share Programs

Several federal conservation program funding opportunities through the USDA Natural Resources Conservation Service (NRCS) can support the establishment and maintenance of forest farming practices. These include the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). Both programs provide funding for several Field Office Technical Guide Practices that can be incorporated into forest farming and receive financial support, including but not limited to:

- Forest Management Plan - 106
- Brush Management - 314
- Herbaceous Weed Treatment - 315
- Forest Farming (tree planting only) - 379
- Riparian Forest Buffer - 391
- Forest Stand Improvement – 666

The payment schedule for each of these practices varies and payment rates will vary based on your county. It is best to work closely with NRCS staff when seeking to enroll in any Conservation Program. The NRCS will provide technical assistance at no cost to help to implement these practices. They also maintain a directory of technical service providers which can filtered based on which practices they are qualified to provide: https://nrcsregistry.sc.egov.usda.gov/prweb/PRAuth/app/NRCSRegistry/

The Sustainable Agriculture Research and Education (SARE) Program is another USDA funded program that provides competitive grants to projects that advance sustainable agricultural practices. These grants are not designed to help with startup costs for a new forest farmer, but for someone with an existing operation they could be used to investigate new aspects or methods of forest farming or to develop educational programs related to forest farming.

State Cost-Share Programs

There are additional conservation programs and grants funded by state agencies that are available to assist landowners in implementing forest management practices. The Missouri Department of Conservation (MDC) offers a cost-share program that funds private landowners who are not enrolled in any other federal or state incentive program. There are two practices supported by the MDC Cost-Share Program that can be applied to agroforestry: MDC 700 tree/shrub establishment and MDC 900 woodland improvement. Both offer a 75 percent cost-share on all approved practices unless a flat fee has been established for the practice (Godsey, 2005). Additionally, the Missouri Department of Natural Resources (DNR) has two programs that are funded through the Soil and Water Conservation Program (SWCP) that can be used to support the establishment of forest farming. These programs include a State SWCP cost-share and the Agricultural Nonpoint Source (AgNPS) Special Area Land Treatment (SALT) program (Godsey, 2005). It is worth reaching out to your local MDC Private Land Conservationist to explore what financial and technical support may be available within your county.

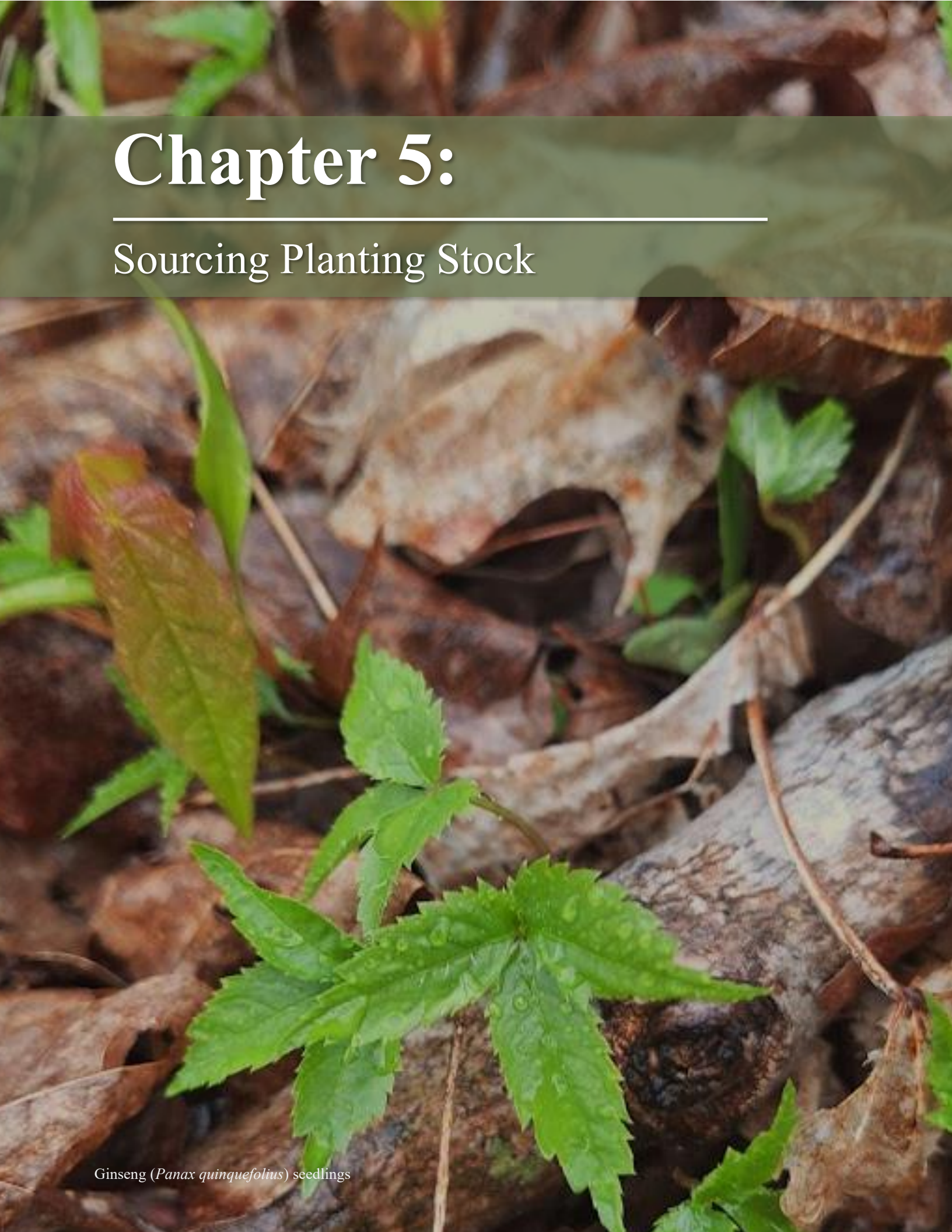
Other Funding Opportunities

As agroforestry has gained recognition and become a well-established practice, several other funding opportunities have become available through non-profit organizations and coalitions. Examples of these organizations include the National Fish and Wildlife Foundation (NFWF), the National Wild Turkey Federation (NWTF), Missouri Ducks Unlimited (DU), and Missouri Pheasants Forever/Quail Forever (Godsey, 2005).

Other mission-driven organizations such as the Edwards Mother Earth Foundation (EMEF) offer competitive grants for farmers to receive financial support for establishing forest farms and other agroforestry practices. One such grant, the Catalyzing Agroforestry Grant Program (CAGP), provides a particularly good opportunity as it is geared directly to agroforestry projects, including forest farming.

Chapter 5:

Sourcing Planting Stock



Ginseng (*Panax quinquefolius*) seedlings

What to Look For

Finding reputable sources for NTFP planting stock and mushroom spawn is a key part of planning activities. It is best to source planting stock locally as it will be adapted to the regional environmental conditions. However, this is not always feasible. Through the internet, it is easy to find and connect with an extensive number of nurseries, individuals, and seed companies from across the country. Keep in mind, the rarity of some forest plants and the specific requirements for seed and root handling and storage to maintain viability make it especially important to be vigilant about who you are buying from.

Wild Populations

One option for sourcing planting stock is to use an existing patch of plants on your property or connect with a neighbor who has a flourishing population of the desired species and is willing to sell roots or seeds. Gathering responsibly from a wild population can be beneficial if your aim is to spread the species to new areas, but care must be taken to ensure any seed or plant removal is done correctly and legally. Missouri currently allows the harvest of ginseng and other forest plants from private lands without a special permit. However, to sell ginseng, the landowner must receive a Landowner Harvest Authorization number, and the roots must be certified by the Missouri Department of Conservation (MDC). Collection of these plants from state land or areas managed by the MDC is prohibited. Questions about specific areas of public land should be directed to MDC. For more information about ginseng regulations, follow this link to the MDC website: https://mdc.mo.gov/about-us/about-regulations/wild-ginseng-harvest-regulations. It is good practice to replant some of the collected seeds nearby to increase the chances of maintaining or increasing the local population. The United Plant Saver and Rural Actions Forest Farmers Handbook names three guiding principles when working with wild populations of NTFPs:

- Only harvest mature plants bearing ripe seeds
- Plant all ripe seeds at the time of harvest or subdivide and replant part of the rhizome (for species that can be propagated by root cuttings)
- Leave an adequate number of mature reproductive plants to ensure future reproduction (generally harvest no more than 10-15% of any one population)

Reputable Suppliers and Nurseries

There are a growing number of nurseries, forest farms, and non-profit organizations that are well known for producing quality plants, seeds, roots, and mushroom spawn and are willing to ship across the country. Purchasing from an established business is a great way to access larger quantities of healthy seeds or roots and be able to connect with someone who has experience growing the plant. Below are a few places that offer a variety of roots, seeds, and mushrooms.

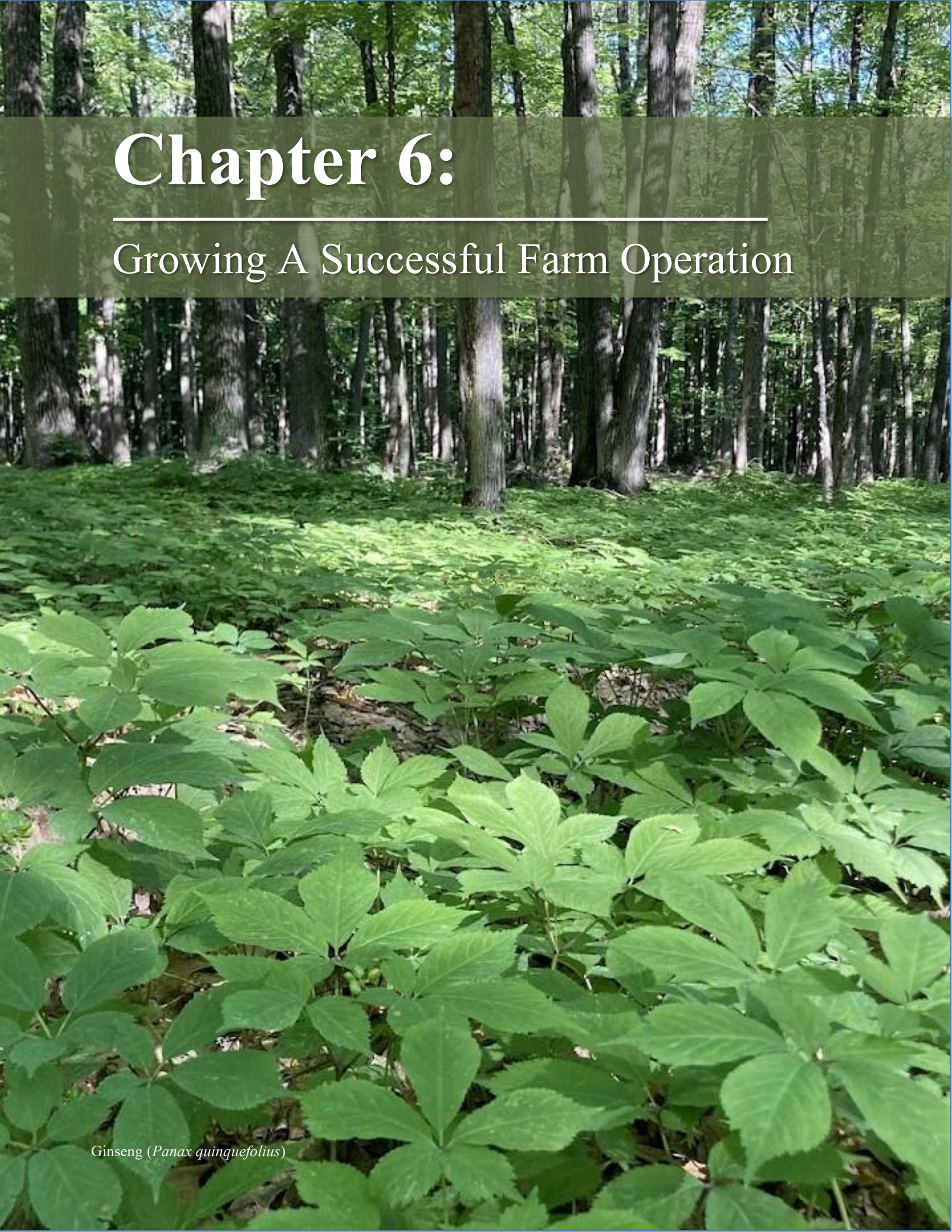
Table 4: Forest farming planting stock suppliers

Business Name	*Location*	*Website*
Farms & Nurseries		
Colwell's Ginseng	New Bethlehem, PA	https://www.colwellsginseng.com/store/
Companion Plants	Athens, OH	https://companionplants.com/
Crimson Sage Nursery	Orleans, CA	https://www.crimson-sage.com
Dairyland Ginseng	Oshkosh, WI	https://dairylandginseng.com/
Fedco Seeds	Clinton, ME	https://fedcoseeds.com/seeds/ramps-2433
Field and Forest Products	Peshtigo, WI	https://www.fieldforest.net/
Gates Hill Farm	Franklin, VT	https://rampfarm.com/
Harding's Ginseng Farm	Friendsville, MD	https://www.hardingsginsengfarm.com/index.htm
Hsu's Ginseng Enterprises	Wausau, WI	https://www.hsuginseng.com/us/control/main
Johnny's Selected Seeds	Winslow, ME	https://www.johnnyseeds.com/
Loess Roots	Stanton, NE	https://landscapingrevolution.com/Loess_Roots/loess_roots.html
Marathon Ginseng	Weston, WI	https://marathonginseng.com/
Native Wildflowers Nursery	TN	https://www.nativewildflowers.net/medicinal-herb-plants/
NC Ginseng & Goldenseal Company	Marshall, NC	https://www.ncgoldenseal.com
Ozark Mountain Ginseng	Thayer, MO	https://www.ozarkmountainginseng.com/
Prairie Moon Nursery	Winona, MN	https://www.prairiemoon.com/
Red Root Native	Barnardsville, NC	https://www.redrootnatives.com/
Shady Grove Botanicals	Pickens, WV	https://www.shadygrovebotanicals.com/
Shaw Black Farm	Morning View, KY	https://www.shawblackfarm.org/
Southern Exposure Seed Exchange	Mineral, VA	https://www.southernexposure.com
Strictly Medicinal Seeds	Williams, OR	https://strictlymedicinalseeds.com/plants/medicinal-herb-plants/
Sunshine Farm & Gardens	Renick, WV	https://sunfarm.com/
Wild Hudson Valley	Freehold, NY	https://www.wildhudsonvalley.com/
Wild WV Ramps	WV	https://wildwestvirginiaramps.com/
Wisconsin Grown Ginseng	Merrill, WI	https://wisconsingrownginseng.com/

Non-Profits & Universities		
Appalachian Sustainable Development	Duffield, VA	https://www.asdevelop.org/product-category/planting-stock/
Mountain Gardens	Burnsville, NC	https://www.mountaingardensherbs.com
Rural Action	The Plains, OH	http://ruralaction.org/programs/forestry/planting-stock-sale/
United Plant Savers	Rutland, OH	https://unitedplantsavers.org/
Warren Wilson College	Asheville, NC	https://www.warren-wilson.edu/programs/ecological-forestry/

Chapter 6:

Growing A Successful Farm Operation



Ginseng (*Panax quinquefolius*)

Certifications

Certifications are a way to set your products apart from others and emphasize your land stewardship values. The two most common certifications in forest farming practices are Organic certification and Forest Grown Verification certification. Organic production for forest farming is like other agricultural practices where production takes place without the use of chemical fertilizers, pesticides, and fungicides. More information about organic production and certification in Missouri can be found through the Missouri Organic Association (https://moaorganic.org/organic-certification/).

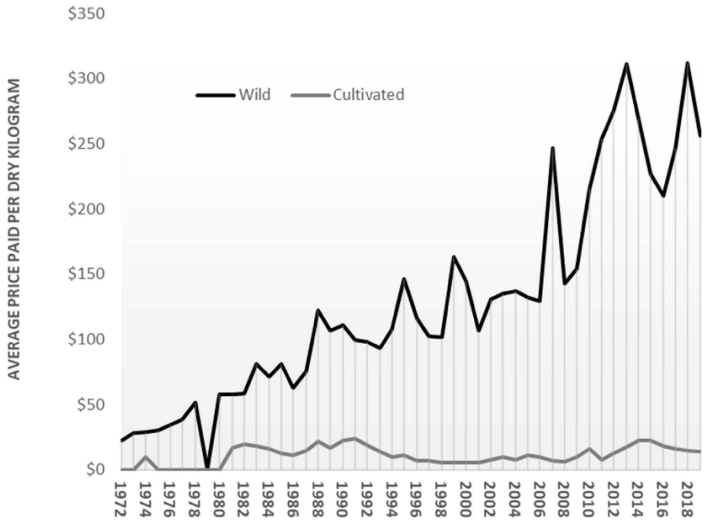
Forest Grown Verification is a separate and specific program to differentiate forest farming from wild harvesting of forest plants. This program is administered through United Plant Savers (UpS), a nonprofit whose work focuses on the protection of medicinal plants and the habitats they grow in. The UpS Forest Grown Verification Program establishes a voluntary, third-party verification system for non-timber forest grown products that are produced sustainably and legally. The standards for the program were developed by UpS through research of federal and state regulations, consultations with industry professionals, and information from scientific publications. Currently, the program includes 10 species, but the goal is to expand the verification guidelines to additional NTFPs. Organic certification is not required for eligibility. Details on the standards and application process can be found on the United Plant Savers Website https://unitedplantsavers.org/fvg/.

Harvest Best Practices

Many NTFPs are slow growing perennial plants grown for their high value roots and rhizomes. Ultimately, harvesting them is a destructive process that takes them out of production. Some NTFPs are priced based on root quality, and roots damaged during the harvesting process fetch lower prices. This means that as a forest farmer, great care should be taken when harvest time comes. Spending a little bit of extra time to carefully harvest high value roots, such as American ginseng, pays off.

Market prices for NTFPs can fluctuate significantly from year to year. The benefit of growing perennial plants is that they afford you the opportunity to wait until the price is right before a harvest, even if your crop is mature. This strategy is most effective for farmers who choose a wild-stewarded or wild-simulated approach because wild roots tend to fluctuate more than cultivated roots. These approaches also typically have less disease pressure, which can force a farmer to harvest regardless of market prices to avoid a total crop loss.

For most root crops, fall is the optimal time for harvest, as the plant has grown over the summer and produced seeds. Depending on your desired approach, these seeds can be immediately replanted nearby, collected for stratification and planting the following year, sold or traded to other growers, or germinated in beds or pots so that the seedlings can be planted or sold. Many NTFPs, including goldenseal, black cohosh, and ramps, can also be propagated by dividing the rhizomes or bulbs. For these species, the best practice is to harvest, divide, and replant a portion of the harvested rhizome. Division is usually most successful in the fall after plants have gone dormant.



Comparison of the average prices paid for wild versus cultivated American ginseng for the years 1972-2019. (Credit: Liu et al., 2019)

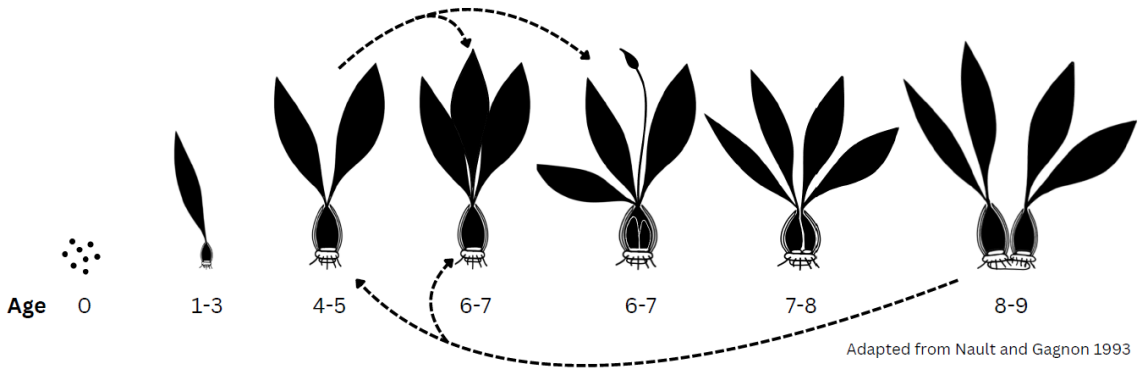
While it takes anywhere from four to ten or more years for many NTFPs to reach a harvestable size, there are other options to generate income sooner, including leaf harvests and propagation for planting stock sales. Leaf parts of medicinal NTFPs are generally marketable, but not as valuable as roots. Leaf harvests are not fully destructive and can be practiced sustainably. However, it is important to note that leaf harvests do slow plant growth and can even kill plants if done frequently, repetitively, or during the wrong part of the season. Early season harvests are most damaging, because plants invest much of their winter reserves into their leaves. It is better to wait to harvest leaves until later in the growing season, when the plants have had time to produce seeds and store the necessary carbohydrates to survive winter dormancy. However, it is important not to wait too long, as leaves which are badly damaged by herbivory, have leaf spots, or have started to senesce (turn yellow and die back for the year) will not sell for much. For "long season" plants, such as ginseng, goldenseal, and black cohosh, the best time for leaf harvest could occur as early as July and typically no later than August. For example: to optimize between plant growth/reproduction and concentrations of medicinal compounds in goldenseal leaf harvests, mature reproductive plants should be targeted a few weeks after fruits ripen, and harvest should take place during the late afternoon (Zuiderveen et al., 2021). For early spring ephemerals such as ramps, the same principles apply but


A small bloodroot freshly dug. (Credit: Raelin Kronenberg).

the harvest season differs. Focusing leaf harvests to 3-leaved plants and delaying until approximately 30 days after the leaves emerge allows more material to be harvested from fewer plants without seriously hindering the health and growth of the population (Nilson et al., 2023).

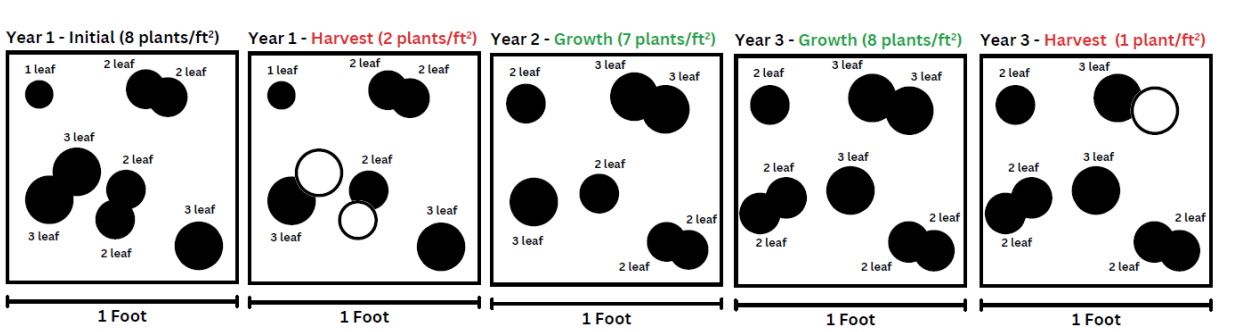
As our knowledge of many NTFP lifecycles improves, we continue to explore more sustainable harvesting practices. For species such as ramps and ostrich fern that produce multiple edible leaves/frons, forest farmers have the option to harvest only a portion of the above-ground growth leaving the rhizome/roots in place to grow another year. Leaf harvests are also an option for other species including ginseng and goldenseal. Aim to take only one leaf per plant. To get a better idea of what sustainable and profitable harvests can look like, here is an example of one approach to managing a ramp population in a forest farm.

The graphic below illustrates the lifecycle of a ramp. For the first three years, ramps grow slowly and produce only one leaf per year. Once they grow big enough to start producing two leaves, their growth rate increases for the next few years until they flower. Some individuals will flower during the two-leaf stage, while others only flower once they reach the three-leaf stage after six or seven years. The process of flowering triggers bulb division, resulting in two connected ramets which will eventually become independent and divide again (Nault and Gagnon 1993). Taking advantage of this clonal growth habit is the best way to harvest sustainably while maintaining high growth rates. Harvests should concentrate on removing one of the connected ramets and replanting or leaving the other in place. In older populations, there may be clustered groups of six or eight ramets where one plant has divided multiple times. Where this occurs, harvest three or four and replant one or two in areas of your forest where the ramp population is less dense.



In natural populations, ramps can reach densities of eight plants/ft^2 or more. At this density, they will increase through clonal division by approximately 0.8 plants/ft^2/year, averaged over a larger patch (Dion et al. 2015). This seems to be the sweet spot for maximizing growth rate. At higher densities, they will compete for moisture and nutrients. At lower densities, there will be fewer plants to grow and divide each year. The graphic below is designed to help visualize the growth

and harvest of individual plants over a three-year span. It demonstrates how selectively harvesting individual plants from a larger patch can help encourage the growth of neighboring ramps and provide additional harvests from the same patch in later years. This approach works well for many NTFP species that grow clonally.



While there are multiple approaches to harvesting, the main goal is to ensure enough mature plants are left to grow another year. The exact numbers will be dependent on the site and species, this is why taking good notes and starting with small harvests is important. Each approach to harvesting, (whole plant, root, or leaf-only), requires slightly different post-harvest handling measures. Generally, roots should be washed and dried soon after harvest to prevent rot and preserve their medicinal value. Medicinal plant leaves are often dried in preparation for use as a tea or part of a tea blend. Edible plants such as ramps and ostrich fern should be kept cool and sold as soon as possible after harvesting to maintain freshness.

Seed Handling and Planting

Propagation by seed is an excellent way to increase your population of plants and support genetic diversity at a lower investment than purchasing additional rootstock. It is important to note that many species take up to two years to germinate and have unique requirements for germination success compared to annual plants. The approach to seed handling varies by species and seed type, but a couple of general principles hold true for working with all perennials: fluctuation of temperature and steady moisture.

Ramp seeds harvested during early fall and stored in a paper bag for re-planting. (Credit: Raelin Kronenberg).

Seeds can be broadly classified into two groups: dry seeds and wet seeds. Wet seeds are covered by a fleshy fruit, as seen with goldenseal and the more familiar tomato plant. In forest farmed species, wet seeds from species like goldenseal and ginseng should be harvested, cleaned, stratified, and kept moist until planting. Wet seeds must not dry out to remain viable. For species with dry seeds (black cohosh, ramps, and many

common vegetable plants), seeds should be harvested, allowed to dry and kept free of moisture in a paper bag if they are not immediately replanted. Properly stored seeds will have much higher rates of germination success.

Regardless of seed type, most species require fluctuating warm and cold temperatures to break dormancy. One low-tech option for cold stratification is to use a milk crate or bin buried in the ground, so the seed is subjected to natural seasonal temperature fluctuations. Many farmers have good success with this. Another option is to place seeds in a refrigerator for three months prior to planting to mimic the first natural cold stratification which can help reduce germination time. Unless the seed is being collected to be sold, it is easiest to replant immediately after ripening in the late summer through early fall to prevent any potential loss of viability. Depending on the size of the seed, they can be either scattered and then raked into a prepared bed or planted individually. The approach is up to the preference of the forest farmer and site conditions.

Some forest farmers choose to start seeds in garden flats or raised beds where they can more readily provide supplemental water and protect seedlings from any predation. This approach can be especially helpful for areas that are prone to drought. Starting seeds in a controlled environment can also support greater germination. Seedlings started in nursery beds or flats can be transplanted into their permanent growing space after two to three years, or when they get their secondary leaves.

Value-Added Products

As with all consumer goods, raw materials do not fetch the same price as those which are processed. Processing the roots and herbs will add value to them and could be a good strategy to increase profit margins. Depending on what species are grown, there are various degrees of processing that can be included in an operation. Drying the roots and herbs is the most basic processing method, and many buyers will only buy dried material. Some herbal shops will only buy chipped or cut and sifted herbal products. These processing methods can add a layer of complexity to an operation, but they can also pay off with higher price points. Some ambitious farmers will go a step further by making end products, such as tinctures and teas. Note that Missouri cottage food laws allow direct sale of dried herbs, herb mixes, baked goods, and canned jams or jellies to a consumer, but other types of products require preparation in an inspected commercial kitchen.

Market Considerations

As with any crop venture, it is important to understand and develop the potential markets for products. Selling non-timber forest products can be challenging since the market is not well-organized and documented. The easiest way to sell raw herbal products is through local

aggregators, who usually advertise on Facebook. However, these buyers are geared towards wild-harvested products and their price points are generally too low to justify cultivation except in the case of high value plants such as ginseng or goldenseal. Herbalists and herbal companies sometimes buy raw materials as well, but many only buy dried, chipped, or cut and sifted materials. Should you choose to sell directly to consumers, potential outlets include online stores or farmers' markets.

Many forest farming operations are small in scale and provide supplementary income. Currently, there are only a few examples of commercial-scale forest farms due to the difficulty in accessing markets and the slow-growing nature of many forest species. Since returns per acre vary widely, it is hard to develop a comprehensive example enterprise budget for forest farming. North Carolina State shares a few rough estimates of potential net profits for ginseng, goldenseal, and ramps determined from a variety of university and commercial studies.

- Wild simulated ginseng: $20,460 US per half-acre after nine years.
- Woods-cultivated ginseng: $5,865 US per half-acre after six years.
- Organic, forest grown goldenseal: $2,490 US per one-tenth acre after four years.
- Wild-simulated goldenseal: $10,100 US per half-acre after five years.
- Woods grown ramps: $770 US per one-tenth acre after three years.

Good marketing and market planning is essential to success, but a full market analysis is beyond the scope of this document. It is important to continue to explore and understand potential markets. It is also helpful to network with other growers to understand your local market opportunities before diving into a new forest-product enterprise.

Planning for the Future

Forest farming is a long-term investment. Most non-timber forest products require years of growth before harvest and great care must be taken to ensure sustainability for future yields. By building a thoughtful plan for future management activities and harvest, you can help ensure your forest farm's productivity over the next growing seasons. Some key things to consider are time to plant maturity, diversity of products and harvest dates, and planting multiple ages of a particular species to space out harvests. While this guide provides a broad overview of forest farming with a focus on the establishment phase, we strongly encourage continued reading, experimentation, and learning from other growers during your forest farming journey. Some additional references, including species-specific growing guides, are shared below. Happy forest farming!

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Appendix I: Additional Resources

Individual Plant Profiles and Guides

American ginseng (*Panax quinquefolius*)
- Lincoln University of Missouri
- Missouri Department of Conservation
- North Carolina Consortium on Natural Medicines and Public Health
- Virginia Cooperative Extension
- Cornell Cooperative Extension
- National Agroforestry Center (Production)
- National Agroforestry Center (Economics)

Black cohosh (*Actaea racemosa*)
- Lincoln University of Missouri
- NC State University
- USDA NIFA and the Extension Foundation

Bloodroot (*Sanguinaria canadensis*)
- Missouri Department of Conservation
- NC State University
- USDA NIFA and the Extension Foundation

False unicorn (*Chamaelirium luteum*)
- Lincoln University of Missouri
- North Carolina Consortium on Natural Medicines and Public Health
- USDA NIFA and the Extension Foundation
- NC State University

Goldenseal (*Hydrastis canadensis*)
- Lincoln University of Missouri
- Missouri Department of Conservation
- NC State University (Overview)
- NC State University (Commercial Cultivation)
- Penn State
- North Carolina Consortium on Natural Medicines and Public Health (adapted)
- USDA NIFA and the Extension Foundation
- Cornell Cooperative Extension
- National Agroforestry Center

Mayapple (*Podophyllum peltatum*)
- Lincoln University of Missouri
- Missouri Department of Conservation

Pine straw
- USDA NIFA and the Extension Foundation
- National Agroforestry Center

Ramps (*Allium tricoccum*)
- Lincoln University of Missouri
- National Agroforestry Center
- Penn State (Overview)
- Penn State (Webinar)

Shiitake and other mushrooms
- Lincoln University of Missouri
- University of Missouri Center for Agroforestry
- Cornell University, University of Vermont
- USDA NIFA and the Extension Foundation
- National Agroforestry Center

Sugar maple (*Acer saccharum*)
- Lincoln University of Missouri
- University of Missouri Center for Agroforestry

Site Selection / Population Assessment

Appalachian Sustainable Development
- Forest Botanical Plant Population Assessment Methods

Lincoln University of Missouri
- Forest Farming Site Selection and Preparation Guidelines

Northeast Forest Farmers Coalition
- Site assessment worksheet

Virginia Tech University
- Plantshoe

Economics, Production, and Marketing

American Herbal Products Society
- AHPA Tonnage Report 2011-2017

Appalachian Sustainable Development and USDA forest Service
- Forest Farming Calculator

National Agroforestry Center
- Where can edible NTFPs be sold?
- Developing Consumer and Market Research for NTFPs
- Marketing Specialty Forest Products

- Marketing Agroforestry Products

NC State University
- Black cohosh enterprise budget
- Bloodroot enterprise budget

University of Missouri Center for Agroforestry
- Economic Budgeting for Agroforestry Practices
- Using NRCS assistance for agroforestry and woody crop establishment
- Maple Syrup Cost, Production, and Sales Worksheet
- 2022 Missouri Maple Syrup Producer Survey and Interviews
- Marketing Maple Syrup in Missouri
- Missouri Maple Syrup Hoppy to Sales

University of Missouri Extension
- Forestry Assistance for Landowners

Virginia Tech University
- RootReport

Handbooks, Summaries and Other Aggregated Info

Appalachian Sustainable Development
- Forest Product Brochure

Jeanine Davis and Scott Persons
- Growing and Marketing Ginseng, Goldenseal and Other Woodland Medicinals

Ken Mudge and Steve Gabriel
- Farming the Woods: An Integrated Permaculture Approach to Growing Food and Medicinals in Temperate Forests

National Agroforestry Center
- What is forest farming?
- Forest Farming: An Agroforestry Practice
- NTFPs and Forest Stewardship Plans
- Indigenous Traditional Ecological Knowledge in Agroforestry
- Forest Farming: Expanding Farm and Forestry Opportunities
- Forest Farming Practices

Richo Cech
- Growing At-Risk Medicinal Herbs: Cultivation, Conservation and Ecology

Rural Action and United Plant Savers
- Forest Farmers Handbook: A Beginners Guide to Growing and Marketing At-Risk Forest Herbs

USDA NIFA and the Extension Foundation
- Basics of Forest Farming

Videos, Webinars, and Podcasts

Appalachian Forest Farmer Coalition

- Forest Farming YouTube Channel (dozens of videos and several webinar series)

Capital RC&D

- Small Scale Mushroom Production

Cornell Small Farms

- Forest Ecology for Mushroom Bolts
- Sourcing Logs for Mushroom Cultivation
- Growing Ginseng with Success
- Sustaining Production and Profits: Research Update from Cornell Maple Program

Cornell University/Cornell Cooperative Extension

- Learning Video Series (online forest farming course)
- Economics of Log-Grown Shiitake: Positive Implications for Forest Management and Grower Profit
- Mushroom Cultivation

Northeast Organic Farming Association of Connecticut

- Forest Farming At Risk Herbs Under a Forest Canopy

Penn State Extension

- Forest Farming Series: Ramps/Wild leeks
- Forest Farming Series: American ginseng and Seed Saving
- Forest Farming Series: Goldenseal
- Forest Farming Series: Introduction to Forest Farming
- Forest Farming Series: Morels

Savanna Institute

- Everything You Wanted to Know About Forest Farming (But Didn't Know to Ask)
- Forest Cultivation of Shiitake and Other Edible and/or Medicinal Mushrooms

University of Missouri Center for Agroforestry

- Agroforestry Podcast
- The Appalachian Harvest Herb Hub: Empowering Plant Conservation through Profit
- Log-Grown Shiitake Mushrooms: A Case Study in Profitable Agroforestry Adoption

Washington State University

- Non-timber Forest Products and Agroforestry
- Forest Farming Specialty Mushroom Crops

Washington Tree Farm Program

- Forest Cultivated Mushroom Production Systems

Woodland Stewards

- More than Timber: Income Opportunities from Non-timber Forest Products

Newsletters

Agroforestry Coalition
- News

Appalachian Forest Farmer Coalition
- Forest Farming Footnotes

American Herbal Products Association
- AHPH blog

National Agroforestry Center
- Inside Agroforestry

University of Missouri Center for Agroforestry
- Action in Agroforestry