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Industry Primer: Agroforestry

KEY TAKEAWAY

Agroforestry – the intentional integration of trees or shrubs with conventional row crop and/or animal grazing farm practices – represents an important option for delivering economic, environmental, and social benefits associated with the wider regenerative agriculture movement. Although relatively small in value today, we believe that agroforestry has the potential to approach $200 million in market value, ahead, as stakeholders begin to discount production volumes that can arise in 2030. There are numerous industry scaling challenges in place, including financial, technical, and cultural hurdles, but groups like Agroforestry Partners stand ready to solve these challenges alongside growing U.S. government support via larger grantmaking actions and improved technical resources. Like any business or investment, the adoption of agroforestry comes with associated risks; it is up to operators and their networks to work collaboratively to minimize these risks while pursuing attractive outcomes for society and our planet.

KEY POINTS

Introduction to Agroforestry. Agroforestry is defined as the intentional integration of trees or shrubs with conventional row crop and/or animal grazing farm practices in an effort to create economic, environmental, and social benefits. The United States Department of Agriculture (USDA) separates agroforestry into five distinct types of practice: windbreaks, alley cropping, silvopasture, riparian forest buffers, and forest farming. Agroforestry can lead to many positive outcomes, including carbon sequestration, improved soil functionality and fertility, heightened water quality, enhanced biodiversity, and more resilient farm incomes.

The Regenerative Agriculture Space. Agroforestry itself is a subset of regenerative agriculture, with the latter defined as a conservation approach to agriculture that repairs and protects productive lands and soil while simultaneously enhancing production from those lands. Regenerative agriculture is therefore a variety of techniques that can be used alone or in combination to achieve a desired set of outcomes. While not exhaustive, the USDA focuses on a handful of regenerative agriculture techniques: agroforestry, composting, cover cropping, crop rotation, green fertilizer, and no/limited tilling.

U.S. Market. As of 2022, the market size for regenerative agriculture in the U.S. is estimated to be near $350 million, based on a global market value estimated at $975 million. Going forward, a mid-teens compound annual growth rate (CAGR) is anticipated for the sector out to 2032. There is limited data in place for agroforestry, as an industry, today. Based on recent-year planting estimates and associated costs, we believe that the cost basis value of the U.S. agroforestry industry amounts to roughly $30 million, or more, with market value likely much higher than this number. Based on volume growth estimates alone, we believe that the industry is growing by roughly 150% YoY, or more, at present. We believe that market value of the U.S. agroforestry industry could approach $200 million in coming years, based on current planted acreage estimates and their anticipated productive value out to 2030.

How to Value the Space. We use a corporate valuation/total addressable market (TAM) approach to value the industry and corporate entities in the market. For individual projects, we use project finance variables like net present value (NPV) and internal rate of return (IRR) to gauge investment attractiveness. The type of agroforestry practice will have some impact on how investors and other stakeholders value a project or industry; we consider three main agroforestry approaches as a part of this primer report: tree nuts, shrub fruit, and timber.

Resources. There is a clear need for educational resources pertaining to regenerative agriculture, broadly, and agroforestry, specifically, in the market today. Agroforestry Partners aims to fill this void with industry primers, segment backgrounders (e.g., carbon offsets, crop insurance, soil and plant growth), spotlight reports, and news headline tracking. We also provide a core list of government and non-government links in this report.

Risks. Although not exhaustive, we see a key number of risks that could ultimately derail or limit agroforestry adoption in the United States. In no particular order, they are: disinterest from the farming community; lack of accurate monitoring, reporting, and verification (MRV) tools; tree crop failure/weather; supply and demand imbalance for agroforestry crops; and regulatory interference.

INTRODUCTION TO AGROFORESTRY

The Basics

Agroforestry is defined as the intentional integration of trees or shrubs with conventional row crop and/or animal grazing farm practices in an effort to create economic, environmental, and social benefits. In this sense, agroforestry relates to the commingling of *perennial* plants and trees that flourish naturally each year together with *annual* crops that are removed from the land after each season. Common examples of perennial plants that are integrated into North American agroforestry systems include nut and fruit trees, shrubs, and timber wood.

The United States Department of Agriculture (USDA) separates agroforestry into five distinct types of practice:

1) Windbreaks
2) Alley Cropping
3) Silvopasture
4) Riparian Forest Buffers
5) Forest Farming

<u>Windbreaks</u>

Windbreaks (aka shelterbelts) are defined as linear plantings of trees and shrubs designed to provide economic, environmental and community benefits. The primary purpose of most windbreaks is to slow the wind, creating a more beneficial condition for soils, crops, livestock, wildlife, and human beings.

Figure 1: Windbreaks Visual

Source: USDA

Alley Cropping

Alley cropping refers to the practice of planting crops between clearly defined rows of trees. The overall system can be designed to drive increased revenue for the producer, leveraging different fruits, vegetables, grains, flowers, herbs, and other plants/feedstocks. Alley cropping is sometimes referred to as intercropping, which is a less defined system of trees and crops together.

Figure 2: Alley Cropping Visual

Source: World Congress on Agroforestry

Silvopasture

Silvopasture is the combination of trees and livestock/pasture on one piece of shared land. Trees can provide a secondary income, similar to alley cropping, while also providing shade and/or shelter for animals.

Figure 3: Silvopasture Visual

Source: Propagate Group, PBC

Riparian Forest Buffers

Riparian forest buffers are defined as natural or re-established areas of trees, shrubs, or grasses that line rivers and streams, helping to control farm runoff, strengthen water banks, and support wildlife and biodiversity.

Figure 4: Riparian Forest Buffers Visual

Source: Virginia Department of Forestry

Forest Farming

Forest farming is sometimes referred to as multi-story cropping, and is the practice of growing food, herbal, or botanical crops under an existing forest canopy that is managed to provide necessary shade and other services for the broader plant system in place.

Figure 5: Forest Farming Visual

Source: Extention.org

Agroforestry can be an important tool for removing carbon dioxide (CO_2) from the atmosphere, with scientific research showing an average 2-5 metric tons (MT) of CO_2e sequestered per acre per year from these practices. Thus, the addition of trees and shrubs to agroforestry systems can be a meaningful tool for helping the country and world to remove heat-trapping carbon from the air. Aside from sequestering CO_2 from the atmosphere, agroforestry has a wide number of co-benefits for the environment, farmers/landowners, and society more broadly. These co-benefits include: the prevention of nitrous oxide (N_2O) emissions, reduced soil erosion, improved crop yields and nutrient densities, increased water quality, enhanced biodiversity, and improved farm profitability dynamics.

Prevention of N_2O Emissions

In the U.S., the agriculture industry generates roughly 10% of all greenhouse gas (GHG) emissions produced in the country. Of this amount, crop cultivation is ~50% of the total, while livestock and fuel combustion are 44% and 6%, respectively. Most of the GHGs from crop cultivation are N_2O, which has a global warming potential (GWP) of 300x that of CO_2. Denitrification is a common problem where microorganisms become oxygen starved in wet or compacted soils and instead turn to nitrate from nitrogen fertilizers for their energy, leading to N_2O release into the atmosphere. As trees and shrubs are planted and expand their root structures over time, soils are kept from becoming compacted while also benefiting from less water-saturated conditions as water is intercepted and moved throughout the plant structures themselves. Agroforestry systems can also be less intensive, requiring less nitrogen than row crops over a long term management period.

Reduced Soil Erosion

American soils have been eroding by 1.9 millimeters (mm) of depth per acre per year, with roughly 40% of this coming from water erosion and the other ~60% coming from wind erosion. Soils typically do not naturally regenerate anywhere close to these levels of erosion taking place. Average topsoil height in the U.S. today is around 178 mm, or 6-8 inches, meaning that current net soil erosion rates could lead to U.S. farms only having ~100 more years of production, theoretically. Aside from the scary prospect of no longer having enough soil to grow food, soil erosion rates of this magnitude lead to annual crop losses of 0.4%, on average, each year. Perennial tree and shrub roots bind the soil in place so that it doesn't wash or drift away during heavy rains or wind. Scientific studies have shown that agroforestry practices can reduce total soil loss by roughly 40%, on average. Given that rainfall frequency and intensity is increasing, farmers are becoming more pressed to find adaptive techniques to protect their soils.

Improved Crop Yields

U.S. crop yields for staples like corn, soybeans, and wheat have been rising steadily for decades, however this year-over-year (YoY) yield improvement has been slowing more recently. U.S. corn yields have dropped from a 20-year average growth rate of 1.8% down to roughly flat over the past 5 years. U.S. soybean yields have dropped from a 20-year average growth rate of 1.6% down to 0.2% over the past 5 years. And U.S. wheat yields have dropped from a 20-year average growth rate of 1.9% down to 0.3% over the past 5 years. This is concerning, given that global food demand is expected to potentially double over the next 50 years. Soil erosion likely has something to do with slowing crop yield improvement; it is now estimated that 30% of American farms have lost their entire A horizon, or their most fertile topsoil. Trees and their perennial root structures help to re-establish important microorganisms that rebuild soils and foster plant nutrition/growth.

Improved Nutrient Densities

Aside from slowing yield growth, nutrient densities in American crops have also been on the decline. The mineral content (phosphorus, iron, calcium, vitamin C, vitamin B2) in the average U.S. vegetable has fallen by 5%-40% into the 21st century, relative to 1950. Plants get their nutrients from the soil. When soils are depleted, that means that the nutritional quality of our food is depleted. The more fungi and microbes that are active in the soil, the better equipped it is to get nutrients into plants and human diets, according to hypotheses and ongoing trials from the Rodale Institute. Today's soils are increasingly devoid of such microorganisms due to heavy synthetic nutrient application rates, soil compaction and erosion, and annual cropping practices currently in place. Without permanent root structures in place to develop and sustain these microbiological communities, soils become depleted and nutrient content in many food crops suffers as a result. Perennial trees and shrubs cycle nutrients that feed other plants, animals, and fungi, nourishing soils in the process. Scientific studies show that agroforestry practices can increase soil organic matter (SOM) by 50%-100%, on average, boosting soil microbiological activity by up to 30% in the process, leading to increased plant nutrient uptake. Aside from the ability to enhance nutrient profiles in soils, fruit and nut trees used in agroforestry systems tend to produce more nutrient-dense crops (fruit and nuts) relative to traditional row crops like corn, soybeans, and wheat.

Increased Water Quality

Agricultural runoff and leaching of synthetic fertilizer nutrients is the leading cause of water quality impacts to rivers and streams in the U.S., the third leading source for lakes, and the second largest source of impairments to wetlands. Roughly 60% of nitrogen fixed by human activities is released back into the environment without being incorporated into food. Due to soil erosion and heavy application rates of fertilizer, pesticides, and other substances, runoff can move contaminants into waterways and affect aquatic life, while also moving into groundwater supplies and affecting drinking water supplies. The addition of trees and shrubs to farmland can help to hold more water in the soil; each 1% increase in SOM helps soil hold 20,000 gallons more water per acre. Additionally, trees can intercept 25%-50% of precipitation and shrubs can intercept 10%-25% of precipitation, with water never touching the ground due to evapotranspiration off their leaves. Studies have shown that water infiltration rates (velocity at which water is absorbed by soil) can increase by up to 500% when agroforestry is implemented.

Enhanced Biodiversity

Agriculture is the leading driver of biodiversity loss in the United States, based on land expansion and production intensification. Biodiversity helps to purify air and water, produce oxygen, create food, decompose waste, and create medicine. Today, 12 plant crops and 14 animal species provide 98% of the world's food needs, compared to 7,000 plant species and several thousand animal species that were used for human nutrition and health when agriculture began roughly 12,000 years ago. Agroforestry systems are more diverse than monocultures of crops and livestock, providing potential pest control for crops while also allowing movements of species between habitat remnants. Agroforestry can also benefit biodiversity downstream due to reduced nutrient/chemical runoff into waterways. Available scientific research suggests that agroforestry practices can enhance crop pollination and yields, as tree and shrub species offer abundant nectar with relatively high sugar contents. It has been observed that pollinator populations and nesting densities can be up to 50% greater when agroforestry systems are in place, leading to crop yields that are 5%-50% greater, on average.

Improved Farm Profitability Dynamics

Agroforestry leads to healthier soils and diverse crop types which, in turn, create a more robust and resilient set of income opportunities for farmers and landowners. Aside from the opportunity of increased crop yields and thus greater revenues, agroforestry practices can also help lower input costs for farmers via greater biodiversity-led pest control and reduced purchase/application of nutrients due to greater retention in the soil. As an example, studies have shown that agroforestry can lead to upwards of 50% greater nitrogen retention on-farm, reducing the need for commercial fertilizer application over time. Agroforestry Partners projects that farm profitability can increase by 20%-40% under its planned project scope. Multiple international reports show African and Asian farmer incomes rising anywhere from 15%-100% when agroforestry practices are implemented.

History of Agroforestry

Agroforestry has been practiced around the world for thousands of years, and it still exists – uninterrupted – as a default common practice in many countries. It is only in recent centuries that large agricultural producers like the United States have moved to dissociate farming and trees in an effort to intensify food production. However, this dissociation has led to many of the negative externalities named previously, while calling into question the ability of conventional agriculture to meet forward global food demand expectations. Evidence of silvopasture practices dates back to over 4,000 years ago in Spain. In the Middle Ages, records of German farmers exist whereby crops were grown on cleared land only to let trees grow back and provide new resources and opportunities over time. Likewise, the Middle Ages in the Americas are evidenced by multi-story agricultural practices akin to forest farming. Asia and Africa also hold specific records of agroforestry practices dating back thousands of years.

However, in the early 20th century, a period known as the Green Revolution – or the Third Agricultural Revolution – started to take hold across developed countries as mechanization, plant breeding, and the mass production of pesticides and fertilizers gained steam into the 1950s and ‘60s. Farmers began clearing mass quantities of land and producing large quantities of individual staple crops, helping to meet a global jump in population numbers. By the 1970s, the world was starting to become more concerned with societal impacts to the environment, evidenced by the UN Stockholm Conference held in 1972 and the World Climate Conference held in 1979. It was during 1977 when a group of researchers at the International Development Research Center in Canada formally coined the term “agroforestry” in a research paper as a means for addressing agricultural-related impacts to the environment. This led to the creation of the International Center of Research on Agroforestry (ICRAF) in 1978, focused on promoting agroforestry research in developing countries. Unfortunately, most multilateral conventions and agreements related to climate and the environment have centered on chemicals, water, and air quality for the past three decades at the expense of systemic change in the form of agroforestry.

Today, agroforestry is growing in its importance and popularity as a tool for regenerative agriculture solutions, as society looks more broadly across the whole of its impacts on the environment and our planet. In 2014, India established a National Agroforestry Policy. In Europe, the European Agroforestry Federation (EURAF) aims to promote the use of trees on farms, with twenty different countries taking part in the effort. And in the U.S., the National Agroforestry Center (NAC) has been created to accelerate the adoption of agroforestry inside the country. To better understand the forward opportunity for agroforestry, it is first important to understand the broader conversation to which agroforestry belongs – that of the regenerative agriculture movement.

INTRODUCTION TO REGENERATIVE AGRICULTURE

The Basics

Agroforestry itself is a subset of regenerative agriculture, with the latter defined as a conservation approach to agriculture that repairs and protects productive lands and soil while simultaneously enhancing production from those lands. Regenerative agriculture is therefore a variety of techniques that can be used alone or in combination to achieve a desired set of outcomes. While not exhaustive, the USDA list below considers the following as some of the main techniques associated with regenerative agriculture in the U.S. today:

1) Agroforestry
2) Composting
3) Cover Cropping
4) Crop Rotation
5) Green Fertilizer
6) No/Limited Till

Composting

Composting is defined as the natural process of recycling organic matter like plants and food waste into fertilizer that can be used to enrich soils. Composting speeds up the natural decomposition process by providing the right conditions (controlled aerobic environment) for bacteria, fungi, and other organisms to process and decompose matter.

Figure 6: Composting Visual

Source: rts.com

Cover Cropping

Cover crops are plants that are planted in the ground to cover and protect the soil as a first line of intent, as opposed to the direct purpose of being harvested for financial profit or gain (although cover crops can in many cases be harvested for profit). Cover crops help to increase microbial activity and manage soil erosion on land that would otherwise be kept bare during non-productive seasons.

Figure 7: Cover Cropping Visual

Source: SARE.org

Crop Rotation

Crop rotation is the practice of growing alternating/different crops on the same plot of land to optimize soil health and nutrients in the ground, with an intent of maintaining diversity and balance across the broader ecological system.

Figure 8: Crop Rotation Visual

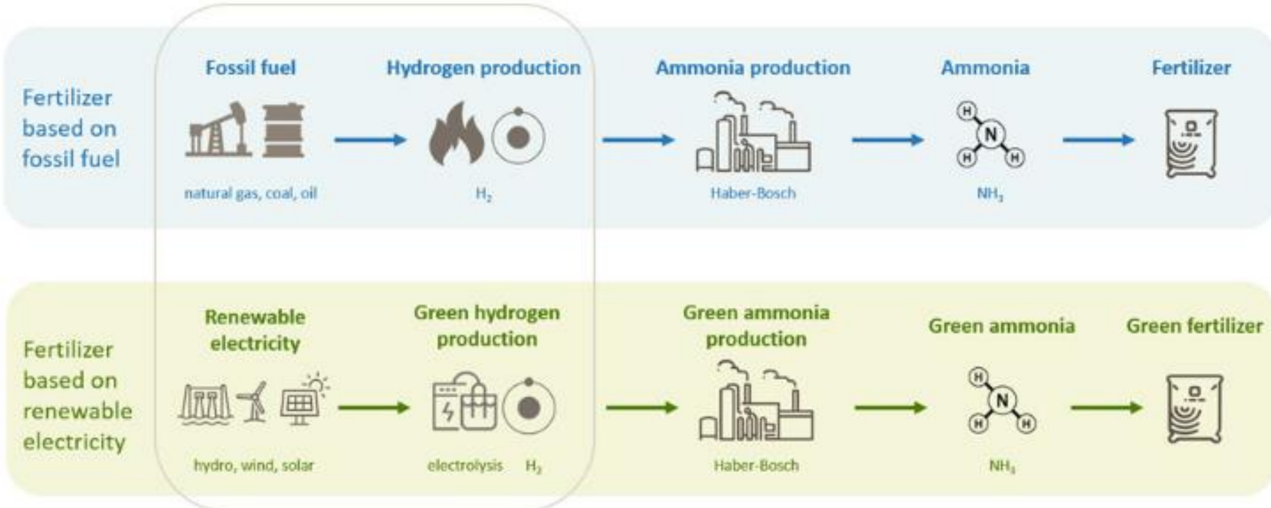
Source: U.S. Farmers and Ranchers Alliance

Green Fertilizer

Green fertilizer pertains mainly to the production of ammonia-based nitrogen fertilizers, whereby renewable energy is used in place of fossil fuels during the production process. Nitrogen is a key commercial fertilizer used by farmers, alongside potassium and phosphate.

However, green fertilizer can also refer to fertilizer made from waste crop residues, and it can also be associated with adjacent products like biochar and biostimulants (bacteria, enzymes, and other microorganisms).

Figure 9: Green Fertilizer Visual



Source: Yara

<u>No/Limited Till</u>

No or limited till practices are a planting preparation technique that involves moderated disturbance of the soil via no or limited tillage of the ground prior to seeding, allowing key nutrients and microorganisms to remain in the soil while also protecting against erosion.

Figure 10: No-Limited Till Visual

Source: EOS

The techniques above – and regenerative agriculture more broadly – are sometimes referred to as climate-smart agriculture (CSA), meant to envelop an approach that addresses and plans for the risks presented by climate change on the agriculture sector. In early 2022, the USDA Secretary, Tom Vilsack, announced that the agency had created a program called Partnerships for Climate-Smart

Commodities (PCSC), designed to help U.S. farmers, ranchers, and forest landowners adopt climate-smart practices to successfully navigate developing climate risks and opportunities. As discussed in the **POLICY** section ahead, the PCSC program makes available $3.1 billion for partnerships that support the production and marketing of climate-smart commodities via a set of pilot projects lasting 1-5 years. USDA anticipates reaching more than 60,000 farms and 25 million acres of working land as part of PCSC.

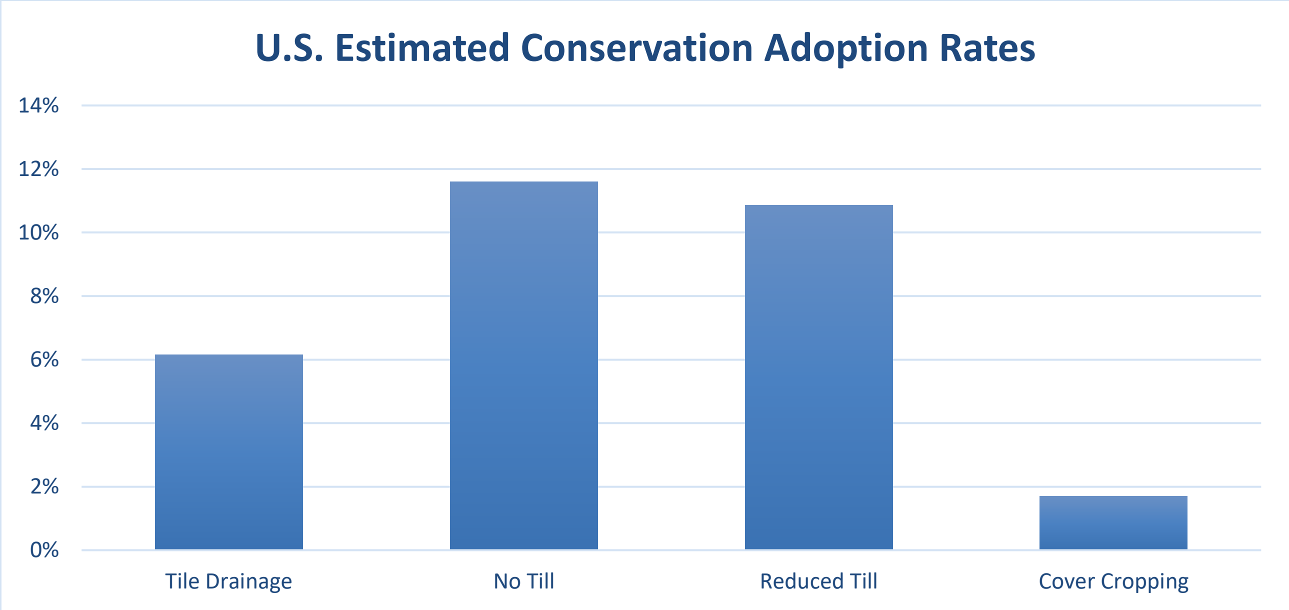
U.S. MARKET SIZE & PROJECTED GROWTH

Regenerative Agriculture

As of 2022, the market size for regenerative agriculture in the U.S. is estimated to be near $350 million, based on a global market value estimated at $975 million. Going forward, a mid-teens compound annual growth rate (CAGR) is anticipated for the sector out to 2032. It is important to note that estimates of market value for regenerative agriculture vary meaningfully, depending on definition of practices used within the space. The aforementioned $350 million value for the U.S. includes only practices consistent with the USDA's focused view towards regenerative agriculture (see previous section). However, if one includes products like agricultural biologicals such as biostimulants and the like, the estimated market value for the space swells to roughly $3 billion in size. A similar CAGR is projected for the larger market estimate, as well.

The USDA tracks some regenerative agriculture-related conservation practices in its annual *Farms and Land in Farms* report published each February. These practices include No-Till, Reduced-Till, Cover Cropping, and Tile Drainage (we consider tile drainage to be a regenerative agriculture practice based on purposeful investment into farms in an effort to remove flood/erosion risk and redirect water supplies). AP has built a workbook for each state and then consolidated results into a U.S. average figure. Across the country, as a whole, cover cropping occurs on 2% of American farmland, while tile drainage is implemented on 6% of farms. Reduced till practices take place on 11% of farmland, while no till takes place on 12% of farms (see **Figure 11**). The highest cover cropping percentage is in Maryland, where 21% of farms are estimated to use the practice. The highest tile drainage percentage is in Iowa, where 46% of farms are estimated to use the practice. The highest reduced till percentage is in Illinois, where 35% of farms are estimated to use the practice. And the highest no till percentage is in Delaware, where 46% of farms are estimated to use the practice.

Figure 11: U.S. Regenerative Agriculture Practice Adoption

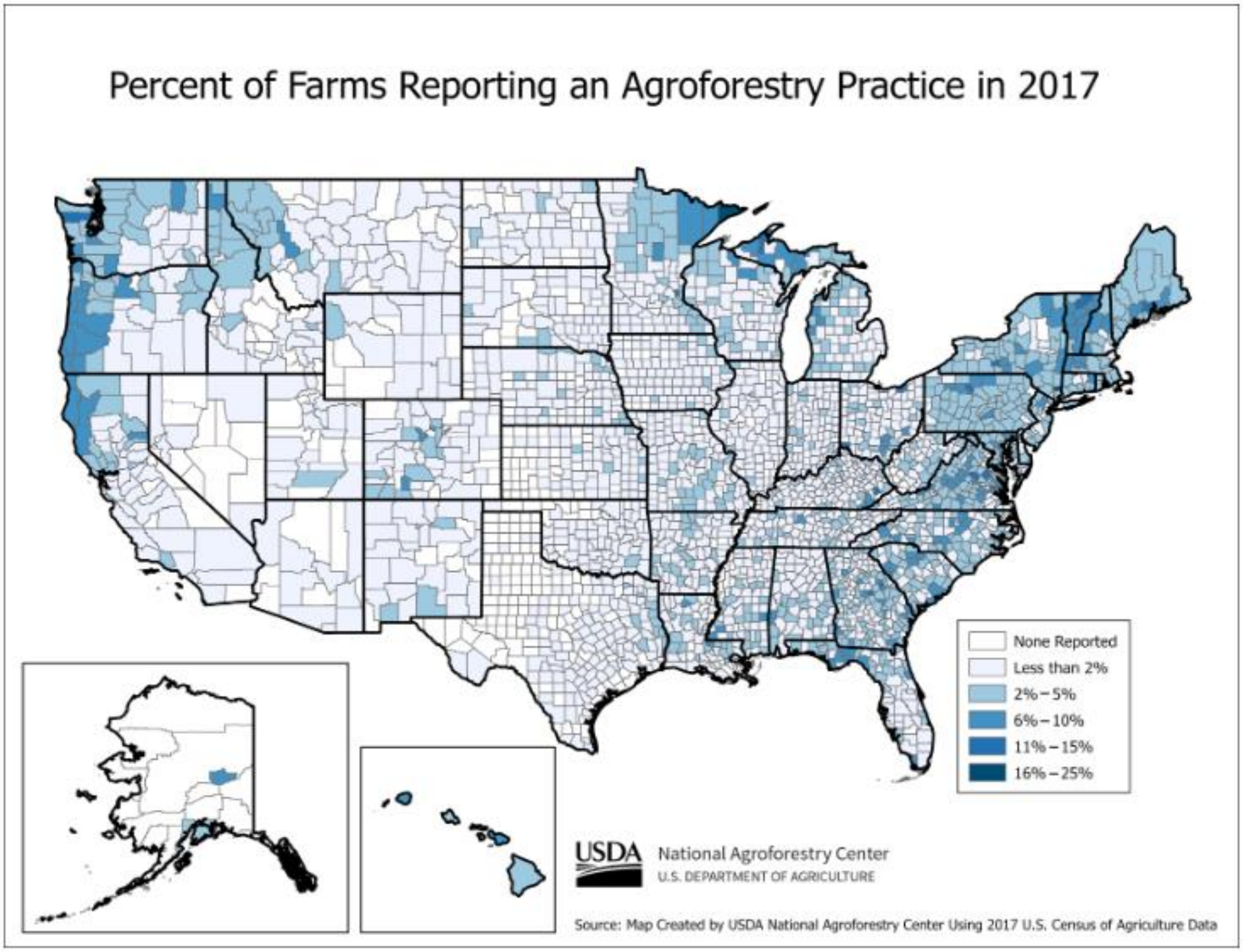


Source: USDA, Agroforestry Partners

Agroforestry

In the 2017 Census of Agriculture, the USDA added the following question to its survey, "At any time in 2017, did this operation practice alley cropping, silvopasture, or forest farming, or have riparian forest buffers or windbreaks?" Today, the only official datasets on agroforestry in the United States stem from this question. Based on collected data, a little under 31,000 farm operations in the U.S. responded that they had at least one agroforestry practice in place at the time, representing 1.5% of all farm operations in the country.

Figure 12: U.S. Agroforestry Map



Source: USDA

The states with the highest overall number of farms practicing agroforestry are Pennsylvania (1,657), Virginia (1,526), Oregon (1,467), Texas (1,347), and Missouri (1,311).

The states with the highest percentage of farms using agroforestry:

1) Vermont: 7.2%
2) Maine: 4.8%
3) Hawaii: 4.7%
4) Massachusetts: 4.1%
5) New Hampshire: 4.1%

There are a handful of private enterprises conducting agroforestry operations across the U.S. today. Agroforestry Partners is a joint venture between Cargill, Walnut Level Capital, and Propagate, with the latter partner responsible for tree planting, maintenance and management. We believe that AP/Propagate is one of the more active participants in the market today. Canopy Farm Management and the Savanna Institute are active in the space, alongside the Regenerative Design Group, Working Trees, Crannmor, WorldTree, and Terviva. Based on recent-year planting estimates and associated costs, we believe that the cost basis value of the U.S. agroforestry industry presently amounts to roughly $30 million, or higher. We believe that market value is likely well above this number, at present; for instance, if one uses the USDA figure of agroforestry taking place on 1.5% of all farm operations in the country, this equates to almost 500,000 acres of agroforested land when accounting for an average farm size of 446 acres and an assumed farm utilization rate of 3.5% (we assume that agroforestry implementation *per acre* is slightly over double the rate taking place *per farm*). If the tree density stocking rate is 5 trees per acre (to account for a wide variety of agroforestry applications), this would create roughly 2.3 million trees now present in U.S. agroforestry operations today. At a market rate of $30 per tree, this would theoretically create a current market value of ~$70 million for U.S. agroforestry operations. Based on volume growth estimates alone, we believe that the industry is growing by roughly 150% YoY, or more, at present.

AGROFORESTRY MARKET SEGMENTS

No one agroforestry system is inherently better than another, and many different options exist for farmers and landowners around the country. The practice of agroforestry is most often determined in large part through the consideration of A) geographic location and the B) goals of the producer. Geographic location will have a direct say in what type of tree/plant species can grow and thrive in a particular region, with important factors related to the species' ability to withstand heat, cold, drought, flooding, pests, etc. A number of guides exists to help agronomists and farm managers with these decisions:

- NRCS Plant Materials Centers
- USDA Plants Database
- USDA Plant Hardiness Zone Map
- USDA Tree Advisor
- American Horticultural Society Plant Heat-Zone Map

Additionally, producer goals are a critical factor in determining the correct type of agroforestry application to use on a given field or farm. Landowners and farmers may be seeking increased crop production, improved or more resilient income, higher surrounding water quality, better soil health, wind protection, enhanced biodiversity, or a combination of outcomes. Different tree species perform different functions and provide varying services, as a result. Thus, the right type of agroforestry approach combines technical knowledge and expertise with local conditions on the ground, while also catering to farmer/landowner demands. For the sake of this primer, we are focusing on three different market segments: tree nuts, shrub fruit, and timber. Tree fruit & livestock fodder are additional segments.

Tree Nuts

Many different trees can be used in agroforestry systems, however our focus of this report is on nut trees that can supply an added harvest and thus incremental income for farmers and simultaneous returns for investors. Main tree nut varieties include cashews, walnuts, almonds, pistachios, pecans, hazelnuts, chestnuts, and brazil nuts. The global tree nut market is large, with an estimated growth rate (CAGR) of 8.75% from 2022-2030, according to Market Research Future. Demand growth for tree nuts has been driven by consumer preference for healthier ingredients, with nuts used in a variety of applications (direct/raw, culinary, baking, confectionery, breakfast cereals, snacks, beverages, etc.). Specialty crops like tree nuts also tend to provide higher and more consistent returns to growers, relative to traditional row crops.

The cultivation of nut trees will differ depending on the variety or specific cultivar being planted. That said, nut trees will generally grow and mature to a height of over 20-30 feet, with some varieties growing to 50 feet, or higher. Agroforestry operators will generally want to start by planting trees 20 feet apart in length, with between-row width considerations dependent on what type of crop will be intercropped between the trees. Some orchard-band plantings will start with a relatively concentrated planting density of 20x20, while other alley-cropping approaches may plant at a density of 20x80 or 20x120+ in order to allow for a traditional crop to be planted in the tree alleys. As nut trees mature, pruning and thinning (removing trees) will likely be required in order to optimize production from the agroforestry system. Nut trees vary in the time that it takes to produce a commercial harvest; most nut trees will start yielding nuts within a few years, however commercial harvests shouldn't generally be expected until year 7 or later for many species. Some nut trees also produce alternate-bearing crops, meaning that production volume can vary meaningfully year-to-year.

Tree nuts are one of the only food groups that sequester enough carbon to offset their own downstream supply chain's carbon footprint. Chestnut agroforestry systems, for instance, draw down roughly 3 tons of CO_2e per acre per year, for 30+ years, which is a high carbon accrual in an absolute sense. In comparison, cover cropping will draw down roughly 0.2 tons/ac/year for 6 years.

Tree nuts are perennial staple crops, containing protein, oils, and starches. One acre of nuts will produce 3-9 million calories per year, or enough to feed 3-10 people all of their sustenance for one year. Nut trees thus negate tradeoff between "feeding the world" and managing carbon & ecology: consider that chestnuts draw down 1.4 tons of CO_2e per person fed per year. Corn, in comparison, emits 0.6 tons of CO_2e per person fed.

An operational scale of 140 acres of chestnuts constitutes a commercial operation, contingent upon the capacity of one chestnut harvester, which resembles a street sweeper. This minimum-viable-commercial farm size is slightly smaller than the largest mature chestnut farm in the United States.

Shrub Fruit

Shrubs (aka bushes) are generally defined as smaller perennial woody plants that stand erect or lie close to the ground, oftentimes having a height below 10-15 feet and stems that are less than three inches in diameter. There are many different types of shrubs on the market, including witch hazel, lilacs, dogwood, holly, and rose bushes. Many shrubs are used for landscaping purposes, however our focus in this report relates to a shrub's ability to provide fruit and thus an incremental food-crop revenue source for farmers.

Fruiting shrubs make up a wide list and include blueberries, currants, elderberries, serviceberries, seaberry, and goji berries, among others. Shrub fruit tends to produce a first crop much quicker than commercial harvests from trees; for instance, blueberries will return fruit in 2-3 years. Shrubs have different pest and weather risks relative to trees, however they also start yielding income opportunities much more quickly.

Shrub fruit management can be mechanized, from pruning, to weed & pest management, to harvest. Minimum commercial scale for blackcurrants is roughly 30 acres, with the largest blackcurrant farm in the United Kingdom being 700 acres (Ribena supply chain). Shrub fruit is more management-intensive than tree nuts, but less management-intensive than tree fruit. Blueberries, being as appealing as they are to eat, exhibit market saturation with roughly 100,000 acres in production in the United States. Niche shrub fruit such as blackcurrants and serviceberries could likely scale to a much smaller share of market with active development efforts and consumer education, absent a serendipitous boom in popularity.

Shrub fruit exhibits higher carbon sequestration than row crops such as corn and soy: small branches and permanent soil cover are sufficient to provide a net-positive result and a creative impact report. However, carbon-interested parties will likely want to look to other species for meaningful climate impact.

Timber

Timber represents an important raw material for many industries around the world, including housing, infrastructure, paper products, fuel, landscaping, and packaging products, among others. Trees are grown specifically for sale into the global timber industry, representing a potentially attractive return opportunity for agroforestry operators. Although the timber industry generally talks in terms of sawlog and pulpwood/fiber markets, timberland operators generally talk in terms of tree types in production.

Trees are divided into two categories: deciduous and evergreen. Deciduous trees are hardwood trees that shed their leaves for some part of the year. Evergreen trees are generally softwood coniferous trees that remain green and functional across the year. Thus, trees will sometimes be categorized as simply hardwoods or softwoods, with hardwood trees having broad flat leaves that keep their seeds in an outer casing (such as a nut or a berry) and softwood trees reproducing by forming cones that emit pollen and spread to other trees.

Lumber mills and buyers tend to classify timber based on its end use. Roundwood refers to timber that is cut from a single tree, sold as dimension lumber (supports for buildings and structures…e.g., 2x4s), boards (decorative use), or utility poles ("poles"). Appropriate attributes of roundwood include straightness of the trunk, quality of the wood, and larger in size (trees are often evaluated on diameter breast height, or DBH, which is measured at a 4.5 foot height from the ground). Wood sold in roundwood end products tend to retain their carbon storage for long durations. Smaller trees and/or leftover pieces are sold into the pulpwood/fiber markets, which are responsible for producing paper products, wood chips, and other related products. Wood sold in fiber end products tend to retain their carbon storage for short durations. As a general rule of thumb, timber stands are harvested every 20-40 years, with deciduous trees cut in the late fall or winter and coniferous/evergreen trees cut in the spring and summer months.

Timber has the highest potential for scale across acreage. There are currently 35 million acres of pine plantations in the Southeast United States – many of which could be managed as silvopasture (newly planted or existing plantations). Timber *can* scale down to roughly 60-90 acres in a given location, with milling contracted out and sales done in-house. A mid-sized commercial operation can be established with 1,000-1,800 acres of black locust or hybrid poplar.

Timber has traditionally been reserved for low-opportunity-cost sites: wet, excessively well-drained (sand), flood-prone, or steep ground. However, timber yields are greater on prime agricultural land. Riparian areas: along waterways but with prime-ag soil, can be a good location for short-rotation timber trees that will absorb 4.5x as much nutrient runoff as grass buffers.

Alley cropping with timber trees is well studied, but rarer in practice. Rows of short-rotation timber trees spaced at greater than 130 feet, with grain grown in between, can provide significant above-baseline income without compromising grain yields. Farmer buy-in is imperative for this practice to scale. Alley cropping *can* yield an IRR up to 8-10% and 0.63 tons/ac/year CO_2e from the timber component alone, *and* a manager will have to understand cultural constraints.

AGROFORESTRY INDUSTRY SCALING CHALLENGES

Financial

The financial cost of agroforestry adoption is a very real hurdle for scaling the industry. To date, farmers and landowners have been expected to proactively convert productive land over to agroforestry at their own cost, only to wait multiple years to begin receiving a questionable income stream off woody crops that they have never grown before. The calculation has simply not been a good offer.

We believe that tree procurement and installation costs break down anywhere from $3,000 to $10,000 per acre, inclusive of tree stock, equipment, labor, and other capital expenditure and operating expense variables. This estimate is the total cost that we believe most producers would experience over the first three years of the project. We believe that ongoing site management can average anywhere between $400-$1,000 per acre, each year, during the life of an agroforestry project. Additionally, we see harvesting and processing costs approaching $900-$1,500 per acre, each year, during the life of the project, with initial years at zero and one or two years of above-average cost based on related asset purchases. Depending on the first year of commercial harvest, producers are also responsible for sales, marketing, and distribution expense. We believe that the latter averages anywhere from $150-$700 per acre during offtake years. There is no doubt that this substantial up-front cost in the form of procurement, installation, and site management is a clear hurdle for agroforestry adoption, especially as the farmer or landowner is asked to remove production and thus income from these fields.

Once agroforestry revenues commence, returns can be attractive if the operation is structured appropriately. For instance, chestnut fields have the potential to drive revenue of $3,000-$5,000 per acre in many instances, making up over time for up-front costs while also clearing ongoing operating expenses at an attractive margin. Fruit & nut crops have historically been the most profitable crop types per acre in the US. Thus, the right type of financing – along with the structure of this financing – can be a critical factor for farm adoption and land conversion of agroforestry practices. The potential for secondary income options like carbon offsets are an added bonus for economics to the farmer, landowner, or financier.

Technical

Implementation

Many nurseries where tree stock is sourced are not set up for wide scale adoption of agroforestry in the U.S. This is one of the main limiting factors of agroforestry today. To be sure, there is the ability to buy fairly large-sized quantities of trees and shrubs in the spot market, but these will be more expensive, and they will also vary in quality. Ultimately, such conditions will hurt production, financial return, and scalability/confidence over time. Ideally, tree stock will be pre-purchased 18-24 months prior to accepting delivery, such that nurseries can properly plan and prepare for the type of scale and uniformity desired by the producer. This requires appropriate financing, knowledge, and confidence of forward projects.

Agroforestry implementation and land conversion also requires an appropriate amount of ground preparation, such that trees begin a healthy life in soils that are properly appropriated for their growth. Soils that have been in consistent monocropping over time could require subsoil ripping, soil amendments, and time under cover crops in order to rebuild their microbiology and structure. Seasonal planting windows are also important, as bare root trees tend to establish better during the early spring while potted trees tend to establish better during the fall. Thus, if the appropriate tools and planning aren't in place for proper system design – or if these design/planning tools aren't scalable or repeatable, themselves, across varying landscapes – agroforestry implementation work will likely suffer as a result.

Management/Marketing

Once woody crops have been planted, ongoing maintenance and management will present new challenges for producers, varying over timescales and geographic locations. As a category, the pest and nutrient profile for these crops will differ from traditional row crop pests and nutrient needs. As well, pest concerns and nutrient needs for young trees and shrubs will be different than those of older trees and shrubs. The same can be said for weed management and water requirements. New crop types come with new pest management strategies where we can learn from existing scaled up systems with a lot of expertise, such as apples or almonds. Likewise, near-term experience gained on one field may not be easily transferable to a different field in another state (or county). Harvest equipment and knowledge is a related area of concern for the industry. Depending on the crop types selected, the equipment set for agroforestry crops is not as mature as traditional row crops, which could lead to physical asset gaps as the market expands. These dynamics place pressure on the ability of the agroforestry space to scale efficiently and will likely lead to competitive advantages for those operators that have select expertise in this area.

The marketing profile of woody crops is also much different than traditional row crops like corn, soybeans, and wheat. The latter can be easily sold to grain traders that act as a broker for moving these crops further down the wholesale channel to food or beverage companies. Such avenues may not exist for fruit or tree nut crops. Instead, farmers and their partners may be responsible for negotiating direct offtake of these crops with consumer packaged goods companies or retail buyers, in many instances. This dynamic adds another layer of complexity for the scaling of agroforestry practices, insofar as the ability to market and deliver large volumes of product. Aside from relationships and negotiating prowess, stakeholders will also need to be knowledgeable about ingredient nutrition, product formulation characteristics, market fundamentals, and consumer trends. If offtake agreements are not structured appropriately – or if they end up deteriorating after initial execution – this could severely hurt return dynamics for agroforestry operators and thus future expansion plans.

Monitoring, Reporting, and Verification (MRV)

It is our expectation that external financing will be required to fund early agroforestry adoption and continued expansion in coming years, through both public and private sector channels. Although some of these capital sources will seek financial returns as a frontline consideration, we believe that the vast majority of them will simultaneously demand a wide set of nature-related returns, as well. We expect private sector funds to be held accountable by their own investors and managers, while public sector funding sources will likely be held accountable by voters and the media. As such, proof of positive nature-related outcomes will become increasingly important in coming years…and are likely to serve as a governor on agroforestry industry scaling efforts going forward. These monitoring, reporting, and verification (MRV) actions will therefore take center stage as important proof points for a number of different stakeholders. To date, some nature-based carbon offsets like REDD (reducing emissions from deforestation in developing countries) projects have come under considerable pressure due to measured results vs. advertised sequestration promises. AP is aware of some energy companies that have stopped buying REDD offsets, as a result, removing an inherent layer of funding for deforestation projects.

Scientific research has shown that agroforestry practices can drive significant benefits for agricultural soils, to include enhanced soil carbon storage levels, improved water infiltration rates, and greater microorganism presence (which in turn helps plant growth). However, numerous papers have recently been written on the challenges associated with soil carbon measurement. Agroforestry does not rely on soil carbon for sequestration, and rather, relies most heavily on above ground and below ground woody biomass, which is more easily modeled, monitored, and verified relative to soil carbon. Modeling is done through allometric equations which are well accepted as reliable modeling tools.

Many of the new MRV technologies on the market are unproven and/or rely on computer modeling that may lead to questionable results in varying locations. MRV services can also be expensive, prohibiting some producers from scaling and/or delivering a required service to financiers and other stakeholders. In short, it will be critical for MRV providers to scale themselves and deliver products and services that gain trust among users and the broader public. Without successful MRV data development, the agroforestry industry might expand quickly, only to suffer an eventual collapse. Select projects and organizers can insulate themselves from this risk, in our view, however this will take careful planning and development.

Cultural

Multiple cultural hurdles exist regarding the adoption of agroforestry in the United States. Farmers, as a group, are more risk-averse in the sense that they eschew novel practices and instead tend to rely on experience and historical methods of production. Many farmers work on land that has been handed down through generations, and they are particularly fearful of being the one family member to “lose the farm.” Thus, familiarity, comfort, and experience/confidence tend to breed a repetitive approach year after year, particularly given that U.S. government support and private food markets center on a handful of staple crops in the U.S. The average age of American farmers has been steadily rising in recent decades, and we believe that older farmers are less likely to take a chance and implement new practices on their fields late in their careers, with the exception of a select number of legacy focused farmers. Farmers are also increasingly being sold a wide array of regenerative agriculture practices available to them, with a litany of advertised benefits potentially becoming “noise” that can lead to inaction. Carbon market benefits and their related calculations for each farm have left some farmers confused about why their farms score a certain way on carbon evaluations, along with what this means for their bottom line.

A separate cultural hurdle relates to the adoption of practices that may not be aligned with community values and ideologies. Rural American communities put farmers and their neighbors in close contact with one another on a consistent basis. The adoption of trees on agricultural fields could be viewed by some as politically-charged, while other neighbors might confuse prep work and/or tree tubes for solar energy installations, another hot-button topic in rural communities.

Finally, farmers simply like to plant corn, soybeans, and wheat. Corn, in particular, is viewed as an attractive crop to grow on American fields, and farmers tend to take pride in having this crop planted on their properties. There are also strong established markets for these crops, which makes farmers feel more comfortable about their ability to manage sales and offtake, relative to potential lack of wholesale or retail demand for agroforestry crops.

All of these cultural factors together create very real headwinds for the adoption of agroforestry in the U.S., on par if not more important than financial and technical hurdles. The industry would be wise to proactively understand these cultural challenges, while working with trusted voices and partners in these communities to tell its story. Importantly, the agroforestry story should center on the economic case for adoption, along with direct benefits to the producer’s land.

AGROFORESTRY VALUATION

Corporate Valuation vs. Project Finance

Corporate Valuation

Agroforestry Partners believes that the total addressable market (TAM) value of the American agroforestry industry can be viewed in terms of asset value or revenue value. From an asset value perspective, an investor can consider existing or future tree purchases/plantings and then attach a per unit price assumption to these trees. This analysis would be followed by a market share assumption for any given entity. Likewise, a revenue value approach could consider average crop (volume x price) and carbon offset receipts for the industry and attach a market share assumption for the given entity.

For chestnuts, as one crop example, it is estimated that 2017 acreage in the U.S. was roughly 3,500 acres. As the industry approaches 2024, we believe that American chestnut acreage currently sits in a range of 7,000-9,000 acres, inclusive of spring 2024 plantings. We assume an average planting density of 50 trees per acre across the U.S. to arrive at a total commercial tree count of 400,000 trees at the midpoint of our acreage estimate. Purchased chestnut tree costs have a wide range, with 1–2-foot seedlings going for ~$3.50/tree, 1–2-year bare root seedlings going for ~$8.50-$13.25 per tree, container seedlings going for upwards of $17.50 per tree, and specific cultivars ranging anywhere from $17-$40 per tree. We assume an average price of $30 per tree off the nursery to arrive at a total asset value of $12 million for the commercial chestnut industry in the U.S., however this value will of course change relative to existing conditions on the ground alongside fundamentals in the wholesale chestnut market. Clearly, weather events or poor management can impact the asset value of specific fields, while supply/demand imbalances for chestnuts can reverberate back onto asset values of specific farm or orchard operations. Based off a perpetuity calculation of the industry’s total asset value (see revenue assumptions below), inclusive of a 20%

cash flow margin, a 2% growth rate, and an 8% weighted-average cost of capital (WACC), one could approximate an industry market value near $125 million, at present.

Agroforestry Partners assumes an average yield of 30 pounds per tree for the commercial chestnut industry in the United States. Based on this assumption, the U.S. would produce an annual run-rate chestnut volume of at least 12 million pounds by the year 2030, as all plantings current through spring 2024 begin to yield commercial harvests. For context, it is estimated that 2017 chestnut volumes produced in the U.S. approached roughly 3 million pounds. Domestic chestnut prices have averaged $4.50/lb over the past 5+ years. U.S. export prices for in-shell chestnuts have averaged $2.72/lb over the past 5+ years. These prices will likely see pressure as more volume comes onto the market. A third market opportunity related to chestnut flour in food and beverage formulations is in development and offers attractive pricing in the $3.50-$4.50 per raw pound-equivalent range. Chestnuts can also be used for animal feed, however market prices are not viable at roughly $0.10-$0.50 per pound, in our view. If we assume an average market-wide price of $3/lb, the TAM value for American chestnut industry revenues would approach $36 million by 2030. Alongside an assumed revenue multiple of 5.0x, one could approximate an industry market value near $180 million, at present.

Project Finance

For valuation pertaining to the financing of individual projects, we believe that net present value (NPV) and internal rate of return (IRR) calculations are most appropriate. Agroforestry Partners has built a proprietary model for 10,000 acres of chestnuts that informs investment decisions into its first fund. Interested investors may request access to this model, which showcases an NPV of almost $60 million and a net IRR to investors of 15%-20%. Agroforestry Partners plans to build additional models for hazelnuts and timber roundwood.

According to private markets data firm *Burgiss*, historical global real asset returns (measured as IRR) averaged 9.5% from 2000 to 2022. Within this asset class, global natural resource returns averaged 8.6% over the same time period, while North American natural resource returns averaged 10.3%. Global timber returns have averaged 5.1%. Nature-based investment opportunities have been relatively limited during the past 20 years, and their returns have not allowed for much alpha over the cost of capital for many asset managers. All the while, nature remains under significant pressure, with much of this due to current agricultural practices.

POLICY

Solid Federal Support in Place Today

The U.S. government provides a wide network of support to farming enterprises and their rural communities, mainly as a result of policies within the U.S. Farm Bill. The Farm Bill itself is a comprehensive piece of legislation, passed by the government every five years, governing American policies related to food, farming, and general rural interests. The last bill was passed in late 2018, which makes 2023 another "Farm Bill year." At the time of this writing, Congress is presently negotiating this year's bill, with expectations that total funding could ultimately amount to over $1 trillion for the first time in history. The majority of Farm Bill funding typically goes towards the cost of the Supplemental Nutrition Assistance Program (SNAP), or what is typically referred to as food stamps. Sizeable amounts of funding also go towards the federal crop insurance program, related Agriculture Risk Coverage (ARC) and Price Loss Coverage (PLC) programs (a.k.a. Commodity and Related Programs), and conservation funding.

There are three main government agencies within the United States Department of Agriculture (USDA) that are tasked with dispersing funds and knowledge related to crop insurance, commodity programs, and conservation efforts: the Farm Service Agency (FSA), the Natural Resources Conservation Service (NRCS), and the Risk Management Agency (RMA). These agencies are largely organized around the type of work and support that they offer, stretching across four areas: 1) funding/finance, 2) risk management, 3) conservation, and 4) disaster recovery. As shown in **Figure 13** at the end of this report, FSA is entirely responsible for broad funding/finance applications like Farm Operating Loans, while also being entirely responsible for disaster recovery applications like the Livestock Indemnity Program (LIP). FSA also does some key work within the risk management and conservation silos, managing ARC and PLC in the risk management area and governing the Conservation Reserve Program (CRP) in the conservation area. RMA is solely responsible for the federal crop insurance program, which is housed inside the risk management silo. By and large, NRCS administers most programs inside the conservation area – which is the focus of this report.

The U.S. Farm Bill is responsible for spending some appropriated funds, to include agricultural funding that was passed as part of the Inflation Reduction Act (IRA) in 2022. The IRA aims to spend $369 billion on energy security and climate change programs in the U.S.

over the next 10 years, including $19.5 billion over 5 years for climate-smart agriculture via the NRCS. Within the NRCS, most of these funds will be disbursed through EQIP, RCPP, and CSP (please see **Figure 13**). The IRA also makes available $4.6 billion in Climate Pollution Reduction Grants (CPRG) from the EPA to all industries working to improve air quality.

Outside of the IRA, the USDA also announced in 2022 that it would fund $3.1 billion into partnerships that support the production and marketing of climate-smart commodities (PCSC) via a set of pilot projects lasting 1-5 years. Funding is delivered through the Commodity Credit Corporation (CCC), which itself has access to $30 billion of borrowings from the U.S. Treasury. Targeted practice categories include soil health, nitrogen management, livestock partnership, grazing and pasture, agroforestry, land restoration, energy efficiency, wetlands, and rice production. AP and its partners are a party to a $60 million award under the PCSC program to expand agroforestry adoption across the United States.

Other U.S. government support includes grantmaking from the National Institute of Food and Agriculture (NIFA) and The Sustainable Agriculture Research and Education (SARE) Program. NIFA was created as part of the 2008 Farm Bill and is a USDA agency that provides leadership and funding for programs that advance agriculture-related sciences. Under NIFA, the Agriculture and Food Research Initiative (AFRI) is the nation's leading competitive grants program for agricultural sciences. NIFA awards AFRI research, education, and extension grants to improve rural economies, increase food production, stimulate the bioeconomy, mitigate impacts of climate variability, address water availability issues, ensure food safety and security, enhance human nutrition, and train the next generation of the agricultural workforce. Appropriations funding from 2022 funded AFRI at $445 million. SARE was established in 1988 and is now funded by NIFA, working to fund projects that advance agricultural innovation and stewardship of the land, air, and water. Its competitive grants program has provided $383 million in funding across 8,467 projects since 1988.

RESOURCES

Research

There is a clear need for educational resources pertaining to regenerative agriculture, broadly, and agroforestry, specifically, in the market today. Agroforestry Partners aims to fill this void with industry primers, segment backgrounders (e.g., carbon offsets, crop insurance, soil and plant growth), spotlight reports, and news headline tracking. Much of this information can be found on our website and our LinkedIn page.

Other quality research-related resources that we've found include:

- Sustainable Markets Initiative Agribusiness Task Force
- American Sustainable Business Network
- Kiss the Ground and Regenerate America
- The Association for Temperate Agroforestry
- The Savanna Institute
- World Agroforestry (ICRAF)
- University of Missouri Center for Agroforestry
- Foundation for Food & Agriculture Research
- UIUC Institute for Sustainability, Energy, and Environment (iSEE)
- The Land Institute

Government

As mentioned previously, the National Agroforestry Center (NAC) has been created by the USDA to accelerate the adoption of agroforestry inside the United States. The USDA Agroforestry Strategic Framework provides the roadmap for the agency's role in advancing agroforestry around the country. A wealth of related resources can be accessed, here.

The PCSC program related to an available $3.1 billion for partnerships that support the production and marketing of climate-smart commodities will likely be an important catalyst for industry growth. The program can be found, here. Additional government funding options made available to agroforestry operations could include funding under the Inflation Reduction Act (IRA) in the form of $19.5 billion from the Natural Resources Conservation Service (NRCS) for climate-smart agriculture conservation efforts and/or $4.6 billion of EPA funding under the same law for Climate Pollution Reduction Plans. NIFA's funding for programs that advance agriculture-related sciences and the SARE Program that funds projects to advance agricultural innovation and stewardship of the nation's land, air, and water are important contributors to industry growth, as well.

The NRCS is a key entity within the USDA that oversees conservation-related funding and management. A wealth of related resources can be found by accessing its website, here.

Soil/Agronomy

There is a wealth of soil data and related educational materials available to investors, farmers, and other stakeholders when evaluating agroforestry operations. We have broken these resources out into two buckets: USDA and non-USDA (external) resources.

USDA

- NRCS National Resources Inventory - *statistical survey of land use and natural resource conditions and trends on U.S. non-Federal lands.*
- NRCS Soil Survey Geographic Database (SSURGO) – *visual and laboratory review of soils and land across the United States.*
- USDA National Cooperative Soil Survey: Soil Characterization Data – *lab data reports on U.S. soils by location.*
- USDA Web Soil Survey (WSS)
- NRCS Plant Materials Centers
- USDA Plants Database
- USDA Plant Hardiness Zone Map
- USDA Tree Advisor

External

- American Horticultural Society Plant Heat-Zone Map
- Global Soil Partnership (United Nations/FAO)
- Coalition of Action 4 Soil Health (CA4SH)
- Soil Health Academy
- Soil Explorer
- Soil Test/Fertilizer Recommendation Support Tool

RISKS

Agroforestry Partners sees a number of risks that could ultimately derail or limit agroforestry adoption in the United States.

Disinterest from the Farming Community

As mentioned previously, there are numerous hurdles to overcome as it relates to farm adoption of agroforestry practices in the U.S., including financial, technical, and cultural challenges. Each of these is very real and should not be overlooked by investors and other stakeholders. External financing – via private or public sources – could dry up based on any number of factors, including interrelated risks mentioned below. Technical issues may provide surprises to agroforestry managers – some of which may not be successfully addressed until years later. No doubt, a learning curve according to commercial adoption will certainly be in place in many instances. Cultural aspects should not be overlooked, as well. Farmers are already wary of pressures related to societal opinions and/or being the one to take a chance and lose the family farm. If agroforestry adoption stalls or begins to be questioned by prominent voices in the media, government, or food industry, the farming community may feel pressured to step away from such practices.

Lack of MRV Options/Accuracy

Monitoring, reporting, and verification (MRV) of data related to agroforestry systems will be a critical tool for validating and certifying environmental and social benefits to society from this work. Many stakeholders will require data to ensure that trees and shrubs are sequestering intended carbon volumes, protecting soils and water, enhancing diversity, and improving farm profitability and community health. Additionally, soil carbon retention will be a key focus area for many stakeholders. Today, many new startup technologies are entering the space, next to more established manual processes for measuring environmental data. Some of these technologies are still unproven, with questions pertaining to their accuracy. Likewise, many MRV services are expensive, which could prohibit some agroforestry adopters from spending money on the right types of data aggregation, depending on their own financial return and cash flow expectations. Bad actors in the MRV space could also lead to a deterioration of trust and, thus, agroforestry adoption.

Tree Crop Failure/Weather

Local weather conditions across the U.S. are becoming increasingly volatile during the year, particularly in summer months, due to the effects of a warming climate. If not properly monitored, wildlife can also have negative impacts on young trees. Depending on location, woody agroforestry crops may be subject to high wind events (derechos, tornadoes, etc.), flooding, drought, or blight. Improper nutrient management could also lead to tree loss, in addition to potential impacts related to poor quality off the nursery. If a farm or field experiences a widescale loss event, financial performance of the agroforestry system could suffer for multiple years, leading to investor losses and the potential for the broader operation to shut down.

Supply/Demand Imbalance for Agroforestry Crops

Prices for crops like chestnuts have been stable for the past 5+ years, leading to attractive returns for growers. However, as more supply is added to the market via agroforestry practices, prices for certain nut and fruit crops derived from trees or shrubs could see pressure and, thus, ultimately lead to smaller than expected financial returns for stakeholders of these operations. Unless outlets like the export and/or ingredient markets are developed or retail markets expand, compressed pricing and margins could lead to sustained lower returns and the potential for broader agroforestry operations to slow.

Regulatory Interference

Under the Biden Administration, the U.S. government has embraced regenerative agriculture, to include funding for agroforestry operations. However, a different executive branch could reverse this trend and work to place restrictions or roadblocks in the place of regenerative agriculture practices. Likewise, members of Congress could restrict funding for these practices if concern grows regarding the fiscal deficit or staple food crop production trends. Congressional members may also move to restrict direct corporate/capital markets investment into U.S. farmland, tempering growth and development of agroforestry practices. The U.S. is increasingly becoming a nation of balkanized states, as well, which means that certain states or regions where agroforestry is currently present could one day move to restrict these operations, their funding, and/or the marketing of products from these farms, based on changing ideologies of connected political parties/governments.

CONCLUSION

Agroforestry represents an important option for delivering economic, environmental, and social benefits associated with the wider regenerative agriculture movement. Agroforestry delivers carbon sequestration, prevention of N_2O emissions, reduced soil erosion, improved crop yields, better nutrient densities, greater water quality, enhanced biodiversity, and more resilient farm income. Although relatively small in value today, we believe that the intentional planting of nut trees, shrub fruit, and timber together with traditional row crops and animal grazing operations has the potential to approach $200 million in market value, ahead, as stakeholders begin to discount production volumes that can arise in 2030. There are numerous industry scaling challenges in place, including financial, technical, and cultural hurdles, but groups like Agroforestry Partners stand ready to solve these challenges alongside growing U.S. government support via larger grantmaking actions and improved technical resources. Like any business or investment, the adoption of agroforestry comes with associated risks; it is up to operators and their networks to work collaboratively to minimize these risks while pursuing attractive outcomes for society and our planet.

Figure 13: USDA Agency Responsibilities by Designated Conservation Support Area

1) Funding

Name	*Agency*	*Detail*
Biomass Crop Assistance Program (BCAP)	FSA	Provides incentives that help farmers grow bioenergy feedstocks and connect with qualified biomass conversion facilities
Down Payment Loans	FSA	Provides a low-interest government loan to help beginning, minority, veteran, and women farmers purchase a farm or ranch.
Farm Operating Loans	FSA	Help producers pay for normal operating expenses. Direct (up to $400,000) and guaranteed (up to $1.75 million) operating loans are available.
Farm Ownership Loans	FSA	Help producers become owner-operators of family farms. Direct (up to $600,000) and guaranteed (up to $1.75 million) ownership loans are available.
Farm Storage Facility Loans	FSA	Provide low-interest loans to build, purchase, or upgrade facilities and equipment used to store, handle, or transport eligible commodities.
Marketing Assistance Loans	FSA	Provide interim financing at harvest time for producers to meet cash flow needs.
Microloans	FSA	Provide farm loans to underserved farmers serving local markets. Farm Operating and Farm Ownership Loans of up to $50,000 each are available.
Organic Certification Cost Share Assistance	FSA	Provides up to 75 percent of organic certification costs for producers, not to exceed $750 per certification scope.
Youth Loans	FSA	Provide operating loans of up to $5,000 to youth ages 10 to 20 to finance income-producing, agricultural projects.

2) Managing Risk

Name	*Agency*	*Detail*
Agriculture Risk Coverage (ARC) and Price Loss Coverage (PLC) Programs	FSA	Protect farm revenue from changes in market conditions. Provides a safety net to farmers and ranchers.
Conservation Stewardship Program Grassland Conservation Initiative	NRCS	Provides financial assistance to conserve grasslands through a single opportunity to enroll in a 5-year contract.
Dairy Margin Coverage Program (DMC)	FSA	Replaces the Margin Protection Program for Dairy. Offers protection to dairy producers.
Federal Crop Insurance	RMA	Offers hundreds of different insurance products.
Noninsured Crop Disaster Assistance Program (NAP)	FSA	Provides financial assistance to producers of certain eligible crops for which catastrophic risk protection plan of insurance is not available.

3) Conservation

Name	*Agency*	*Detail*
Agricultural Conservation Easement Program (ACEP)	NRCS	Helps landowners protect, restore, and enhance wetlands, grasslands, and working farms and ranches through conservation easements.
Agricultural Management Assistance Program (AMA)	NRCS	Helps agricultural producers manage financial risk through diversification, marketing, or natural resource conservation practices.
Conservation Innovation Grants (CIG)	NRCS	Awards competitive grants that drive innovation and develop the tools, technologies, and strategies for next-generation conservation efforts on working lands.
Conservation Reserve Program (CRP)	FSA	Protects soil, water quality, and habitat by removing highly erodible or environmentally sensitive land from agricultural production through long-term rental agreements.
CRP - Transition Incentives Program	FSA	Encourages landowners to sell or lease long term to beginning, socially disadvantaged, and veteran farmers and ranchers willing to implement sustainable practices.
Conservation Stewardship Program (CSP)	NRCS	Helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities.
Environmental Quality Incentives Program (EQIP)	NRCS	Provides financial and technical assistance to agricultural producers to address natural resource concerns and deliver environmental benefits.
Healthy Forest Reserve Program (HFRP)	NRCS	Helps landowners restore, enhance, and protect forestland resources on private lands through easements and financial assistance.
Regional Conservation Partnership Program (RCPP)	NRCS	Promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners.
Voluntary Public Access and Habitat Incentive Program (VPA-HIP)	NRCS	Provides State and Tribal governments with funding or incentives to expand or improve habitat in existing public access programs.

4) Disaster Recovery

Name	*Agency*	*Detail*
Emergency Assistance for Livestock, Honeybees, and Farm-raised Fish Program (ELAP)	FSA	Provides assistance to eligible owners of livestock, and producers of honeybees and farm-raised fish for losses.
Emergency Conservation Program (ECP)	FSA	Provides funding and technical assistance for farmers and ranchers to restore farmland damaged by natural disasters/drought.
Emergency Forest Restoration Program (EFRP)	FSA	Provides funding to restore privately owned forests damaged by natural disasters.
Emergency Loans	FSA	Provide loans to help producers recover from production and physical losses due to drought, flooding, other natural disasters, or quarantine.
Livestock Forage Disaster Program (LFP)	FSA	Provides compensation to eligible livestock producers that have suffered grazing losses due to drought or fire.
Livestock Indemnity Program (LIP)	FSA	Provides benefits to livestock owners for livestock deaths in excess of normal mortality caused by adverse weather or by attacks by animals reintroduced into the wild.
Tree Assistance Program (TAP)	FSA	Provides financial cost-share assistance to qualifying orchardists and nursery tree growers.

Source: USDA

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