Visualizing and Analyzing Agroforestry Crop Scalability & Marketability

by

Ruilin Meng, Yuxuan Gao, Milan Anderson and Qian Xu

Project Advisor: Shannon Brines

Clients: Nathan Ayers of Michigan Agroforestry Working Group

and Ken Asmus of Oikos Tree Crops

A project submitted in partial fulfillment of the requirements for the degree of Master of Science in the Environment and Sustainability

University of Michigan School for the Environment and Sustainability (SEAS)

April 2026

Table of Contents

1. **Abstract.....3**

Part 1: Agroforestry and Perennial Crop Systems

2. **Introduction.....4**
3. **Data and Methods.....5**
4. **Case Study.....7**
5. **Results.....10**
6. **Conclusion(Part 1).....23**
7. **Discussion(Part 1).....25**

Part 2: Marketability of Select Agroforestry Crops

8. **Introduction.....28**
9. **Methods.....29**
10. **Results.....33**
11. **Discussion (Part 2).....43**
12. **Conclusion and Future Developments.....45**

---

13. **References.....46**
14. **Appendices.....47**

Abstract

The first part of our project aimed to evaluate the spatial suitability of multiple perennial crops within Oikos Tree Crops Farm in Michigan by analyzing fine-scale topographic conditions.High-resolution UAV imagery was used to generate a digital terrain model, from which slope values were derived and classified in ArcGIS Pro. Species-specific suitability maps were then developed through reclassification based on the ecological requirements of each crop, including chickasaw plum, quince, wild apple, American persimmon, thimbleberry, chestnut, magnolia, and hazelnut.The results indicate that most areas of the farm fall within gentle to moderate slope ranges (approximately 2–8%), providing favorable drainage and stable soil conditions. Crops such as chestnut, persimmon, and magnolia exhibit large, continuous areas of high suitability, while species like thimbleberry and hazelnut show more fragmented suitability patterns, reflecting sensitivity to localized terrain variation.Overall, the study demonstrates that even subtle micro-topographic differences can significantly influence crop suitability at the farm scale. The integration of UAV-derived data and GIS-based analysis provides an effective approach for identifying optimal planting zones and supports more precise agroforestry planning. These findings highlight the importance of incorporating high-resolution spatial data into sustainable farm design and management.

The primary objective of the second part of the study was to address the gaps in knowledge about the marketability, grow requirements and harvest requirements of crops that have the potential to be integrated into agroforestry systems and commercially grown in Michigan. We relied on Ken Asmus of Oikos Tree Crops and his experiential knowledge to select six regionally adapted crops that have shown high productivity and resilience to pests and disease amongst other resiliency factors. After harvesting these crops on a small scale, we developed twelve value-added products. We then conducted several taste test events at locales in Detroit and Ann Arbor, Michigan, showcasing these crops to collect consumer feedback. We found that of our six ‘best bet crops, Serviceberries/Saskatoons elicited the greatest customer interest and taste test ratings (43 respondents rated it 4.5/5). We used Ken’s grow recommendations, survey responses from the Michigan Agroforestry Working Group and the marketability data we collected to create an educational pamphlet for growers to use. Since several growers from the Agroforestry Working group requested short videos, webinars and/or Youtube videos, future efforts would be to create filmed educational media. After our final taste test survey, we also conducted a Fruit & Nut Cooperative meeting and got together with 9 growers to discuss future efforts to have a shared space, processing equipment and distribution channels to improve marketing capabilities of agroforestry crops.

Part 1: Agroforestry and Perennial Crop Systems

I. Introduction

Agroforestry is a sustainable farming practice that has gained momentum across the world over the second half of the 20th century. The practice originated alongside agriculture itself and has evolved from indigenous knowledge. As a scientific term, agroforestry was first coined in 1977 to describe the practice of combining trees and agriculture and can be defined as follows:

> A collective name for land-use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (crops, pastures) or livestock, in a spatial arrangement, a rotation, or both; there are usually both ecological and economic interactions between the trees and other components of the system. [1]

In the United States, The Natural Resources Conservation Service of the USDA recognizes five official practices of agroforestry that include windbreaks, riparian forest buffers, alley cropping, silvopasture and forest farming and has set standards for its design.

Though it is practiced all over the world, agroforestry practices have had more limited study and application in temperate regions compared to tropical regions [2]. Only an estimated 1.5% (30,853) of U.S. farmers practice agroforestry [3]. These benefits include enhancing soil fertility, reducing nutrient leaching, reducing soil and wind erosion, improving water quality and more regulated hydrological cycles, enhancing biodiversity and landscape quality, increasing aesthetic value, remediation of polluted land, mitigation of greenhouse gases and sequestration of carbon [4].

Technical Barriers

Agroforestry has long been recognized as a land-use system capable of delivering substantial ecological and economic benefits by integrating woody perennials with agricultural crops or livestock [5]. However, adoption and research of agroforestry in temperate areas are limited. According to Smith et al. (2022), only an estimated 1.5% of U.S. farmers actively practice agroforestry, and specific documentation of production-oriented perennial systems in the Great Lakes agricultural landscape is rare

[3]. Some rationale for this difference is that tropical regions provide consistent warmer temperatures and abundant rainfall, which allows diverse tree and crop combinations to grow well together. With proper management, however, temperate agroforestry systems have the capacity to generate income and provide a host of ecological services. Despite the benefits, farmers in Michigan and the Great Lakes region face several barriers to adopting agroforestry practices:

- High initial investment cost
- Complexity of managing cropping systems
- Limited access to region-specific knowledge and technical support
- Limited equipment availability
- Time required to manage agroforestry systems
- Social and economic uncertainties about long-term returns

Recent studies have highlighted the importance of visualizing agroforestry systems to help farmers decision-making, showing that spatial planning tools, GIS mapping, and 3D visualization significantly enhance confidence in agroforestry adoption [6]. Responding to this need, our project focuses on the documentation, geospatial mapping, and scalability assessment of perennial woody crops at Oikos Tree Crops, a pioneering site in southwestern Michigan. By developing accessible digital tools and ranking species scalability through the Farm-SAFE model, the project seeks to bridge the gap between theoretical knowledge and field application, supporting the broader expansion of agroforestry across the Great Lakes farming region.

In order to achieve our goal of providing educational documentation of a productive agroforestry system in a temperate region, we will be working with one grower, Ken Asmus of Oikos Tree Crops. Ken's 40-year-old farm houses over 277 perennial, self-regenerating woody crops and reflects his extensive knowledge of crop propagation and breeding resilient perennials. As he transitions to the next stage of the farm to no longer growing new starts as a nursery, some of this knowledge also risks being lost.

First, we plan to make a database that catalogs the main tree crops that are successfully grown using a 3D digital map that links spatial information with qualitative information about propagation and growth of documented crops. We will also make a structural rating system that can be used to determine the scalability of crops on the commercial level. Once created, we will make these resources digitally available to the Michigan Agroforestry Working Group (MAWG). The Michigan Agroforestry Working Group is a growing organization that aims to create demonstration sites and share

educational resources to help expand the practices of agroforestry across the state. We also plan to share information with other partner organizations, producers, and institutions to support regional agroforestry initiatives.

Secondly, we plan to provide farmers with educational resources and marketability information of select tree crops bred for taste, high yield, etc. at Oikos Tree Crops, so that more farmers have growing, harvesting and marketability information they potentially need to adopt tree crops into their growing systems. We intend to create value-added products and offer taste-test events to gauge potential customer interest and market demand. In turn, we will present this consumer information in combination with grow requirements so growers can see potential market opportunities and avenues of development for value-added products.

We visited Ken's farm in several phases of the Spring, Summer, and Fall of 2025 to assess growth, map precise crop locations, and rate crop scalability. By collecting and organizing information into digital forms and providing crop growth and marketability information, we will be able to aid agroforestry practitioners and help expand the practice of it as a whole.

II. Data and Methods

Data Collection

The primary data used in this study were high-resolution aerial images collected using an unmanned aerial vehicle (UAV). Drone-based imaging provides detailed spatial information that is particularly useful for environmental monitoring and ecological assessments at fine spatial scales. The drone flights were conducted over the study area during favorable weather conditions to ensure optimal image quality and minimal atmospheric interference.

Multiple overlapping photographs were captured during each flight mission to ensure complete coverage of the study area. The drone followed a pre-programmed flight path with consistent altitude and overlap settings, which allowed the images to be processed using photogrammetric techniques. High image overlap was necessary to generate accurate three-dimensional reconstructions and orthomosaic imagery.

Image Processing

The collected drone imagery was processed using ArcGIS Drone2Map, which enables automated processing of UAV images into geospatial products. Drone2Map applies photogrammetry algorithms to align overlapping images, reconstruct the terrain surface, and generate georeferenced datasets. During processing, the software performed several steps including image alignment, point cloud generation, and orthomosaic creation. The resulting orthomosaic provides a high-resolution, geometrically corrected image of the entire study area. In addition to the orthomosaic, other derived products such as digital surface models were generated to support further spatial analysis.

Spatial Analysis

After photogrammetric processing, the orthomosaic imagery and derived datasets were imported into ArcGIS Pro for further analysis. ArcGIS Pro was used to visualize the spatial data, perform land cover interpretation, and conduct spatial measurements within the study area. Visual interpretation techniques were applied to identify key environmental features visible in the high-resolution imagery. These features included vegetation cover, water bodies, and other landscape characteristics relevant to the objectives of the study. Using the GIS environment, spatial features were digitized and organized into thematic layers for analysis.

Mapping and Data Analysis

Spatial analysis tools in ArcGIS Pro were used to quantify the distribution of environmental features identified from the drone imagery. Polygons were created to represent different land cover types or ecological features observed in the orthomosaic image. The spatial extent of each feature type was calculated using GIS measurement tools. These results allowed for the evaluation of landscape composition within the study area. Maps were then produced to visualize the spatial patterns and distribution of the identified features.

Terrain and Tree Height Calculation

To estimate terrain elevation and tree canopy height across the study area, digital surface models and digital terrain models derived from UAV imagery were used. The DSM was generated from the leaf-on survey conducted during the harvest season, when tree canopies were fully developed. This dataset represents the elevation of the highest surfaces captured in the imagery, including tree canopies and other vegetation structures. In contrast, the DTM was generated from imagery collected during the leaf-off survey, when most deciduous trees had shed their leaves. Under these conditions, the

photogrammetric reconstruction was able to better capture the underlying ground surface with reduced canopy interference.

Both datasets were processed in ArcGIS Drone2Map and further analyzed in ArcGIS Pro. To derive vegetation and tree height, the DTM representing ground elevation was subtracted from the DSM representing surface elevation using raster calculation tools within the GIS environment (DSM − DTM). This process generated a canopy height model (CHM) that represents the relative height of vegetation above the ground surface. The resulting dataset was used to visualize both terrain variation and tree height distribution across the farm landscape.

Slope suitability

The slope suitability analysis was conducted using ArcGIS Pro. First, DTM was clipped to the farm boundary.Slope was then derived from the clipped DTM to characterize terrain steepness across the farm. The resulting slope raster was subsequently reclassified into four suitability categories: highly suitable, suitable, marginal, and unsuitable. The reclassification was performed independently for each crop species, with threshold values defined according to species-specific slope preferences reported in the literature. This procedure generated individual slope suitability maps for each crop, representing the spatial distribution of terrain conditions appropriate for cultivation within the farm.

III. Case Study

Study Site

This case study was conducted at Oikos Tree Crops Farm, an agroforestry demonstration farm located in southwestern Michigan. The farm focuses on the cultivation of perennial tree crops that are suitable for temperate agroforestry systems in the Midwest United States. Compared with conventional annual cropping systems, agroforestry integrates woody perennials with agricultural production, offering ecological benefits such as improved soil health, increased biodiversity, and long-term carbon storage, while also providing diversified farm income.

The farm grows a variety of perennial crops including persimmon, chestnut, and other specialty tree crops. These crops are considered promising components of sustainable agricultural systems due to their long productive lifespan and increasing interest in specialty food markets. The spatial arrangement of tree crops across the farm

includes orchard blocks, experimental planting areas, and mixed vegetation zones, creating a heterogeneous landscape that is suitable for geospatial visualization and spatial analysis.

Because of this diversity in crop types and planting patterns, the site provides an ideal case study for applying drone-based mapping and GIS tools to visualize farm structure and analyze the spatial scalability of agroforestry crops.

Drone Data Collection

To document the spatial structure of the farm and support geospatial analysis, aerial imagery was collected using an unmanned aerial vehicle (UAV). Two drone surveys were conducted during different seasonal conditions in order to capture variations in canopy structure and improve the identification of tree locations.

The first drone survey was conducted in **October during the harvest season**, when most trees still had leaves and fruit production was active. Imagery collected during this period clearly captured canopy coverage, tree density, and the distribution of different crop areas across the farm. A second drone survey was conducted in **November after leaf fall**, when most deciduous trees had lost their foliage. Under these leaf-off conditions, the reduced canopy cover improved the visibility of tree trunks, planting rows, and the underlying spatial layout of the farm. This allowed for more accurate identification of individual tree locations and planting patterns.

Both drone flights followed a pre-planned flight path designed to ensure consistent altitude, high image overlap, and full coverage of the farm area. The overlapping aerial photographs enabled accurate photogrammetric reconstruction of the landscape and ensured sufficient data quality for generating geospatial datasets.

Image Processing and Orthomosaic Generation

The drone imagery collected during both surveys was processed using ArcGIS Drone2Map. Drone2Map applies photogrammetric algorithms to align overlapping images and generate geospatial products such as orthomosaic imagery, point clouds, and digital surface models.

The primary output used in this study was a **high-resolution orthomosaic image** representing the entire farm. Orthomosaic generation involved several processing steps including image alignment, dense point cloud generation, surface reconstruction, and

orthorectification. The resulting orthomosaic provides a geometrically corrected aerial image in which spatial measurements can be performed accurately. After processing, the orthomosaic datasets from both October and November surveys were imported into ArcGIS Pro for visualization and spatial analysis.

Spatial Mapping of Agroforestry Crops

Within the GIS environment, the orthomosaic imagery was used to map key landscape features across the farm. Digitization tools in ArcGIS Pro were used to identify and map farm boundaries, field areas, and the locations of tree crops. Particular attention was given to mapping the spatial distribution of agroforestry crops such as persimmon and chestnut. Individual trees or clusters of trees were identified visually from the high-resolution imagery and digitized as point features within the GIS system. These points represent approximate tree locations and provide a spatial dataset for analyzing crop distribution across the farm. In addition to tree locations, broader landscape features such as orchard blocks, open fields, and surrounding vegetation areas were also mapped. The resulting spatial layers collectively represent the structural layout of the agroforestry system.

Seasonal Imagery Comparison

The availability of imagery from both leaf-on and leaf-off conditions provided complementary perspectives for spatial analysis. The October imagery, captured during the harvest season, highlighted canopy coverage and crop productivity, making it easier to identify areas with dense vegetation and active fruit production.

In contrast, the November imagery offered clearer visibility of structural features such as tree spacing, planting rows, and field boundaries due to the absence of foliage. This improved the accuracy of identifying individual trees and mapping planting patterns across the farm. By comparing these two datasets, the project was able to generate a more complete visualization of the agroforestry landscape and improve the reliability of the mapped features.

Relevance to Agroforestry Scalability

The spatial datasets generated from the drone imagery provide valuable information for evaluating the scalability of agroforestry crops. Mapping the current distribution of tree crops allows for the identification of existing production zones as well as potential areas for future expansion. The geospatial visualization of farm layout also

helps reveal patterns related to planting density, available open land, and land use efficiency. These insights can support decision-making regarding where additional agroforestry crops could be integrated into the farm landscape. Furthermore, the detailed spatial representation of crop distribution provides a foundation for future analyses related to farm productivity, landscape planning, and agroforestry system design.

IV. Results

Oikos Farm is located near Kalamazoo, Michigan, and the soils in this area are primarily derived from glacial deposits, forming well-drained loam to sandy loam soils that are typical of the Midwestern United States. **(USDA)**These soils generally have moderate organic matter content and favorable drainage conditions, supporting the growth of a wide range of perennial crops. Within the relatively small extent of the farm, the farm is characterized by a largely uniform soil type, which means that soil variability is minimal across the site. As a result, topographic characteristics, especially slope, become the dominant environment variable influencing crop suitability and affecting microclimatic conditions in the farm.

To better understand the topographic structure of the study site, a terrain height map was generated from drone-derived data and processed within ArcGIS Pro. The resulting map (Figure 1) illustrates the spatial distribution of terrain elevation and tree height across Oikos Tree Crops Farm. The visualization combines a continuous height surface with mapped tree locations, allowing both the underlying terrain and vegetation structure to be examined simultaneously.

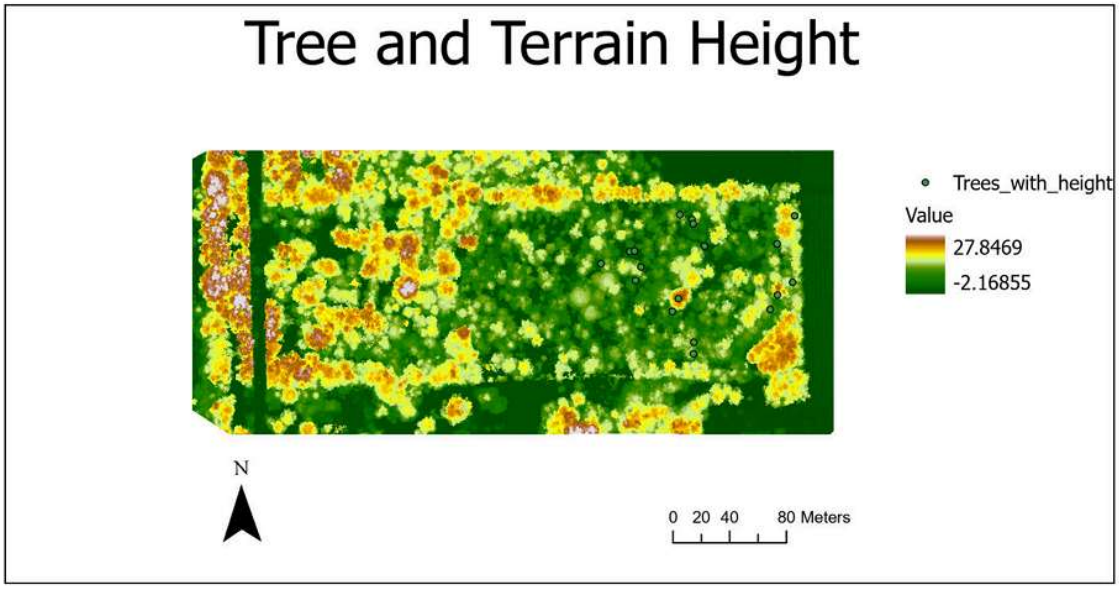

Figure 1. Tree and terrain height distribution across Oikos Tree Crops Farm derived from UAV imagery and processed in ArcGIS Pro

Although the overall elevation range within the farm is relatively small, the map reveals noticeable micro-topographic variation across the landscape. Areas shown in darker green represent relatively lower terrain positions, while yellow and orange areas indicate higher elevations or taller vegetation structures. These subtle differences in elevation influence local drainage patterns, soil moisture conditions, and microclimatic variation within the farm. In agroforestry systems, such small variations in terrain can affect plant establishment and growth by influencing water movement, cold air drainage, and soil stability.

The elevation model also provides the basis for deriving slope, which is a critical factor for evaluating crop suitability. While elevation itself describes vertical variation across the landscape, slope more directly reflects the steepness of the terrain and therefore influences erosion risk, surface runoff, and soil drainage. For perennial tree crops, moderate slopes are generally preferred because they provide adequate drainage while maintaining stable soil conditions.

Based on this terrain elevation dataset, slope values were calculated and classified to evaluate the suitability of different areas of the farm for agroforestry crops. The slope classification results presented in the following section build directly on this elevation

analysis and provide a more detailed understanding of how topography influences crop suitability across the study area.

Based on the slope classification shown in the figure, the terrain of the Oikos farm exhibits moderate topographic variability despite its relatively small size.Most areas of the farm fall within the gentle to moderate ranges. These moderate slopes typically support stable soil conditions, and manageable erosion risk, making them suitable for the majority of crop types such as American Persimmon, American Chestnut. According to **Perennial Pathways: Planting Tree Crops**, slopes of 3–8% are considered ideal for orchard crops, while slopes up to 15% remain acceptable under proper management. Steeper slopes occur in smaller and more localized portions of the landscape.Although these areas occupy a relatively small part of landscape, they still provide suitable planting locations for certain species whose optimal slope preferences occur in steeper terrain,allowing them to be incorporated into the overall agroforestry design.

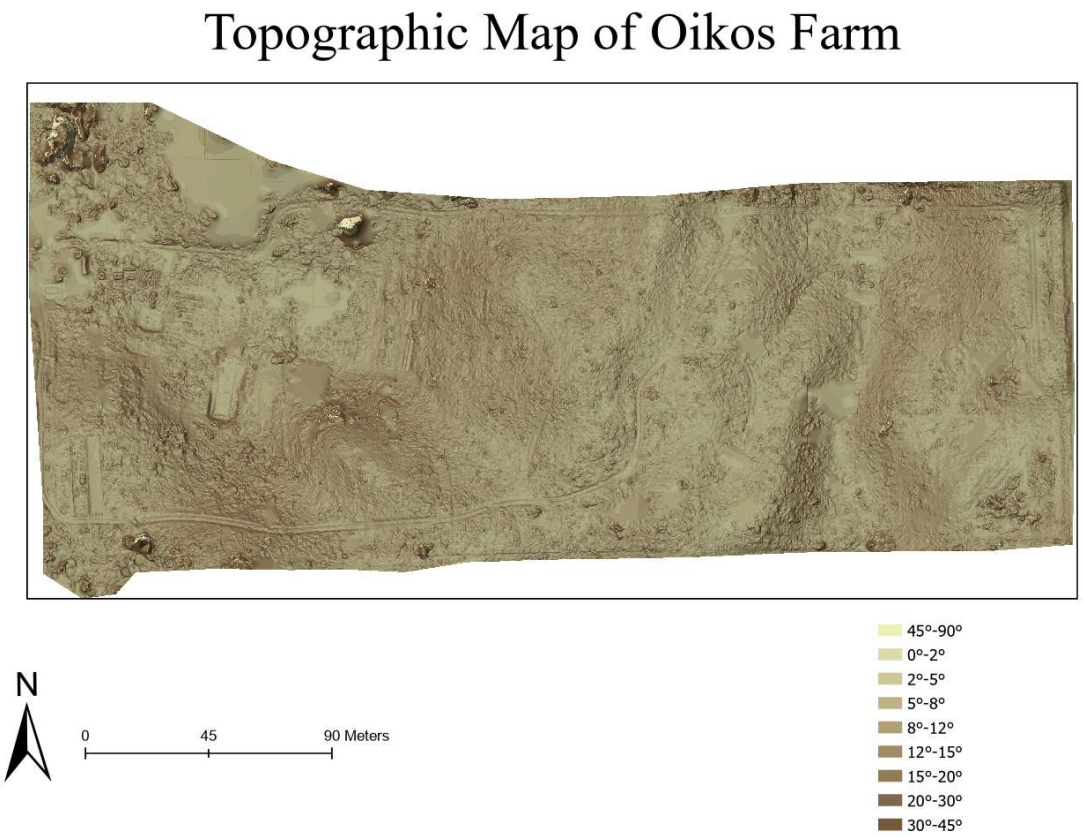

Figure 2.Topographic map of Oikos Farm based on the digital terrain model

Using these slope characteristics as a guideline, species-specific suitability maps were developed to identify the most appropriate planting locations for each crop within the farm.

Chickasaw Plum（Wild Plum)

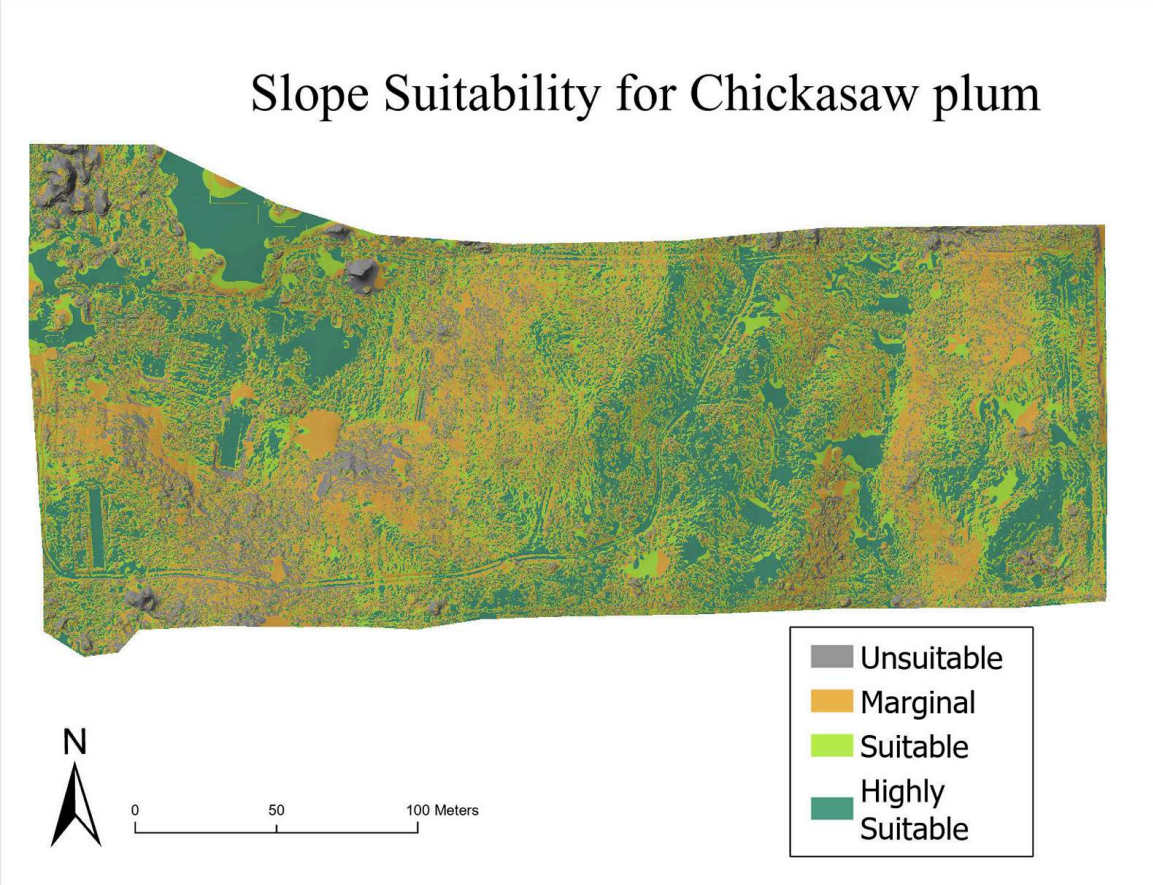

Figure 3.Slope suitability map for Chickasaw plum (wild plum) in Oikos Farm

Wild plum typically grows in prairies, woodland edges, pastures, and along riverbanks, indicating its adaptability to well-drained soils and moderately variable terrain. The species is commonly found in natural landscapes where soil drainage is adequate and environmental conditions are relatively stable. (https://gulfcoastswcd.org/wp-content/uploads/2014/03/PG-American-Plum.pdf)

The slope suitability map produced for the study area shows that suitable and highly suitable zones for wild plum are primarily distributed across gentle to moderate slopes

within the farm. These areas provide favorable drainage conditions and stable soil environments that support plant establishment. In contrast, areas with steeper slopes or less stable terrain appear more frequently classified as marginal or unsuitable, resulting in a more fragmented distribution of optimal planting locations.

Quince

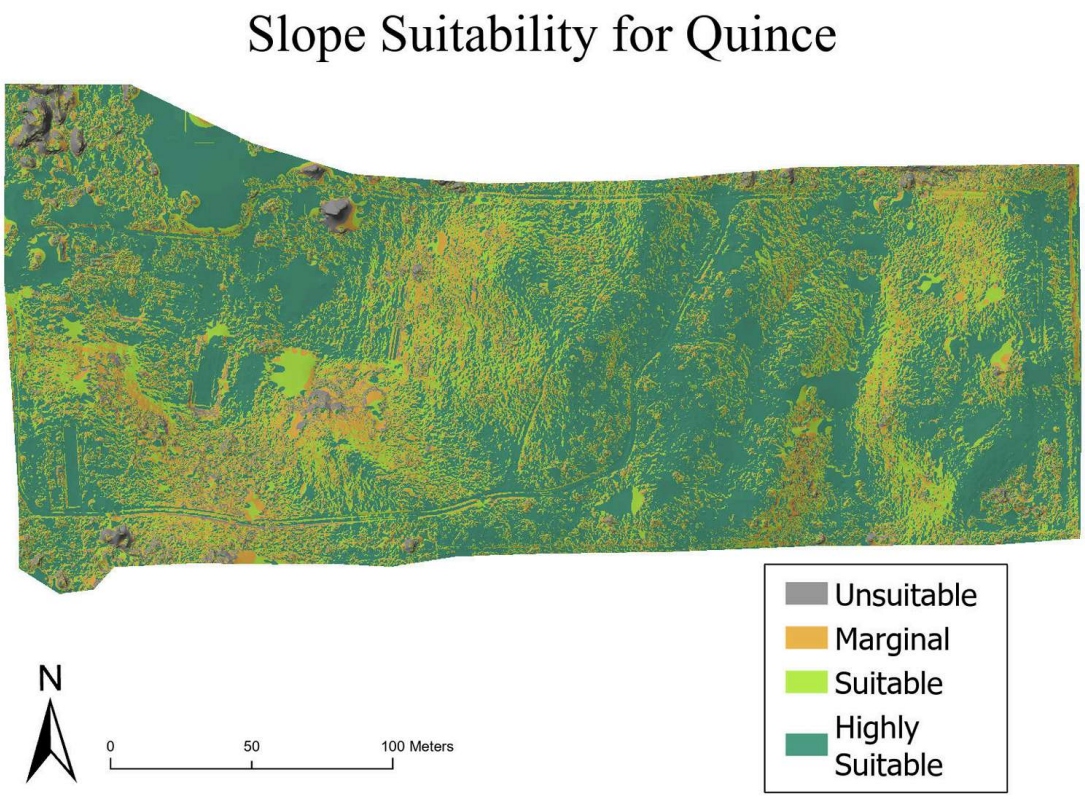

Figure 4.Slope suitability map for Quince in Oikos Farm

Quince is a fruit tree that generally grows well in well-drained soils and open environments where sunlight and air circulation are sufficient. The slope suitability analysis for Oikos Farm indicates that quince has a relatively broad tolerance to terrain variation across the study area. According to the generated suitability map, most of the farm is classified as suitable or highly suitable for quince, particularly in areas with gentle to moderate slopes between approximately 2–8°. These slope conditions provide favorable drainage while maintaining stable soil structure, supporting consistent plant

establishment. Very flat areas (0–2°) appear more frequently as marginal suitability zones, likely due to slower surface drainage, while steeper slopes above approximately 12–15° show a slightly higher proportion of marginal classifications because of potential erosion and reduced soil stability. Spatially, suitable and highly suitable zones are distributed widely across the central and mid-slope portions of the farm, forming relatively continuous planting areas compared with some other species. Overall, the results suggest that the majority of the farm terrain provides appropriate slope conditions for quince cultivation.

Wild Apple

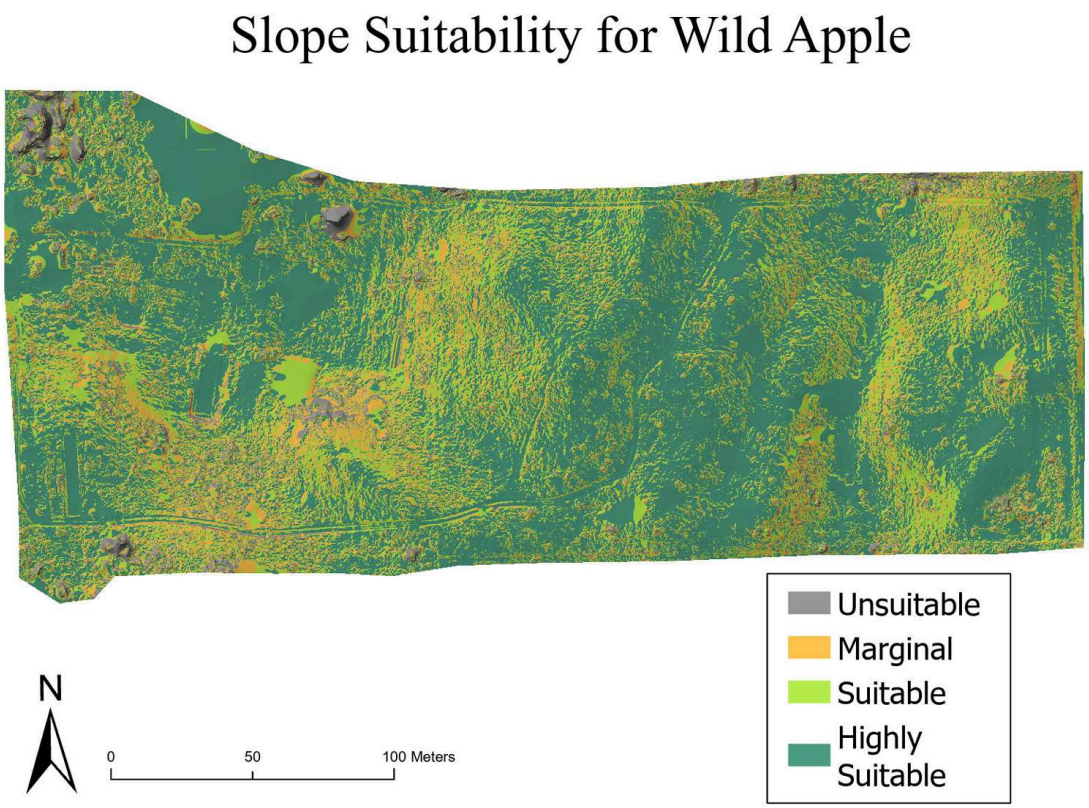

Figure 5.Slope suitability map for Wild Apple in Oikos Farm

Wild apple species are commonly found in temperate regions of North America and are well adapted to the environmental conditions of the Midwestern United States, including Michigan. They typically occur in open landscapes and forest edges where soils are well drained and environmental conditions are relatively stable. The slope suitability analysis for Oikos Farm indicates that wild apple can tolerate a range of terrain conditions but performs best on gentle to moderately sloping sites. In the generated suitability map, areas classified as suitable and highly suitable are primarily associated with slopes between approximately 2–8°, where soil drainage and surface stability are optimal for tree establishment. Very flat areas (0–2°) tend to appear more frequently as marginal suitability zones, likely due to limited drainage and potential water accumulation. In contrast, steeper slopes above approximately 12–15° show a higher proportion of marginal or unsuitable classifications, reflecting increased erosion risk and reduced soil stability. Spatially, suitable zones are distributed across the mid-slope portions of the farm and occur in multiple patches throughout the landscape, indicating that several areas within the site provide appropriate terrain conditions for wild apple cultivation in the Michigan study area.

Persimmon

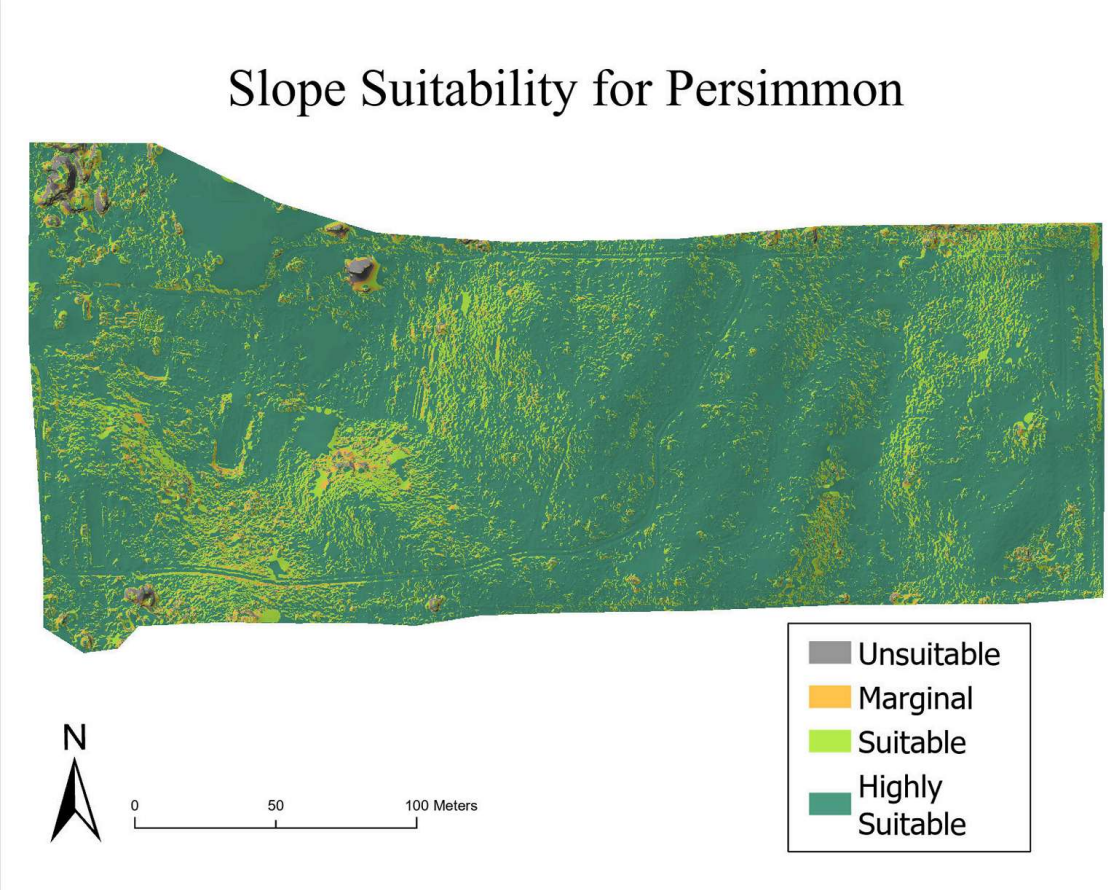

Figure 6.Slope suitability for Persimmon in Oikos Farm

American persimmon is widely distributed in the eastern and Midwestern United States and is well adapted to the climatic conditions of Michigan. The species can tolerate a range of environmental conditions but generally performs best in well-drained sites with moderate topographic variation. The slope suitability analysis for Oikos Farm indicates that persimmon has relatively high adaptability to the terrain conditions present within the study area. In the generated suitability map, large portions of the farm are classified as suitable or highly suitable, particularly within gentle to moderate slope classes of approximately 2–8°. These slopes provide favorable drainage and stable soil conditions that support tree establishment and long-term growth. Very flat areas (0–2°) appear more frequently as marginal suitability zones, likely due to reduced drainage potential, while steeper slopes above approximately 12–15° show increased occurrences of marginal suitability because of potential soil erosion and reduced site stability. Spatially, suitable zones form relatively continuous areas across the mid-slope sections of

the farm, indicating that a substantial portion of the site provides appropriate terrain conditions for persimmon cultivation.

Thimebleberries:

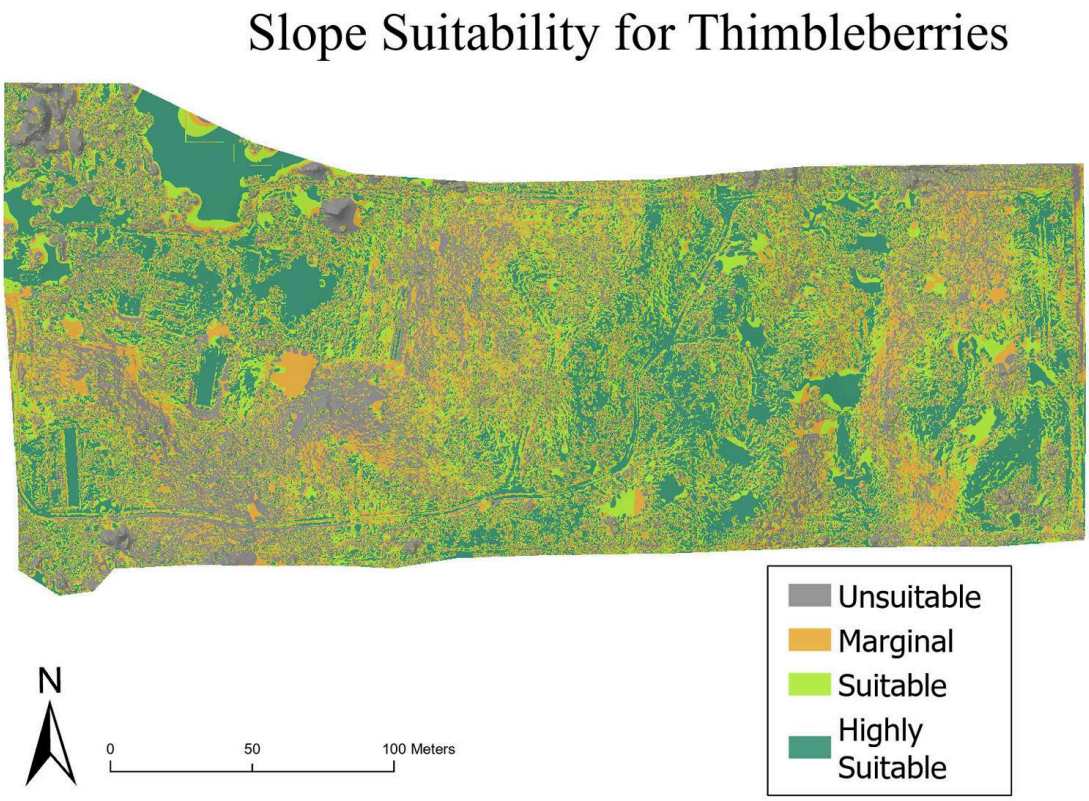

Figure 7.Slope suitability for Thimbleberries in Oikos Farm

Thimbleberry is a native shrub species that commonly grows in open woodlands and forest edges and can tolerate a range of terrain conditions.The map indicates that most areas within the farm fall into the suitable categories, although they appear highly fragmented and scattered rather than forming large continuous patches. Marginal and unsuitable zones are also present throughout the site, reflecting sections where slopes are either very flat or relatively steep and therefore less favorable for stable establishment. Highly suitable areas occur only in smaller pockets, suggesting that optimal slope

conditions are limited and occur mainly in localized micro-topographic positions within the farm.

chestnut

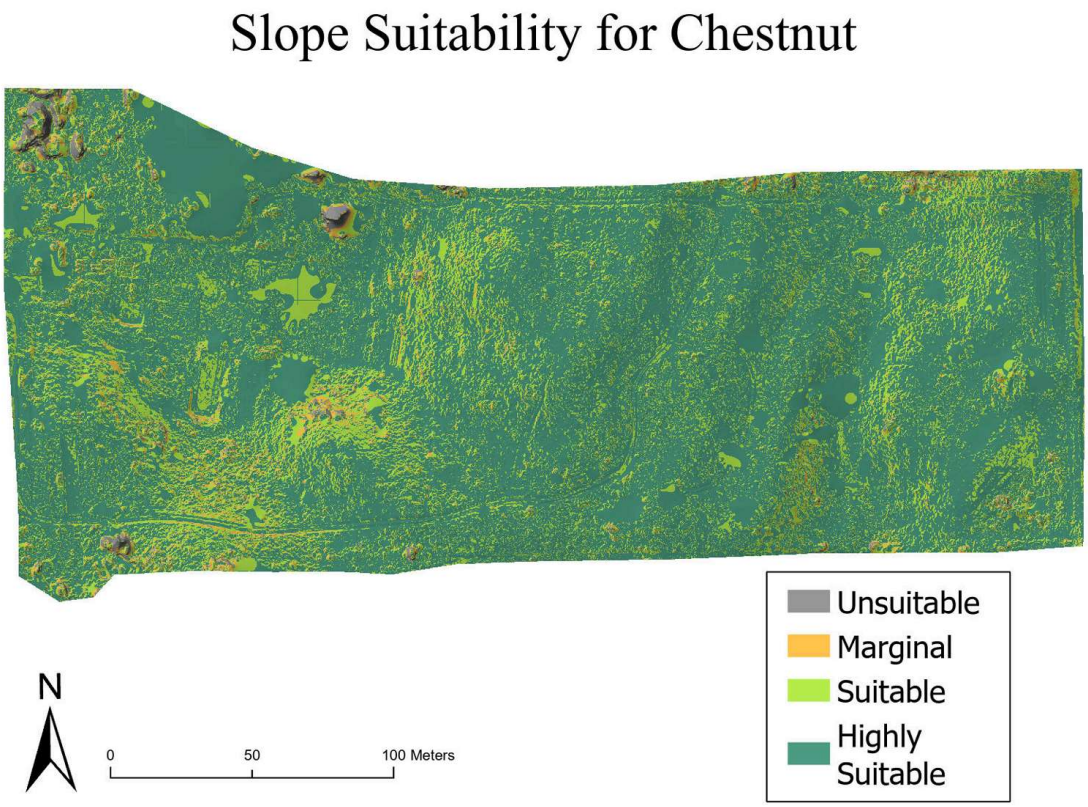

Figure 8.Slope suitability for Chestnut in Oikos Farm

Chestnut trees generally grow well on well-drained soils and moderate slopes that provide good drainage and stable soil structure. The slope suitability analysis shows that highly suitable areas dominate most of the farm, indicating that the terrain conditions are broadly favorable for chestnut cultivation. Suitable zones are also widely distributed

across the landscape, while marginal and unsuitable areas occur only in relatively small and scattered patches where slopes are either very flat or locally steeper. Spatially, highly suitable areas form relatively continuous zones across much of the central and mid-slope portions of the farm, suggesting that large areas of the site could support chestnut planting.

Magnolia

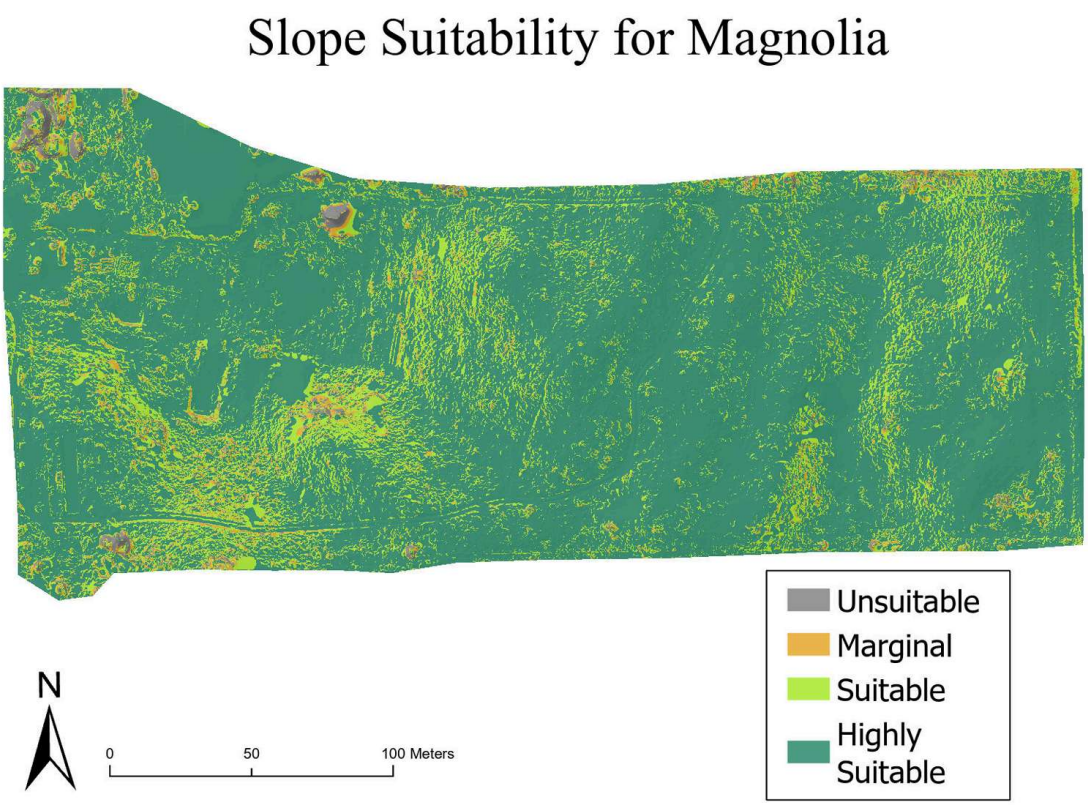

Figure 9.Slope suitability for Magnolia in Oikos Farm

Magnolia shows a high level of slope suitability across Oikos Farm, with highly suitable areas dominating much of the landscape. The suitability map indicates that the majority of the farm provides favorable terrain conditions for magnolia establishment.

Highly suitable zones are widely distributed across the central and mid-slope portions of the site, forming relatively continuous areas suitable for planting. In contrast, marginal suitability areas appear in smaller and more scattered patches, typically associated with localized variations in terrain. Unsuitable areas are very limited and occur only in isolated locations. Overall, the results suggest that the topographic conditions of the farm are largely appropriate for magnolia cultivation, making it one of the species with the broadest suitable planting areas within the site.

Hazelnut

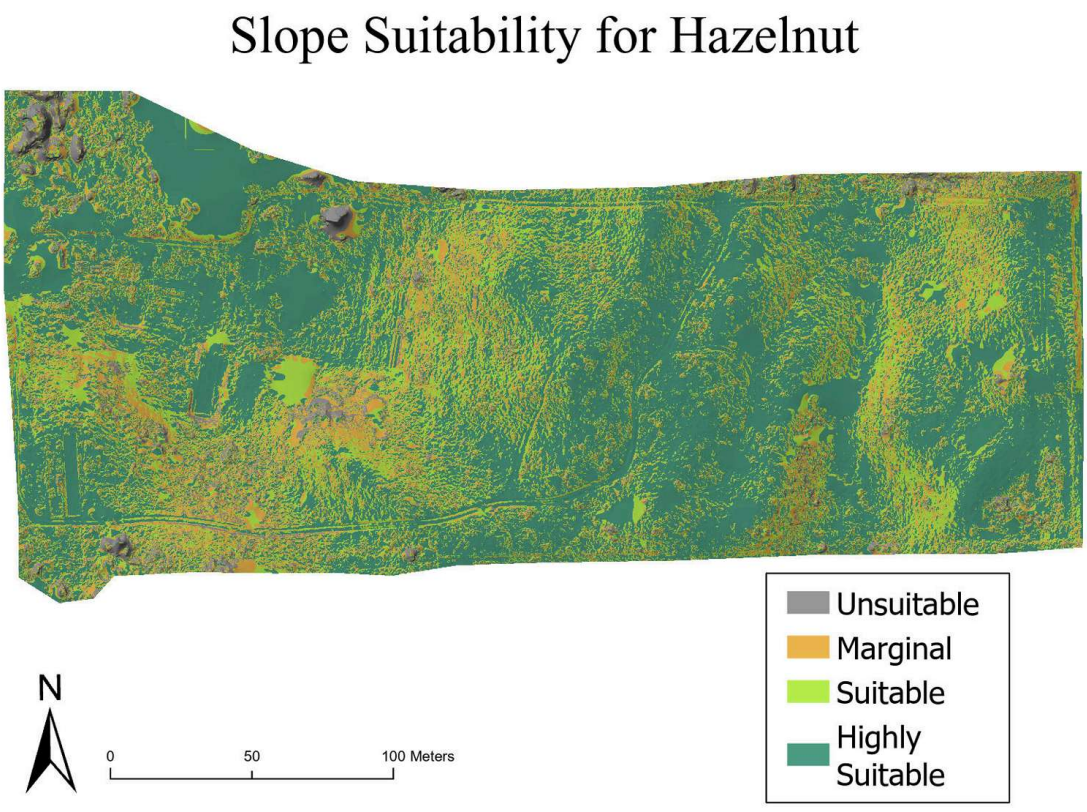

Figure 10.Slope suitability for Hazelnut in Oikos Farm

Hazelnut is a temperate shrub species widely distributed in North America and well adapted to the environmental conditions of the Midwestern United States, including Michigan. It typically grows in open woodlands and forest edges and prefers well-drained soils with moderate environmental stability. The slope suitability map for hazelnut indicates that a large portion of Oikos Farm provides favorable terrain conditions for its cultivation. Highly suitable areas are widely distributed across the landscape, particularly throughout the central and mid-slope portions of the site. However, compared with some other species, hazelnut shows a more heterogeneous spatial pattern, with marginal suitability areas appearing more frequently across the farm. These marginal zones occur in scattered patches associated with localized variations in terrain conditions. Suitable areas form transitional zones surrounding the highly suitable regions, creating a mosaic distribution across the landscape. Unsuitable areas are limited and occur only in isolated locations. Overall, the analysis suggests that while hazelnut can be planted across much of the farm, the most favorable planting locations are concentrated in the mid-slope areas where terrain conditions are more stable.

V. Conclusion

The first part of our project demonstrates how high-resolution geospatial data derived from drone imagery can support the visualization and spatial analysis of agroforestry systems at the farm scale. By integrating UAV data processing and GIS-based terrain analysis, this study provided a detailed spatial understanding of crop suitability and landscape characteristics at Oikos Tree Crops Farm. The combination of drone surveys, digital surface and terrain modeling, and slope-based suitability mapping allowed for a comprehensive assessment of how topographic variation influences potential planting locations for multiple agroforestry species. The results highlight the value of geospatial technologies in improving the planning and scalability of perennial agriculture systems.

One of the most important findings of this study is that even within a relatively small agricultural landscape, subtle variations in terrain can significantly influence crop suitability. The elevation and slope analyses revealed that the farm exhibits moderate micro-topographic variation despite its limited spatial extent. While the overall elevation range across the farm is relatively small, small differences in terrain height create localized variations in slope, drainage patterns, and soil stability. These factors are particularly important for perennial tree crops, which depend on stable soil conditions and well-drained environments for long-term establishment. The terrain analysis showed

that most areas of the farm fall within gentle to moderate slope ranges, which are widely considered ideal conditions for orchard and agroforestry crops. According to established guidelines for perennial crop production, slopes between approximately three and eight percent provide good drainage while maintaining soil stability and manageable erosion risk. The results therefore indicate that the general topographic conditions of the farm are broadly favorable for perennial agriculture.

Building on the terrain analysis, species-specific suitability maps were developed to identify appropriate planting zones for a range of agroforestry crops. The analysis suggests that several species show particularly strong potential for expansion across the farm landscape. For example, chestnuts demonstrate one of the most favorable suitability patterns among the analyzed species. Large areas of the farm were classified as highly suitable for chestnut cultivation, particularly across the central and mid-slope regions where terrain conditions provide adequate drainage and stable soils. These results suggest that chestnut production could potentially be expanded across significant portions of the site without encountering major topographic limitations. Similarly, American persimmon also shows a high degree of adaptability to the terrain conditions present at the farm. The suitability analysis indicates that a large portion of the landscape falls within the optimal slope ranges for persimmon establishment, suggesting that this species could also be scaled effectively within the agroforestry system.

Other species included in the analysis demonstrate more spatially variable suitability patterns. Hazelnut, for example, shows a relatively broad distribution of suitable areas but with greater heterogeneity across the landscape. Although many areas of the farm remain favorable for hazelnut cultivation, the suitability map indicates a more mosaic-like distribution of optimal planting zones. This pattern likely reflects the species' sensitivity to localized terrain variations such as small changes in slope or drainage conditions. Similarly, species such as thimbleberry display more fragmented distributions of suitable terrain. In these cases, optimal planting zones occur in smaller and more scattered patches rather than forming large continuous areas. While these crops may still be successfully integrated into the agroforestry system, their spatial distribution may need to be more carefully planned to align with localized terrain conditions.

The results of this study also illustrate how drone-derived spatial datasets can provide valuable insights into the structure and management of agroforestry landscapes. By conducting UAV surveys during both the harvest season and the leaf-off season, the project was able to generate complementary datasets that captured different aspects of the farm environment. The leaf-on imagery collected during the harvest season provided detailed information about canopy structure, vegetation density, and the spatial

distribution of productive crops. In contrast, the leaf-off imagery collected after leaf fall allowed for improved visualization of the underlying terrain surface and planting patterns. Combining these datasets made it possible to generate both digital surface models and digital terrain models, which in turn allowed for the calculation of canopy height and terrain slope across the farm. This workflow demonstrates how multi-season drone imagery can significantly improve the accuracy of spatial analysis in agroforestry landscapes.

Beyond its immediate findings for crop suitability, this project highlights the broader role that geospatial tools can play in supporting agroforestry development. Agroforestry systems often involve complex spatial arrangements of trees, crops, and landscape features, making them well suited to analysis using GIS and remote sensing techniques. High-resolution drone imagery allows researchers and farmers to visualize the structure of agricultural landscapes with a level of detail that is difficult to achieve using conventional satellite imagery. When combined with spatial analysis tools, these datasets can help identify optimal planting locations, evaluate land use efficiency, and support long-term farm planning. In the context of expanding interest in perennial agriculture across the Midwestern United States, these geospatial approaches can provide valuable decision-support tools for farmers and land managers.

Overall, the findings of this study suggest that Oikos Tree Crops Farm possesses strong potential for supporting a diverse range of agroforestry crops. The terrain characteristics of the site are generally favorable for perennial tree cultivation, and several species analyzed in this study—including chestnut, persimmon, and magnolia—show particularly high suitability across large portions of the farm. By combining drone-based mapping with GIS-based terrain analysis, this project demonstrates an effective approach for visualizing agroforestry landscapes and evaluating crop scalability at the farm scale. As agroforestry continues to gain attention as a sustainable agricultural strategy, geospatial methods such as those applied in this study will likely play an increasingly important role in guiding the design and expansion of resilient perennial farming systems.

VI. Discussion

The results of this study highlight the critical role of fine-scale topographic variability in shaping crop suitability within small agroforestry systems. Although Oikos Farm exhibits a relatively narrow elevation range, the derived terrain and slope analyses reveal meaningful micro-topographic heterogeneity that strongly influences drainage

patterns, soil stability, and localized growing conditions. This finding reinforces the idea that, at the farm scale, subtle variations in slope can have disproportionate ecological and management implications.

Across the species analyzed, slope suitability patterns demonstrate both shared and species-specific responses to terrain conditions. Most perennial crops, including chestnut, persimmon, and magnolia, show a clear preference for gentle to moderate slopes (approximately 2–8%), where drainage is sufficient and erosion risk remains low. These areas form relatively continuous zones across the central and mid-slope portions of the farm, suggesting strong potential for coordinated planting and efficient land use. In contrast, species such as thimbleberry and hazelnut exhibit more fragmented suitability patterns, indicating a higher sensitivity to localized terrain variability. This spatial heterogeneity implies that certain crops may require more precise, site-specific placement rather than broad-scale allocation.

The comparison among species further suggests that terrain suitability alone does not uniformly translate into optimal planting outcomes. While several crops appear broadly suitable across the farm, their spatial configuration differs significantly, which has implications for agroforestry design. Continuous suitable areas (e.g., for chestnut) support scalable cultivation strategies, whereas patchy distributions (e.g., for thimbleberry) may be better suited for integration into diversified or edge-based planting systems. Therefore, slope suitability mapping not only identifies where crops can grow, but also informs how they should be spatially arranged within the landscape.

From a methodological perspective, the integration of UAV-derived elevation data with GIS-based analysis proved effective for capturing high-resolution terrain characteristics that are often overlooked in conventional assessments. The ability to distinguish micro-topographic features enables more precise suitability classification and supports fine-scale decision-making. However, this study also has limitations. Slope was treated as a primary determinant of suitability, while other important factors—such as soil chemistry, aspect, moisture dynamics, and management practices—were not explicitly incorporated into the analysis. As a result, the suitability maps should be interpreted as a topography-driven baseline rather than a comprehensive evaluation.

Future work could improve the robustness of the analysis by integrating additional environmental variables and applying multi-criteria decision analysis (e.g., weighted overlays combining slope, aspect, and soil properties). Temporal variability, such as seasonal moisture conditions, could also be incorporated to better reflect dynamic growing environments. Despite these limitations, the current study demonstrates that

high-resolution geospatial analysis provides a powerful framework for understanding and optimizing agroforestry systems at the farm scale.

Part 2:Marketability of Select Agroforestry Crops

Introduction

Perceptions and Social Barriers

Some social factors leading to low agroforestry adoption in the United States which include farmer age, social influences, low performance expectations [5,6,7,8]. Amongst these challenges, researchers have found that the majority of agroforestry knowledge comes from experimental research in limited locales and the literature focuses more on potential adoption rather than current practitioners [9]. In fact, only a handful of studies have documented farmers using production-oriented agroforestry practices [10, 11, 12]. Given the lack of experiential knowledge about proper management of agroforestry systems in temperate regions, our project aims to examine and document a working, productive, and replicable agroforestry system in order to provide management information to the greater agricultural community.

In a recent study on Agroforestry adoption was done by the Center for Agroforestry in 2025, researchers surveyed 137 Missouri land managers to assess the level of agroforestry adoption within their state, participant's perceptions regarding agroforestry and their likelihood to work with agroforestry systems going forward [13]. We've decided to use key takeaways from this robust study to inform our own research, the target audience we decide to work with and the type of information we provide. The following results shed light on the level of understanding and perceptions on agroforestry practices:

- A majority of respondents reported having minimal to low knowledge of agroforestry.
- Respondents typically held more positive perceptions of agroforestry for its **environmental benefits than for its economic benefits.**
- Twenty respondents indicated they were currently practicing agroforestry.
- Respondents showed greatest interest in adopting forest farming, silvopasture, and windbreaks.

The researchers found that lack of knowledge and skills were a significant barrier to growers' willingness to incorporate agroforestry practices. In fact, this was so much the case, that farmers were willing to forgo some of the incentive payments (at about $1,670 per acre) for the guarantee of technical assistance. In the same study, researchers

found that for some of the other practices like alley farming, there was less interest because of factors such as perceived competition between trees and annual crops, insufficient markets and high input costs [13]. Given the emphasis on financial concerns regarding willingness to adopt agroforestry systems, we decided to focus on market factors for our project through providing crop marketability information in addition to growing information and visualization tools.

I. Methods

Best-bet Crops and Marketability Study

Research Questions: The overarching question regarding crop marketability project is what tree crops at Oikos Tree Crops are most marketable and easiest to grow, and how can we best share this and other pertinent information with growers to promote early adoption?

Additional guiding questions are as follows:

- What specific propagation, growth, harvest and value added product information would growers like and how would they like it presented so that they can implement agroforestry in their grow systems?
- What kinds of value added products can we create with crops from Oikos Tree Crops?
- What value added products from Oikos Tree Crops get the highest customer ratings in taste tests?

We decided that one line of action would be to survey potential early adopters to determine what kinds of information they would like us to provide and through what format. This decision was based on expert recommendations from researcher Alison Bressler who researches adoption of farmer adoption of cover crops in the Erie basin, and the work of Kendra Esparza-Harris, a doctoral candidate with the Center for Agroforestry at Missouri. Based on their work, we learned that input from producers can highlight important practical needs that might otherwise be overlooked from a pedalogic perspective. Therefore, we decided to ask the community of farmers in the region **what information** they want about tree crops and agroforestry and **how they want materials** communicated.

Building on this approach, one of the most well-studied, bottom-up frameworks for understanding the adoption of new practices is “diffusion of innovations” [14]. In this model, uncommon practices such as cover cropping can spread when innovators and early adopters communicate with and influence the majority [14]. In a meta-analysis of 46 studies, Baumgart-Getz, Prokopy, and Floress (2012) identified networking and access to and quality of information as strong predictors of the adoption of conservation practices. They found that farmers’ connections to agency personnel, and networks with neighboring farms and grassroots organizations, were particularly influential.When local, site-specific ecological knowledge is coupled with peer-peer learning in communities of practice, a larger number of farmers can overcome structural barriers and adopt conservation practices [15]. Based on these well-studied factors, when it came to engaging with local farmers we decided to do the following:

- tap into existing networks such as the Conservation Districts and other farmer networks
- go to existing farm group meetings and conferences to conduct surveys within existing events
- make contacts with community leaders who are well connected
- focus on building relationships with small-scale, organic farmers in Michigan who would be able to integrate tree crops into their current production systems.

In order to answer our guiding questions and engage with early adopters, we developed the following sequential plan of action:

1) Provide an open-ended survey to the Michigan Working Groups to determine what information they would like and how they would like it presented for growing fruiting, nut bearing and timber trees in agroforestry systems.

2) Create and send a proposal letter and budget for sponsorship from Slow Food of Huron Valley

3) Interview Ken Asmus from Oikos Tree Crops to determine what crops are high yielding, pest and disease resistant, flavorful and in his opinion, show commercial potential as value added products that are marketable.

4) Interview Ken for information on crop propagation, harvest methods and general grow requirements of crops selected for value-added products.

5) Harvest Ken’s recommended fruit varieties and collaborate with local vendors and chefs to create value added products. Document the methods for developing the

value added products.

6) Present samples of the value added products at various locales such as Eastern Market, Michigan Fruit & Nut Growers Association, Argus Farmstop, and Blom Meadery. Have consumers fill out brief surveys on the samples.

7) Aggregate data from the taste testing, Ken's grow information and farmer surveys. Based on the combination of this information, create educational resources that small-scale growers can utilize to incorporate these select tree crops into their systems.

For step one, we handed out an open ended survey with growers part of the Michigan Agroforestry Working Group during meetings and demonstration events in the Spring of 2025. Our research survey questions primarily focused on what crops people might be interested in growing, what they currently know about agroforestry practices, what is most useful for them to learn about and how they want educational materials to be presented. The official survey we presented is provided below:

Early Adopter Survey

1. **Do you currently manage land, animals and/or grow crops? Please specify**
2. **Are there tree crops you are currently interested in growing? If so, please explain why.**
3. **What agroforestry practices are you interested in learning more about and why?**
4. **What information would be most helpful to you in terms of growing tree crops?**
5. **How would you like to receive educational information? ie. webinars, youtube videos, physical brochures, peer to peer workshops, etc, or a combination of the above. (You can select more than one medium if desired).**
6. **What kinds of value added products are you interested in selling and/or buying?**
7. **Is there anything else you wish to share?**

In addition to the surveys, we consulted with a recent Michigan State University forestry graduate student and agroforestry nursery grower, Jackson Orland based in Ann Arbor, Michigan. The takeaway from this meeting was that for people to want to incorporate trees into their grow systems, they need to know there is a market for the end product. This notion is also aligned with the research study previously conducted on the main barriers to agroforestry, ie. there being a perceived limited market for products [13].

The following is the official customer taste test survey handed out at events.

Agroforestry Crop Product Survey

These products are made from resilient, lesser-known trees and shrubs farmers in Michigan can grow at a large scale. We are seeking to understand consumer responses to these fruits and provide information to growers.

1. What type of fruit sample did you taste?

   Mark only one oval.

   - ◯ Serviceberry
   - ◯ Common Persimmon
   - ◯ Gooseberry
   - ◯ Chickasaw Plum
   - ◯ Lemony Quince
   - ◯ Cornelian Cherry

2. What are your top priorities when it comes to buying a food product? (Select up to 3)

   Check all that apply.

   - ☐ Cost

3. If you have had the fruit in the past, did you like the taste?

   Check all that apply.

	Y	N	N/A
Row 1	☐	☐	☐

4. Score the taste of the sample on a scale of 1 to 5, 5 being the highest rating.

   Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

5. How likely would you be to buy this product based on taste alone?

   Check all that apply.

   - ☐ Very likely
   - ☐ Likely
   - ☐ Neither likely nor unlikely
   - ☐ Unlikely
   - ☐ Very unlikely

6. Are there any changes to the flavor profile that you would like to see?

   For example:"_____ needs to be Sweeter", or "_____ is not tart enough"

   Please include the product you are referring to.

7. How likely are you to tell a friend about this product?

   Check all that apply.

   - ☐ Very likely
   - ☐ Likely
   - ☐ Neither likely nor unlikely
   - ☐ Unlikely
   - ☐ Very unlikely

8. What value would you put on an 8 ounce jar (1 cup) of this product?

   Check all that apply.

   - ☐ <$6
   - ☐ $6
   - ☐ $8
   - ☐ $10
   - ☐ >$10

9. If you are a grower, what crop(s) would you be most interested in growing and why?

10. What information would help you feel more confident to grow the above crop(s)?

11. Do you have any additional feedback and/or ideas for the project?

III. Results

In order to engage with early-adopters, we distributed an open-ended survey to the Michigan Agroforestry Working Group which is composed of growers and Conservation District personnel. Below is a summary of the responses we received from the four growers that filled out the survey.

Michigan Agroforestry Working Group Survey Results:

Own or Manage Land?	Current Crops Grown	Agroforestry Practices of Interest	Information requested	Medium requested	Value Added Product Interest
no	Elderberry, Chestnuts	Windbreaks, riparian buffers, forest farming	Access to land and funding to get started	Webinars, youtube	No response
yes	15 species, hazelnuts most successful growth and commercial potential	All of them!	**What works well in my location? How do we manage trees?**	any	Still learning what these are
yes	fruit and nut crops	Intercropping/alley cropping and small animal silvopasture	**How to market your products?**	Youtube, webinars	Not sure
yes	hazelnuts, persimmons, plums, paw paws, cherries, apples, peaches	Forest farming and alley cropping	**Michigan specific data and tree nursery sources**	Shorter youtube videos are great	Medicinal honeys and teas

Figure 1: Summary of Working Group Members' responses to the Working Group Survey distributed March, 2025.

After collecting this data from our grower database and consulting with an agroforestry nursery grower and recent forestry graduate, Jackson Gorland, we proceeded

with the next step of our project, determining ‘best-bet’ crops with Ken Asmus. We selected crops based on minimal maintenance requirements, adaptability to Southern Michigan’s climate, resistance to pests and diseases, high yield, harvestability and marketability as value added products. The crops selected are as follows: Serviceberry/Saskatoons, Cornelian Cherry, American Persimmon, Lemony Quince, Gooseberry, and Chickasaw Plum. We then submitted a request for additional funding to Slow Food of Huron Valley and were able to secure funding to pay for ingredients, extra crop to supplement our harvests, some processing equipment, chef reimbursement and taste-test supplies.

We harvested Serviceberry/Saskatoons over a three week period in June in spots throughout Ann Arbor, including several abundant trees alongside the parking lot on Ashley Street between W Huron Street and W Washington Street, outside the Samuel T. DANA building, and Traverwood Drive off of Plymouth Road. We then washed and froze them. We also ordered some frozen Serviceberry/Saskatoons from Northwest Wild Foods company to supplement our harvests. We harvested Gooseberries in July from Detroit Partnership for Learning and Innovation, an orchard managed by Michigan State University personnel and delivered these to chef Will Brinkerhoff for processing. In late August, over the course of several weeks, we harvested Cornelian Cherries from a courtyard at Woodby Gardens Apartments & Townhomes. The Chickasaw Plums, American Persimmon and Lemony Quince were all harvested the same day in late September from Oikos tree crops.

We researched recipes online, consulted with Ken, board members from Slow Food of Huron Valley, and met with Lauren of Blom Mead + Cider to learn about potential recipes. After our research and conversations, we decided on the following value added products: Serviceberry fruit leathers, Serviceberry Mead, Cornelian Cherry Mead, Cornelian Cherry mild and spicy salsas, Chickasaw plum jam, Lemony Quince jam, Lemony quince gummy bears, Persimmon Mead and Persimmon pie listed in the table below. We also worked with two chefs, Jakob Cook and Will Brinkerhoff who developed recipes of their own for the Gooseberry and Saskatoon samples which included a Cardamon Gooseberry jam, a savory Gooseberry ‘ketchup’ sauce and a Serviceberry and pear pie.The recipes we used for each crop are provided in the appendix.

Crop	Value-added products made		
Serviceberry/Saskatoons	*Serviceberry and Pear pie*	*Serviceberry fruit leathers*	*Serviceberry mead*
Cornelian Cherry		*Cornelian cherry salsa (mild +medium)*	*Cornelian cherry mead*
Gooseberry	*Gooseberry jam*	*Gooseberry 'ketchup' sauce*	
Chickasaw Plum	*Chickasaw Plum jam*		
Lemony Quince	*Lemony Quince jam*	*Lemony Quince gummybears*	
American Persimmon	*American Persimmon pie*		*American Persimmon mead*

Figure 2: List of value-added products created for each type of crop selected (12 total).

We set up our first taste test event in partnership with Aunt Nee's Chips and Salsa company at their booth at Eastern Market and used their chips for marketgoers to sample our Cornelian cherry mild and spicy salsas. We collected consumer feedback through a QR code that was linked to an online Google form. We had 23 people provide feedback at the Eastern Market tasting on October 4th. We later hosted a taste test at Argus Farmstop on Liberty Street in Ann Arbor on October 25th where we collected 13 surveys. We hosted our final taste test even at Blom Mead + Cider in Ann Arbor on November 23rd and collected surveys from 93 respondents. The following figures represent a summation of the data collected from the tree taste testing events we conducted.

Minimum	Maximum	Average Score	Standard Deviation	Participants (N)
2	5	4.5	0.77	43

Figure 3: Serviceberry Taste Test Results. A score of 5 is the best rating

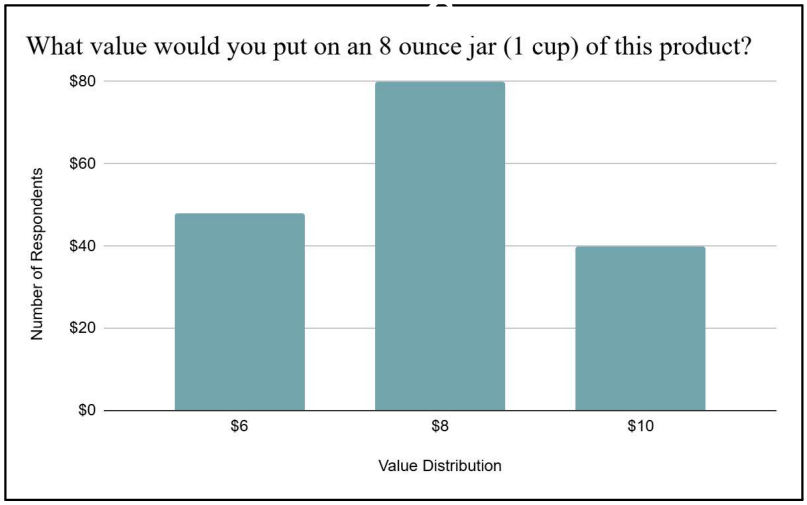

Figure 4: Consumer values for an 8 ounce sample of Serviceberry products

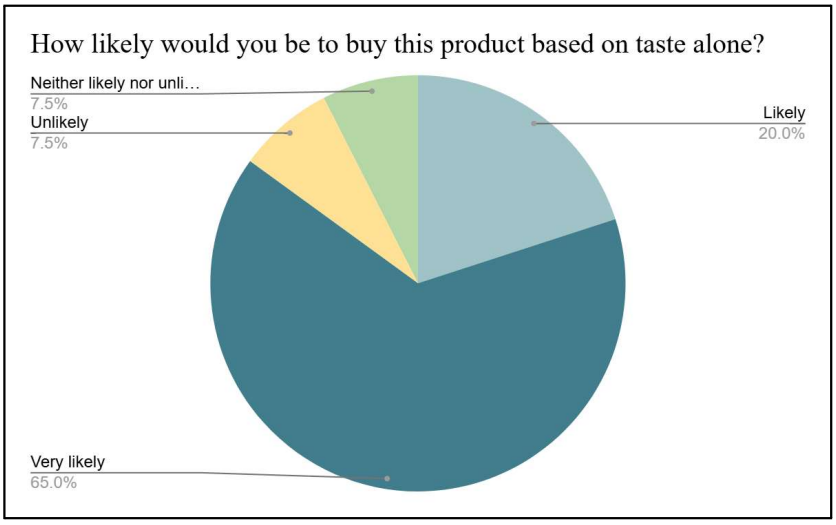

Figure 5: Consumer likelihood of buying Serviceberry products based on taste

Minimum	Maximum	Average Score	Standard Deviation	Participants (N)
2	5	4.24	0.85	43

Figure 6: Cornelian Cherry Taste Test Results. A score of 5 is the best rating

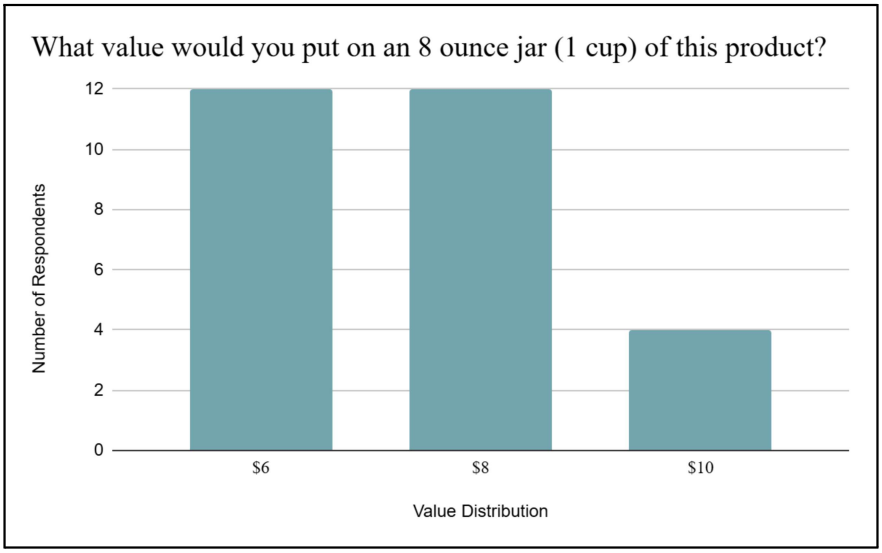

Figure 7: Consumer values for an 8 ounce sample of Cornelian Cherry products

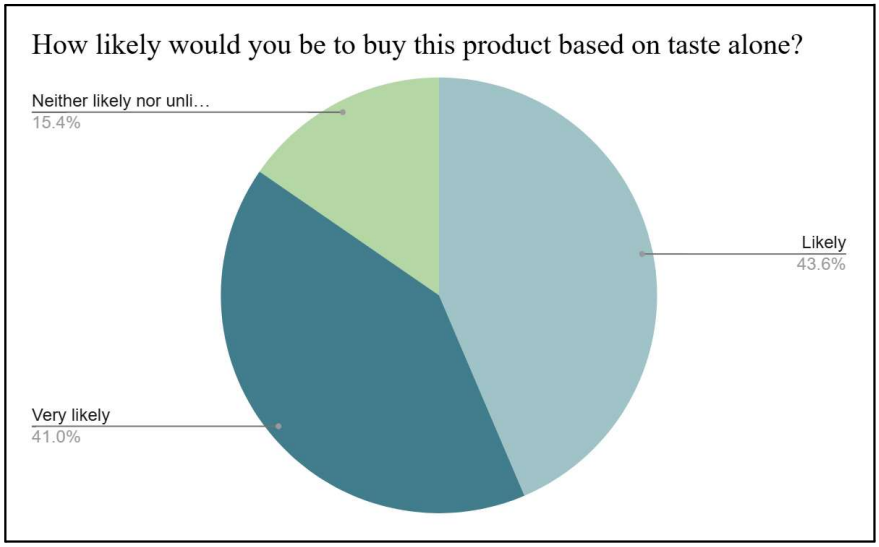

Figure 8: Consumer likelihood of buying Cornalian Cherry products based on taste

Minimum	Maximum	Average Score	Standard Deviation	Participants (N)
3	5	4.17	0.79	36

Figure 9: Gooseberry Taste Test Results. A score of 5 is the best rating

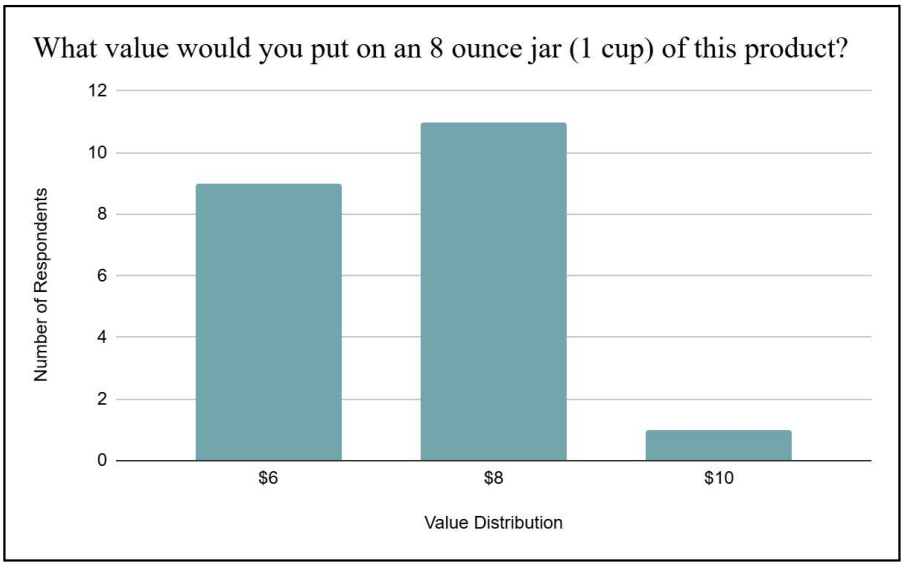

Figure 10: Consumer values for an 8 ounce sample of Gooseberry products

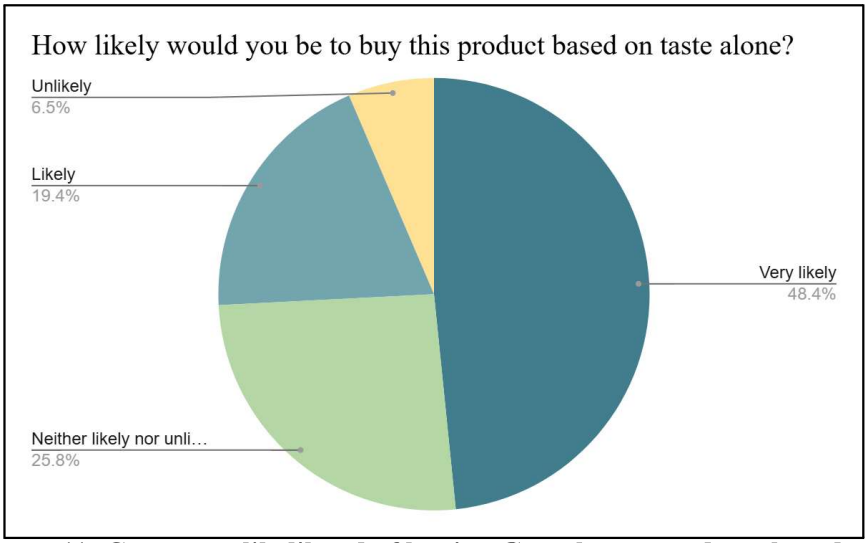

Figure 11: Consumer likelihood of buying Gooseberry products based on taste

Minimum	Maximum	Average Score	Standard Deviation	Participants (N)
1	5	4	1.23	30

Figure 12: American Persimmon Taste Test Results. A score of 5 is the best rating

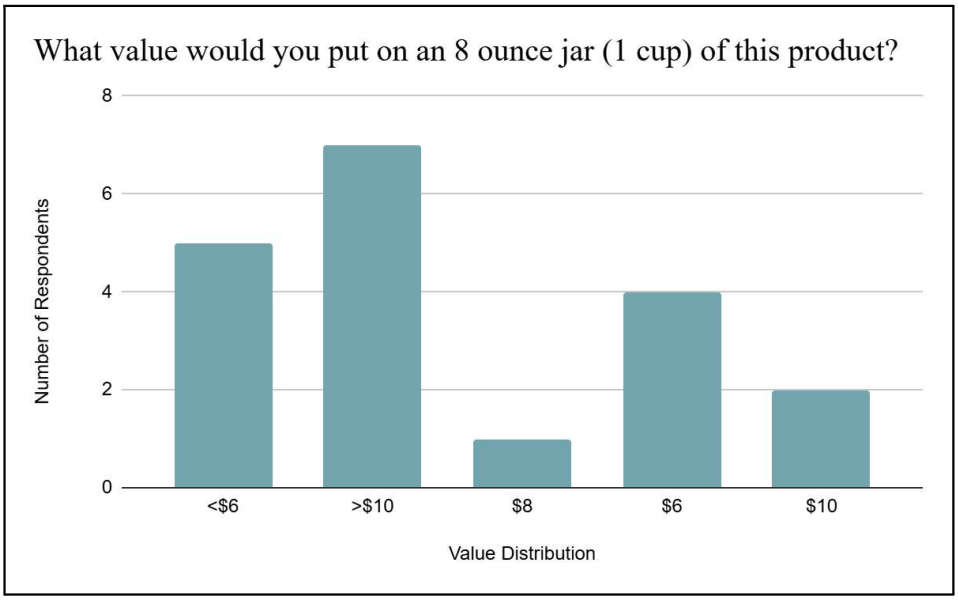

Figure 13: Consumer values for an 8 ounce sample of American Persimmon

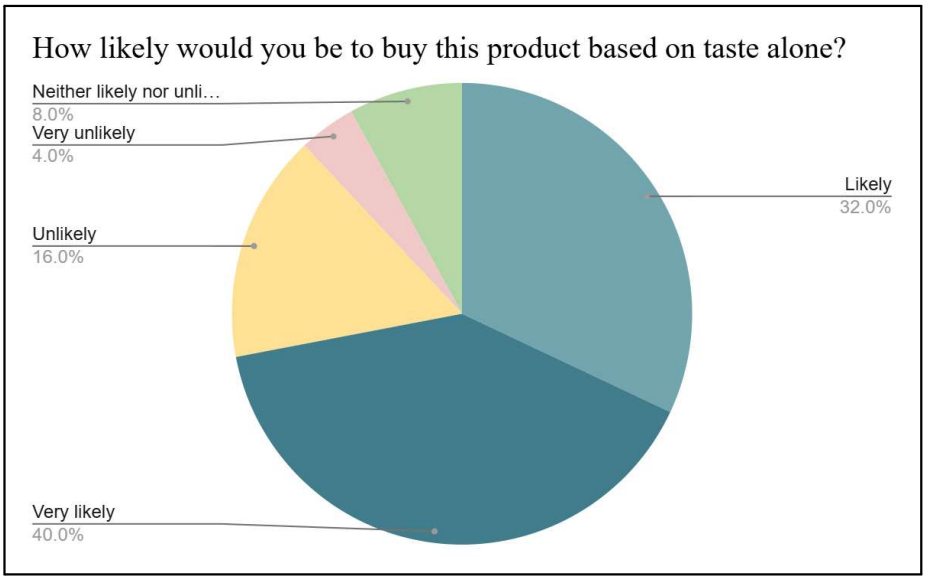

Figure 14: Consumer likelihood of buying American Persimmon based on taste

Minimum	Maximum	Average Score	Standard Deviation	Participants (N)
2	5	3.9	0.94	29

Figure 15: Lemony Quince Taste Test Results. A score of 5 is the best rating

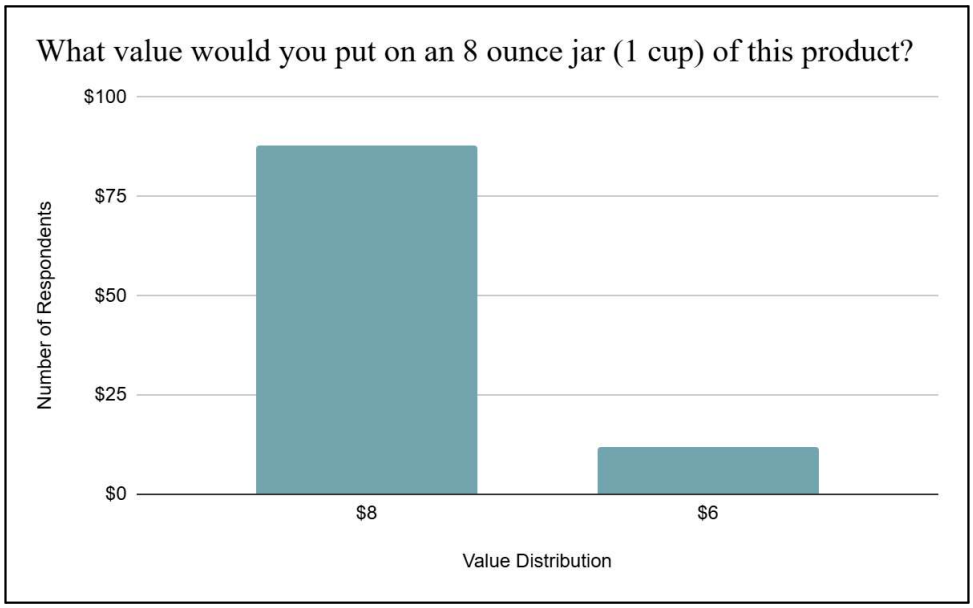

Figure 16: Consumer values for an 8 ounce sample of Lemony Quince products

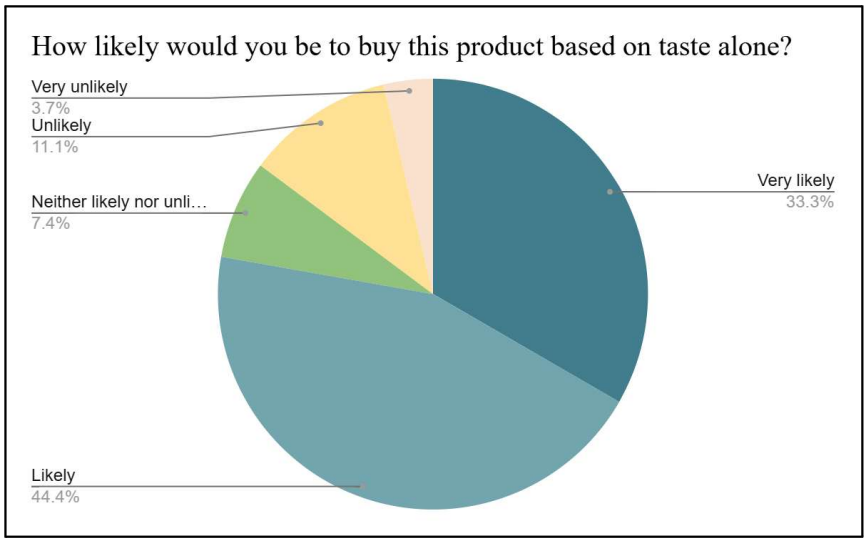

Figure 17: Consumer likelihood of buying Lemony Quince products based on taste

Minimum	Maximum	Average Score	Standard Deviation	Participants (N)
1	5	3.83	1.15	19

Figure 18: Chickasaw Plum Taste Test Results. A score of 5 is the best rating

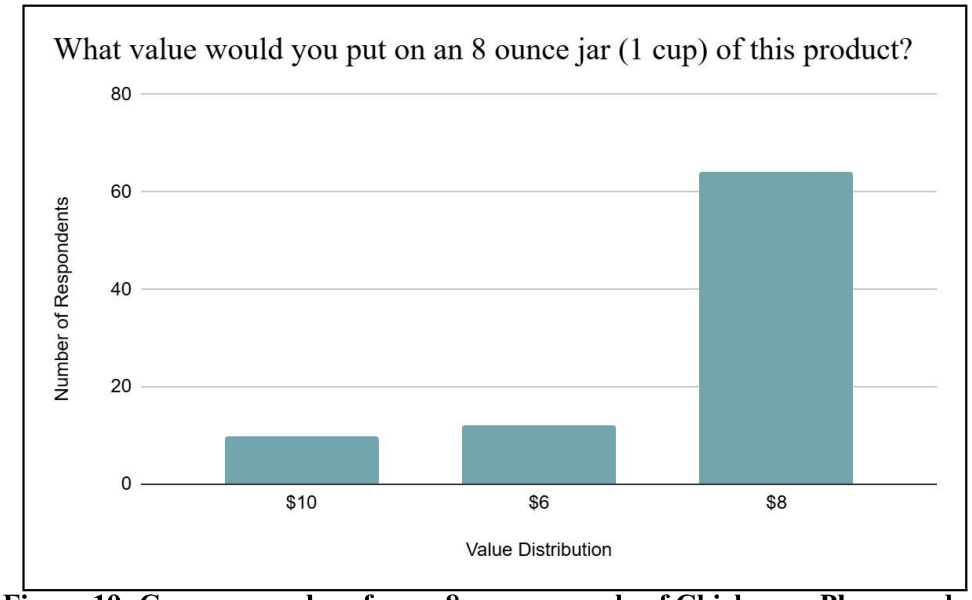

Figure 19: Consumer values for an 8 ounce sample of Chickasaw Plum products

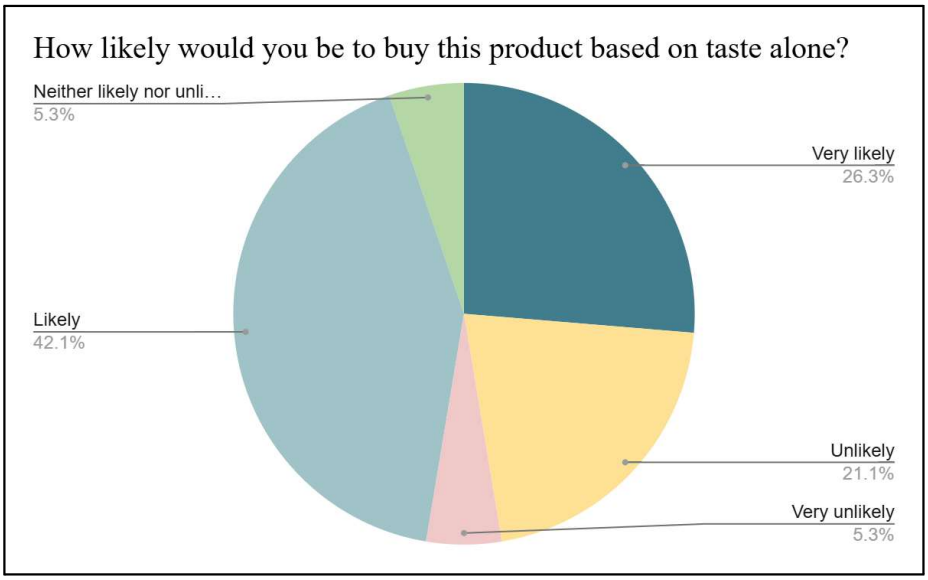

Figure 20: Consumer likelihood of buying Chickasaw plum products based on taste

Crop	Average score	Standard Deviation	Average value
Serviceberry	4.5	0.77	$8
Cornelian Cherry	4.24	0.85	$7
Gooseberry	4.17	0.79	$7
American Persimmon	4	1.23	$7
Lemony Quince	3.93	0.94	$8
Chickasaw Plum	3.83	1.15	$8

Figure 21: Crop Comparison of Taste Test and Value Scores. A score of 5 is the best.

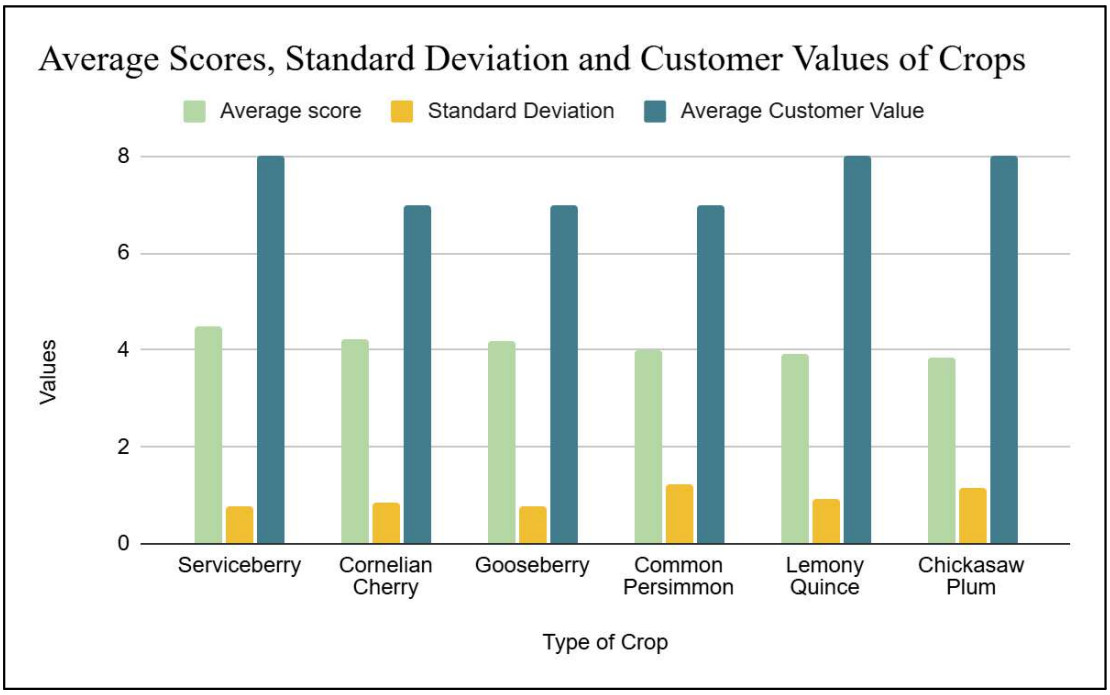

Figure 22: Scores, Standard Deviations of scores and Customer Values of an 8 ounce sample of each crop.

According to the surveys collected from all three tasting events, Serviceberry had the highest taste test scores with an average of 4.5 out of 5, with 5 being the highest, most favorable rating. Serviceberry also had the lowest standard deviation with a value of 0.77. Consumers valued an 8 ounce sample of Serviceberry at $8 on average. Serviceberry also tied with Cornelian Cherry with the highest number of participants that sampled it with 43 total. Samples of Serviceberry included fruit leathers, Serviceberry and Pear pie and Serviceberry mead. Cornelian Cherry earned the second highest taste test score with a value of 4.24 and a slightly higher standard deviation of 0.85.Consumers on average valued an 8 ounce sample of the Cornelian Cherry at $7. Samples of mild and spicy Cornelian Cherry Salsa were provided in addition to Cornelian Cherry mead. Gooseberry received an average taste test score of 4.17 out of 5, with a standard deviation of 0.79. On average, consumers valued an 8 ounce sample of Gooseberry at $7. Thirty six people sampled the Gooseberry Ketchup and Gooseberry jam. American Persimmon earned a taste test score of 4 and had the highest standard deviation of all the crops at 1.23. The average consumer value for an 8 ounce sample was $7. Thirty people sampled the Persimmon pie and the Persimmon mead. Lemony Quince earned the second lowest taste test score, with a rating of 3.93. Lemony Quince had a standard deviation of 0.94 for its taste test score. Consumers valued an 8 ounce sample of Lemony quince at $8. Twenty nine people sampled the Lemony Quince jam and Lemony Quince gummy bears. The Chickasaw Plum jam received the lowest taste test rating with a score of 3.83 and a relatively high standard deviation of 1.15. Consumers valued an 8 ounce sample of the Chickasaw Plum at $8. Only 19 people sampled the Chickasaw Plum jam.

IV. Discussion

Our project sought to gather examples of value added products, consumer preferences and essential crop required growth and harvest information to share with growers. We worked with Ken Asmus to determine the ‘best bet’ crops based on his decades of experience with the crops. He made his recommendations based on the criterion of crops being high yielding, pest and disease resistant, flavorful, harvestability and having high commercial potential. We developed value added products and then coupled consumer feedback with essential growing and harvest information so that growers could more aptly integrate these crops within their production systems.

Although our Agroforestry Working Group survey had a small sample size of 4 respondents, it still gave us key insights about the kind of information that growers would like to have, such as crops that grow well in their location, how to manage trees, how to market products, and examples of value added products since the majority of respondents

wrote that they were unfamiliar. Respondents also requested information about nurseries that supply these types of crops. Based on this initial survey and a subsequent interview of a nursery grower from the Agroforestry Working Group, Jackson Gorland, we decided to develop examples of value added products, and to include specific crop information that addresses their questions, ie. location, crop management, marketing, and nursery sources in our official document to be shared with farmers.

In addition to harvesting these crops both at Ken's site, Oikos Tree Crops, we also harvested Serviceberry/Saskatoons and Cornelian Cherry's in Ann Arbor city proper. The fact that these two crops were growing freely, untended and most likely not given fertilizer or sprays for production, adds even more evidence of their low maintenance and adaptability to a variety of conditions such as drought.

After analyzing the data from the taste test surveys, it appears that Serviceberry/Saskatoon garnered high consumer interest and the highest ratings of all fruits with a score of 4.5 out of 5. They were the only fruit made into a fruit leather, so perhaps part of the high rating could be the novelty of the product itself. Cornelian cherry salsa also garnered high consumer interest with 43 respondents tasting the salsas and the mead samples, and filling out the survey. These top crops were followed by Gooseberry, which consisted of a Gooseberry jam and 'ketchup' sauce. Although sample sizes were small with 43 maximum respondents per variety, there was a great deal of positive feedback from consumers overall during the tasting events. At the relatively busy Eastern Market location, it was anecdotally interesting to see people stop and spend time talking about the varieties of plants and ask questions. One family told us stories about the cultural significance of Cornelian cherry within Iranian heritage and how this product was so hard to find in the states. Consumers also were asking about the recipes and the nutritional information so we ended up providing a booklet of these requests as well in future tastings.

In the written feedback portion of our taste test survey, we found a general consensus amongst consumers that they wanted some samples to have less spices in order to showcase the flavor of each fruit on their own. For instance, a handful of consumers wanted less cinnamon in the Serviceberry pear pie and less garlic in the gooseberry 'ketchup' sauce. The exception to this is that some people wanted more heat in the Cornelian Cherry salsa and more ginger to 'mask' the bitter aftertaste of the Chickasaw plum. Also, some consumers believed we should increase the valued price options due to the uniqueness and local sourcing of these fruits.

One area of improvement for the study would have been to collect surveys of only one type of sample per fruit because results were relatively variable for American

Persimmon, and Gooseberry based on what type of sample consumers tried. The Gooseberry jam anecdotal had better in person reviews on average than the Gooseberry Ketchup so separating out each product on its own would have allowed for a more precise demonstration of customer preferences. Still, we were happy to provide as many examples of value added products as possible so that people would be exposed to the variety of uses each crop can provide.

V. Conclusion and Future Developments

These value-added products should be developed further to increase consumer education and demand. In addition, we recommend larger scale feasibility studies be performed to better inform growers of the marketability of these agroforestry crops. The educational growth guide with the crop growth, harvest and marketability information is available via the following link: Growing Guide for Resilient Fruit Crops in Michigan - Google Docs. This document will be shared with producers via presentation to partner organizations such as Michigan Agroforestry Working Group and at Northern Small Farm Conference to support state-wide agroforestry initiatives.

A couple months after the final taste test event, the lead researcher followed up with growers from Washtenaw County who had attended the final tasting event to further learn about their needs around growing tree crops. During this hybrid in-person and online meeting, growers expressed that some of the biggest challenges for incentivizing growth of these crops have been the cost of processing equipment, access to a commercial kitchen to make value-added products and the need to educate consumers about tree crop products to develop a market. Through this meeting and subsequent meetings with Fruit & Nut Cooperatives such as Keystone Tree Crops and Black Squirrel Farms, the lead investigator began to envision a cooperative that helps growers more readily earn revenue from selling fruit and nut crops in Michigan. She worked to create a proposal for a so-called Detroit Fruit & Nut Cooperative and received some funding through an OptiMize Innovation Grant. After graduation, she plans to use funds to acquire business licenses, purchase processing equipment and acquire a shared space for growers to create their value-added products.

References

[1] Lundgren, B. 1982. Introduction [Editorial]. Agroforestry Systems 1:3-6.

[2] Nair, PKR, Kumar, BM, Nair, VD. 2021. Global distribution of agroforestry systems, *An introduction to agroforestry* [ebook]. Switzerland: Springer. DOI: http://dx.doi.org.proxy.lib.umich.edu/10.1007/978-3-030-75358-0_4.

[3] Smith, MM, Bentrup, G, Kellerman, T, MacFarland, K, Straight, R, Ameyaw, L. 2022. Agroforestry extent in the United States: A review of national datasets and inventory efforts. *Agriculture* 12(5): 726. DOI: https://doi.org/10.3390/agriculture12050726

[4] Jose, S. 2009. Agroforestry for ecosystem services and environmental benefits: an overview. Agroforestry Systems 76:1-10. http://dx.doi.org.proxy.lib.umich.edu/10.3390/agriculture12050726.

[5] Valdivia, C, Poulos, C. 2009. Factors affecting farm operators' interest in incorporating riparian buffers and forest farming practices in northeast and southeast Missouri. *Agroforestry Systems* 75(1): 61–71. DOI: http://dx.doi.org.proxy.lib.umich.edu/10.1007/s10457-008-9129-2.

[6] Bentrup, G., & Leininger, T. (2002). Agroforestry: Mapping the way with GIS. In *JOURNAL OF SOIL AND WATER CONSERVATION N|D*. DOI:https://www.fs.usda.gov/nac/assets/documents/research/publications/2002agroforestrygis.pdf

[7] Trozzo, KE, Munsell, JF, Chamberlain, JL. 2014. Landowner interest in multifunctional agroforestry riparian buffers. *Agroforestry Systems* 88: 619–629. DOI: http://dx.doi.org.proxy.lib.umich.edu/10.1007/s10457-014-9678-5.

[8] Mattia, CM, Lovell, ST, Davis, A. 2018. Identifying barriers and motivators for adoption of multifunctional perennial cropping systems by landowners in the upper sangamon river watershed, Illinois. *Agroforestry Systems* 92(5): 1155–1169. DOI: http://dx.doi.org.proxy.lib.umich.edu/10.1007/s10457-016-0053-6.

[9] Schoeneberger, Michele M ; Bentrup, Gary ; Patel-Weynand, Toral. (2017). *Agroforestry: Enhancing Resiliency in U.S. Agricultural Landscapes Under Changing Conditions* (1962nd ed.). https://doi.org/10.22004/ag.econ.344570

[10] Orefice, Joseph ; Carroll, John ; Conroy, Drew ; Ketner, Leanne. (2017). Silvopasture practices and perspectives in the Northeastern United States. *Agroforestry Systems*, *91*(1), 149–160. https://doi.org/10.1007/s10457-016-9916-0

[11] Brodt, Sonja B. ; Fontana, Nina M. ; Archer, Leigh F. (2020). Feasibility and sustainability of agroforestry in temperate industrialized agriculture: preliminary insights from California. *Renewable Agriculture and Food Systems*, *35*(5), 513–521. https://doi.org/10.1017/S1742170519000140

[12] Kreitzman, Maayan ; Eyster, Harold ; Mitchell, Matthew ; Czajewska, Aldona ; Keeley, Keefe ; Smukler, Sean ; Sullivan, Noah ; Verster, Adrian ; Chan, Kai M. A. (2022). Woody perennial polycultures in the U.S. Midwest enhance biodiversity and ecosystem functions. *Ecosphere (Washington, D.C)*, *13*(1). https://doi.org/10.1002/ecs2.3890

[13] Stubblefield, K., Smith, M., Lovell, S. *et al.* Factors affecting Missouri land managers' willingness-to-adopt agroforestry practices. *Agroforest Syst* 99, 16 (2025). https://doi.org/10.1007/s10457-024-01117-0

[14] Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). Free Press.

[15] Baumgart-Getz, A., Prokopy, L. S., & Floress, K. (2012). Why farmers adopt best management practice in the United States: A meta-analysis of the adoption literature. *Journal of Environmental Management*, *96*(1), 17–25. https://doi.org/10.1016/j.jenvman.2011.10.006

Appendix I: Crop Growth, Management, Harvest, Marketability & Nursery Source Information

Saskatoon, Juneberry, Serviceberry

Amelanchier spp.



INTRODUCTION

The *Amelanchier* family comprises 20-30 species native to North America. The *Amelanchier alnifolia* or Saskatoon is the most commonly grown species for fruit. They are extremely cold hardy and do well in northern climates. Given the genus's ability to hybridize freely, it is difficult to identify them at the species level. Saskatoons are about the size of a blueberry and have a sweet berry-taste with an undertone of almond. Saskatoon fruits are used for wine, sauces, pies and jams, eaten raw or dehydrated. They are extremely nutritious with higher antioxidant content than most berries (Hosseinian & Beta, 2007). They are also a favorite among many species of birds.

GROWING REQUIREMENTS

Saskatoons grow well in cold, cool climates and Zones 2 through 5. The fruits are adaptable to a wide range of soils and especially thrive in sandy soils with good drainage. They also do best where there is good airflow, cold winters, dry summers and a short fall

season. According to Oikos Tree Crops, the Smokey, Northline and Pembina cultivars are great varieties known for high quality fruit and good yield. These varieties will fruit in 1-3 years from seedling and grow almost identical fruit to their parents.

They can be propagated from seeds or from cuttings. Plant them in full sun for maximum quality of fruit. The recommended spacing is 3 to 5 feet apart, with a between-row spacing of 12 to 16 feet for hand harvest and 17 to 20 feet for mechanical harvest (Wilson, 2017). They typically grow to a height of about 15 ft-20 ft tall and 10-15 ft wide. If drip irrigation tape is set up in the orchard, connect the tape as each row is planted or have a ready supply of water from a hose to water the plants as they go in.

MANAGEMENT

Saksatoons are in the Rosaceae family, which is the same family as the apple, so they are susceptible to a number of similar pests, but in general pests are typically kept in check by natural predators (Spencer, R. et al., 2013). Careful monitoring can still be done. For more detailed pest information see Saskatoon_Berry_Production_Manual.pdf (Spencer, R. et al., 2013).

Most Saskatoon varieties fruit when there is limited moisture or humidity as they are susceptible to fungal scab. If planted in an optimal location, they are easy to grow with their main problem being some fungal diseases that often come from apples. This is a common issue with saskatoons as well as most species of Amelanchier. A number of readily available amendments and organic sprays such as Azomite and neem oil can help prevent fungal scab. Given the berry's attractiveness to a wide range of birds, growers might need to use protective netting during harvest time.

HARVEST

Saskatoons can be harvested by hand or using a machine. The sideways Joanna harvester is a commonly used commercial grade machine that also allows for harvest of aronia berry. Due to its high investment cost, growers might consider sharing equipment in a cooperative. The bushes begin yielding in their third year, with an average rate of production that ranges from 4-5 pounds to 10 pounds per bush depending on variety (Spencer, R. et al., 2013). An acre could produce anywhere from 2,000 to 6,000 pounds. Typically, fruits ripen over a two week period in June and do not ripen evenly. Therefore, it is recommended to harvest twice about 5 days apart. Fruit can be sorted before sale by color, but should be either kept refrigerated or frozen upon harvest since it does not keep long.

MARKETING

Saskatoon berries are most often frozen and shipped to different markets in boxes lined with food grade plastics. Berries can also be flash frozen using extra low temperatures in order to both better preserve flavor and texture and keep individual berries from sticking to one another. Berries can also be processed into value-added products such as filling for pies, tarts, hams or as an ingredient in juices, vinegars, wine, vinaigrettes or chutney in both frozen or as a fresh ingredient (Spencer, R. et al., 2013). The berries also dehydrated well in a fruit rollup or fruit leather spread on parchment paper. In a Master's Capstone project at University of Michigan's School for the Environment and Sustainability, students found that amongst 43 taste testers, Saskatoons/Serviceberry fruit leathers and pies received the highest taste tests score within the group of value added products provided with an average score of 4.5/5. Respondents valued an 8 ounce sample of the products at $8 on average.

Gooseberry

Ribes grossularia and Ribes hirtellum



INTRODUCTION

Gooseberries are relatively easy to grow and produce a high yielding, tart berry that can be used in pies and jellies (Maughan & Black, 2014). There are two species of Gooseberry, the American gooseberry *(Ribes hirtellum)* and the European gooseberry *(Ribes grossularia).* The European cultivars are usually a 'pure' speces, whereas most American gooseberries have been crossed with European gooseberry. The American cultivars often have smaller berries and can have less flavor (Maughan & Black, 2014). Fruits are usually greenish yellow in color but can also be pink, red or white depending on which cultivar.

GROWING REQUIREMENTS

Gooseberry bushes are ideal for cold climates in Zones 3-6. Most cultivars can survive temperatures of -40 degrees Ferenheit and require a minimum of 1,000 hours of winter chilling for buds to break (Maughan & Black, 2014). They fruit well in a sunny location, but can also be planted in partial shade and on a north-facing slope to help keep the plant cooler in the hottest days of summer. Gooseberries do best in well-drained sandy loam or sandy rock soils of a pH of 6-7 with organic matter incorporated.

Spacing might range depending on the cultivar, but in general they can be planted 3-5 feet apart with spacing of 8 to 10 feet between rows. If bushes are planted too close together, their arching branches might make it difficult to harvest. The bushes can reach a height of 3-5 feet.

Given their shallow roots, they do well with drip system irrigation. The plants should be watered all season, but not waterlogged. They are susceptible to both drought stress and water-stress so it is important to keep them at a balanced moisture range and mulch underneath the plants to retain moisture (Maughan & Black, 2014).

Gooseberry flowers are self-fertile and blossom early in the season. The 'Poorman' American cultivar is cold hardy, highly productive and bears medium-sized fruit. The 'Oregon Champion' produces yellow-green berries that can be readily processed and the 'Downing' is another American cultivar is commonly grown for its resistance to mildew, producing small green fruit with a strong flavor.

Most of the European cultivars produce green fruits and larger fruits. 'Invicta' is resistant to mildew and has an average flavor. The 'Careless' cultivar is one of the most commonly grown of the European cultivars. 'Achilles' is another cultivar grown for its superb flavor.

MANAGEMENT

According to Utah State University Extension, potassium can be a very useful nutrient for promoting fruiting and providing resistance to disease (Maughan & Black, 2014). A possible application is 2 tablespoons of potassium fertilizer per plant. Gooseberry plants also have a generally high magnesium requirement, whereas too much nitrogen can cause mildew. In general, a well balanced fertilizer (10-10-10 or 16-16-16) can be used in order to both promote growth and prevent disease. To prevent powdery mildew, American types can be used, which are less susceptible, pruning to improve air circulation, and drip irrigation instead of overhead irrigation. The Gooseberry fruitworm can also be controlled with Bacillus thuringiensis (BT). Leaf Spot can also be controlled through removing dead leaves, pruning for air circulation and applying basic copper sulfate.

HARVEST

Most varieties of gooseberry have thorns on stems, so it is advisable to wear long sleeves and gloves while harvesting. The fruits will ripen over a four to six week period between June and August. Berries can be both picked while green and used in cooking, or later on when they are fully ripe and eaten fresh. The average yield per gooseberry bush is

between 8-10 pounds of fruit (Maughan & Black, 2014). They should be refrigerated immediately after harvest and in shallow containers to prevent bruising and increase air circulation. They can be refrigerated up to three weeks if properly stored. They can also be frozen or juiced for long-term storage.

MARKETING

Gooseberries are used in a range of value-added products including filling for tarts, pies and as jams, especially when they are picked underripe. Traditionally, they have also been used in Indian cooking for chutneys and for their medicinal properties since they are a good source of Vitamin C and antioxidants. In a Master's Capstone project at University of Michigan's School for the Environment and Sustainability, students found that amongst the 36 taste testers, Gooseberry jam and Gooseberry 'ketchup' sauce received an average score of 4.17 out of 5. Respondents valued an 8 ounce sample of the products at $7 on average.

Cornelian Cherry

Cornus mas



INTRODUCTION

Cornelian Cherry is a small fruiting shrub in the dogwood family and is not a ‘true cherry’. It is native to Southern and Western Europe and Southwestern Asia. The sweet and tart fruit has been used in both cuisines in eastern Europe, Greece, Turkey, Iran and also in traditional Chinese medicine. It is cultivated for use in sauces, conserves, and marmalades. The fruits can be eaten fresh, dried, and in salsas and unripe fruits can be pickled and made into olives. It has a very similar flavor to a tart cherry and is high in vitamin C and pectin. It has bright yellow flowers in the early Spring that persist for a few weeks and almost always produces a good crop of fruit.

GROWING REQUIREMENTS

Cornelian Cherry is partially self-fertile, but produces more if cross-pollinated with another variety. It is cold hardy, growing in Zones 4-9 and in any soil from rock to dense clay (Asmus, n.d). The plant is drought tolerant and can grow in partial shade to full sun. From seed, it can take about 4 to 6 years to fruit. Once it starts fruiting, it is very prolific. Cornelian Cherry can be grown as a hedgerow with denser plantings of 10 feet between

plants. In an orchard, recommended spacing as 15–20 feet apart, with 20–28 feet between rows (*Pioneer Cornelian Cherry Dogwood*, 2025). It grows into a small tree or large bush and can reach 15-20 feet tall and 12-15 feet in width. Cultivated varieties yield larger, tastier fruit and typically are dark red and soft when ready for harvest.

According to the *Philadelphia Orchard Project*, Seeds need between 90-120 days of warm, moist stratification, followed by 90-120 days of cold stratification. Cultivated varieties are propagated via cuttings placed in soil medium and kept moist. Greenwood cuttings taken in July or August are more effective than dormant hardwood cuttings (*Cornelian Cherry Plant facts*. (n.d.)

MANAGEMENT

With the exception of dogwood anthracnose, the plants are extremely pest and disease resistant. Mulching encourages better root growth and drought tolerance. A compost tea can also be applied in the Spring.

HARVEST

Unripe cornelian cherries are bright red, hard and extremely tart and astringent. The fully ripe fruit is soft and a deep red or purple in color. Generally, the fruit is ripe if it is falling from the bush. They ripen at the end of August and will continue to ripen until late September. The best way to harvest is by laying a tarp or blanket down under a tree, gently shaking the branches and gathering only the ripened fruit. All fruit should be immediately washed in cold water and either dried, refrigerated, frozen or eaten fresh. One can shake the branches about twice a week until the end of September. A mature, healthy Cornelian cherry tree typically yields between 20 and 60 pounds of fruit per year, while some prolific cultivars can yield over roughly 110 lbs of fruit per shrub (*Cornelian Cherry Plant facts*. (n.d.)).

MARKETING

Currently cornelian cherry and value-added products with this fruit are primarily sold in Europe. Due to their ease of cultivation and reliable yield, they have the potential to rise in popularity in the United States. The dried fruits are salted and sold as a snack in the Middle East and are also used in traditional Chinese medicine for kidney issues. Due to their slight astringency and pit being entrenched in the fruit, the fruit are more easily cooked into jams, jellies, syrups and sauces than eaten fresh. It is a good source or antioxidants, particularly anthocyanins and high in Vitamin C, various minerals and calcium pectate fiber, which can help reduce levels of LDL cholesterol (Bijelic et al.,

2011). In a Master's Capstone project at University of Michigan's School for the Environment and Sustainability, students found that amongst the 36 taste testers, Cornelian Cherry salsa and mead value added products received an average score of 4.24 out of 5. Respondents valued an 8 ounce sample of the products at $7 on average.

American Persimmon

Diospyros virginiana



INTRODUCTION

There are two types of persimmons, the American *(Diospyros virginiana)* and Asian (*Diospyros kaki*) variety also commonly known as fuyu. The Asian varieties are available commercially. The lesser-known American persimmon has not reached as much commercial popularity but has the potential for wholesale as an ingredient in ice cream, pudding, wine, beer etc. The American persimmon is a slow-growing tall tree native to the eastern United States. The word “persimmon” is of Algonquian origin and Ethnohistorian Charles Hudson stated that persimmons were the most important fruit in the southeast among Native Americans, being incorporated into native diets since at least the Paleoindian time period (over 12,000 years ago). Indigenous cultures would make persimmon bread and stored the dried fruit. When ripe, the sweet fruit of persimmon is reminiscent of dates, however if immature, the fruit is strongly astringent. The orange, edible fruit attracts a plethora of wildlife.

GROWING REQUIREMENTS

Persimmons are generally not self-fertile, so they mostly require a male tree nearby to produce fruit. A ratio of 5:1 females to males is recommended for a high fruiting yield (Lehman, J., 2017). There are however cultivars like Meader, Prok, and Szukis that are

self-fertile and produce seedless fruit. It grows in Zones 5-9 and is adaptable to a wide range of soils and particularly thrives in well-drained, sandy loam and clay loam soils.

The trees are also suitable for erosion control because of their deep taproot system. This deep taproot also makes them hard to transplant.

Persimmon trees are relatively easy to propagate from seed, graft or root cutting and can be directly planted in the garden in the fall or stored in a moistened media in the fridge to be stratified so they can germinate in the spring.

Persimmon trees should be planted in a sunny location that receives at least 8 hours of direct sunlight during midsummer. The sunlight triggers new flower buds the following season, so that there will be fruit. The fruit development also improves when stimulated by the sun and heat (*Raintree Nursery*, 2025). **Standard varieties** are generally planted 20-25 feet between trees and 25 feet between rows. For semi-dwarf varieties or grafts, trees can be planted closer to 15-20 feet apart and for dwarf trees, plantings can be about 10 to 15 feet apart (Paradise Nursery., 2024).

Typically, persimmons reach up to 30 to 60 feet at maturity, however in optimal habitats, they can reach about 70 to 80 feet and can reach up to 3 feet in diameter. They form as a relatively straight upright tree with deciduous leaves.

Flowering takes about 5-10 years from seedling, and grafted trees produce sooner at about 3 years of growth. It can take 10-15 years for trees to come into full production, depending on the variety. The trees generally fruit when they reach about 8 to 15 feet in height.

Several cultivars are available with improved fruit size and quality. In native persimmon areas, top working or grafting on suckers is a good way to get cultivars that bear quickly. Male trees can also be grafted on female trees if needed (McDaniel, J. C., 1973).

MANAGEMENT

Persimmon is valued for its hardiness, its abundant crop of fruits, and its immunity from disease and insects. If the trees are cut or top-killed by fire, vigorous sprouting occurs at the root collar. Trees are usually trained to a central leader and usually do not require pruning after they mature. American persimmons are resistant to most pests and diseases, however the persimmon borer can affect young trees (Lehman, J., 2017). . It is best to avoid injuring the base of the tree while mowing since they are more susceptible to decay

and insects here (Wilson, M. H., 2017). An array of wildlife eat the fruits so provisions should be made to prevent this for commercial growers.

HARVEST

The pulp is very astringent when not ripe, but after a frost in the fall, when the fruit turns yellow to orange, the flesh is sweet in taste. They are one of the most reliable trees to fruit and often have a heavier and lighter alternating yield from year to year due to their two-year fruiting pattern. The average production is 35 to 75 pounds of fruit per mature tree (Lehman, J., 2017). Shaking the trees will drop fruit before they are fully mature so there are limited opportunities to machine harvest the fruit. The fruits will often remain on theso they are easily damaged when they fall to the ground. To prevent injury, one grower, Jerry Lehman spreads clean straw under the trees before shaking them to soften their landing, and then gathers the fruits by hand (Lehman, J., 2017). Fruit can be harvested every other day and should be immediately sanitized with a vegetable and fruit approved sanitizer, then rinsed with pure water. The fruit can then be separated from the seeds and frozen (Wilson, M. H., 2017.

MARKETING

It is imperative that fruit are fully ripe before being sold or that consumers are educated about proper techniques to ensure ripening since the unripe fruits' astringency is highly undesirable. To ripen them, the fruit can be left on the counter in a plastic bag with an apple slice. There are commercial opportunities to market the frozen pulp for use in ice cream, sorbet, puddings, cookies, cakes and preserves, and dehydrated in a date-like manner (Hayhurst, S., 2012). There is also an increasing market for persimmon as an ingredient in alcoholic beverages (Lehman, J., 2017). According to Perennial Pathways, frozen pulp retails at about $5.00 per pound. In a Master's Capstone project at University of Michigan's School for the Environment and Sustainability, students found that amongst 30 taste testers, Persimmon pie and Persimmon mead received an average score of 4 out of 5. Respondents valued an 8 ounce sample of the products at $7 on average.

Chickasaw Plum

Prunus angustifolia



INTRODUCTION

The Chickasaw plum also known as a Sandhill or Cherokee plum is normally thought of as a southern plum, however it can be grown in Zone 5 as well (Asmus, K). It was originally cultivated by Native Americans, particularly the Chickasaw across the Southeastern U.S. The fruit is usually consumed fresh or dried. It's also been used to make wine, jam and jelly. The fragrant, showy flowers have five white petals and the plums are cherry-like and tend to be very tart until they fully ripen in late summer. Chickasaw plums tend to expand by runners and are often used in developing wildlife habitat on sandy soils. The thorny thicket provides excellent habitat for bird nesting, loafing and roosting. Numerous species of birds also consume its fruit (Kansas Forest Service, 2010).

GROWING REQUIREMENTS

Chickasaw plum is self-fertile, but will benefit from two or more of its plants in close proximity (Asmus, K.). It grows naturally on sandy soils and can also grow well on

heavier clay loam soils as long as the soil is not strongly alkaline (Christman, 2008). It does best in full sun and can also tolerate partial shade and grows best in Zones 5-9.

While some wild plum species exhibit "double dormancy" (requiring alternating warm/cold periods), the primary recommendation for Chickasaw plum is a single, extended cold stratification period (Row, J. M. and W. A. Geyer., 2010). Additionally, one-year-old, bare-root seedlings about 18 to 24 inches tall can be used in plantings. These small trees grow quickly but have a relatively short life. Chickasaw plum trees can be spaced about 8 to 15 feet apart depending on if one wants a dense thicket or more individual trees and about 16 feet between rows (Row, J. M. and W. A. Geyer., 2010). They can reach 10-20 feet in height and width upon maturity. According to Ken Asmus of Oikos Tree Crops, “the yields are very high and there really is no reason to create cultivars from it for use now.” Seedlings can produce fruit in 2-3 years depending on climate and care.

MANAGEMENT

Chickasaw plum require very little maintenance and exhibits surprisingly strong hardiness in Michigan with no die back even when exposed to -27 degree Fahrenheit weather (Asmus, K.). It can form a dense thicket, but it is relatively easy to clean up these patches for better ease at collecting fruit (Asmus, K.). Insects and disease will on occasion attack this species, but do not pose a serious problem. The primary pest of the Chickasaw plum is the plum curculio, and it must be managed in commercial plantings which typically involves chemical controls (Row, J. M. and W. A. Geyer., 2010). The two major diseases are brown rot in fruit and bacterial leaf spot, but there are no natural resistances to these diseases yet (Row, J. M. and W. A. Geyer., 2010).

Chickasaw plum seedlings are not as vigorous as American plum seedlings, so it is important to control weed and grass competition during the first and second years of growth if started from seed or a small seedling (Kansas Forest Service, 2010). The plums are drought tolerant once established.

HARVEST

The Chickasaw plum typically ripens in late summer or early fall depending on the climate. In Michigan, they typically ripen late into September and October (Asmus, K.). When they are ready, they will turn from a reddish to deep red or purple color and be slightly soft to the touch. They can be hand harvested from trees with care taken to not damage the branches. The fruit typically will ripen in a matter of weeks and stay ripe on branches for up to two weeks before becoming overripe. One mature, healthy tree can

produce up to 80 pounds of fruit. As a tart fruit with a sour cherry flavor, they are best eaten mixed with some sugar or other fruits in jams, jellies, pies, etc.

MARKETING

Given their immunity to diseases that normally affect European and Japanese plums, they have potential for their productive, low maintenance and adaptable characteristics. They could have a niche market in the US as a locally sourced, native crop for jams and jellies. They can also be sold as a wildlife landscape plant for their early, profuse Spring blooms and ability to host a variety of songbirds such as the bobwhite and the mockingbird, brown thrashers and butterflies. In a Master's Capstone project at University of Michigan's School for the Environment and Sustainability, students found that amongst the 19 taste testers, Chickasaw plum jam received an average score of 3.83 out of 5. Respondents valued an 8 ounce sample of the products at $8 on average.

Lemony quince

Chaenomeles lagenaria



INTRODUCTION

This cultivar of a quince differs from most commonly grown quince in that it has a lemony taste mixed with a sweet apple and ascorbic tartness compared to its bland counterpart. Like all quince, it is a member of the apple and pear family (Rosaceae) and produces a yellow, hard pome fruit that is sour when eaten raw. Quince fruit is used to make jams, marmalades, fresh fruit compote, jellies, dried slices and wines (Laureiro et al., 2009). The quince tree spread from its native region of the Trans-Caucasia and north of Iran to America over 4,500 years ago (Abdollahi, 2019). The lemony quince variety has beautiful red and salmon-colored flowers that bloom in the early spring.

GROWING REQUIREMENTS

Lemony quince is self-fertile and can grow in a wide range of Zones 4-9. It prefers hot and dry conditions and will grow in almost any soil from rock, loam to sand and in moderately or well-drained soil. They fruit best in full sun and can do well in partial shade. This cultivar will reach about 2-4 feet in height and width, whereas some varieties of quince, when trained as a tree can reach a maximum of 15 feet (Bailey, R., 2021). If growing for fruit, it is important to seek cultivars that have been bred for this.

When starting from seed, you can treat it like an apple and do a cold moist stratification for 90 plus days at temperatures between 38-42 degrees Ferenheit. If seeds sprout within

60 days, they can be potted up. If stratified in the fall, the seeds can simply be covered with a half inch of soil or sand and watered. Some seeds will take a second year to sprout, but most will sprout the first year (Asmus, K.). Lemony quince grown from seed will fruit true to seed.

Lemony quince can also be propagated by cuttings or by digging up a piece of it with roots. Quince can also be bought bare-rooted in the spring or potted up in the summer (Bailey, R., 2021).

Depending on the density of plantings desired and the size at maturity for the selection of quince, quinces like lemony quince can be planted 4-10 feet apart for a dense shrub-like thicket, or 10-15 feet apart for more standardized tree varieties with 25 to 30 feet between rows for standard trees, or 15 to 20 feet for smaller varieties. Generally, quince will produce fruit 2-3 years after it is planted as grafted or container-grown trees.

MANAGEMENT

Quince are generally disease and pest free. Quince is however susceptible to fire blight so to prevent this, one can avoid addiing excess nitrogen because it produces a flush that is more susceptible to blight (Bailey, R., 2021). In addition, although they are drought tolerant, quince bears more fruit in moist soil. To maximize fruit production, one can provide compost and mulch around the base every few years (Bailey, R., 2021).

Minimal pruning is needed. It is advisable to cut out branches that cross and rub against one another and to remove any wood that has died or wood that might have become infected with fire blight. Flowering quince can be shaped as needed with minimal damage to fruit production, since quince fruit on the tips of previous years' wood rather than new wood (Bailey, R., 2021).

HARVEST

Lemony quince and most quinces ripen in late September, October and even into November depending on the climate. They can handle a light frost but not a heavy freezing. When ripe, they will turn from green to bright yellow, will be highly aromatic and easily twist off the branch. Although the flesh will remain hard when ripe, the skin bruises easily so they should be hand-picked and stored in a single layer. Unless their flavor is desired, they should be stored away from other fruit, since their aromatic properties will affect any food in close proximity. If they are green and unripe, they can be stored in a cool, dry location for up to six weeks until they fully ripen. Once fully ripe,

they can be stored in the refrigerator for up to two weeks or frozen for 2-3 months. They will become mealy when overripe (Grant, A. 2016).

The quince, both in tree and shrub form are highly productive. The trees can yield 80-100 pounds of fruit when they reach maturity, and the bushes can yield about 40-50 pounds of fruit per season (*Quince growing,* 2007).

MARKETING

According to Ken Asmus, although the raw lemony quince variety can be very tart, "the fruit is completely delicious and usable stewed and mixed with sugar." Commercially, quince is most often made into a jelly. It can also be cooked with apples in sauce to add zest to fruit pies. Poached quince is also a potential use in fine dining. Due to their high pectin content, quince also has potential to be used in gummy bears or other gummy creations. In a Master's Capstone project at University of Michigan's School for the Environment and Sustainability, students found that amongst the 29 taste testers, Lemony quince marmalade and gummy bears received an average score of 3.9 out of 5. Respondents valued an 8 ounce sample of the products at $8 on average.

Appendix II: Recipes for Capstone Taste Testing Value Added Products

Cornelian Cherry Salsa

Ingredients:

2 ½ cups ripe cornelian cherries, pitted*
2 Jalapeños, stems removed
4 Roma tomatoes
1 small red onion, peeled and sliced in half
½ white onion, peeled and sliced in half
2 garlic cloves
2 tablespoons vegetable oil
1 lime juiced
½ bunch fresh cilantro leaves, minced
salt and pepper to taste
1 teaspoon of cumin
2 Tbs brown sugar

*To de-pit cornelian cherries, boil them for a couple minutes, drain and cool, then pop pits out with a friend

Instructions: Preheat oven or grill to broil or 450 degrees. Toss cherries and garlic cloves in 1 to 2 tablespoons of oil. Spread on sheet pan. Add cumin powder. Roast in oven until skins begin to soften or split. Cherries should be al dente, not too soft. Do not char the skins, about 6-9 minutes. Roast separately from the other ingredients so that the cherries are not over done. Remove from the oven and allow to cool.

Toss whole tomatoes, onions and jalapeños with 1 - 2 tablespoons of remaining oil. Spread on sheet pan. Roast in oven or over grill until skins bubble up and begin to loosen and char. Turn halfway through, about 10 minutes. Place in a bowl and cover with plastic wrap, allow to cool. Remove skins.

Add ½ of cherries, jalapeños, tomatoes, onion, garlic and 2 tablespoons lime juice and zest (optional) to the food processor. Pulse until you reach the desired consistency. Stir in cilantro. Pour into a dish.Stir brown sugar into the salsa. Add additional brown sugar and/or honey if still too tart. Season to taste with salt and pepper. Add more lime juice, pepper and cumin if desired.

Cornelian Cherry Mead

Ingredients:

5-6 cups of cornelian cherries (can be ripe or unripe)
12 cups of distilled or fresh spring water
3.5 cups of RAW honey (must be raw for fermentation)

Instructions: Fill up a one gallon pot with 12 cups of water and then add honey. Stir until the honey is fully dissolved in the pot.Add the cornelian cherries. Cover the pot.
For the next 8-10 days, uncover and vigorously stir the mixture in the morning and evening. Take note of the process of bubbles and fizz forming. The mixture should reach a peak and then gradually slow down the development of bubbles and fizzing.

Take a sample when the process has slowed down (around days 8-10).
Once it is the desired flavor, strain out the cherries and bottle up in mason jars with an airlock that allows for carbon dioxide to escape. The mead is now ready to drink or it can also be stored in a cool, dark place for up to a few years.

Serviceberry fruit leather

Ingredients:

¾ lbs of serviceberry
⅓ cup of maple syrup
1 tsp of cinnamon
Pinch of salt
Juice of ½ a lemon
1 cup of apple sauce
⅓ cup of water or more if needed*

Instructions: In a small saucepan, heat the serviceberries, maple syrup, salt, lemon juice, water and cinnamon. When the berries are hot and bubbling, puree the mixture with a handblender or in the bowl of a blender. When blending the mixture, make sure the texture is that of a thoroughly blended smoothie. It should be easy to stir, but not runny. Add a little water if needed.
Pour the mixture on separate parchment papers on baking sheets or dehydrator tray. Make sure to pour the contents into the center, then spread with a spatula and oscillate the trays or sheets side side so that the mixture coats the paper in an even thickness.

Dehydrate at 135 degrees (fruit setting) for about 4 hours, switching the top and bottom trays for more even drying at about 4 hours in. Then dehydrate another hour and check that it is not sticky, nor too dry. It should be pliable but not stick to a utensil when pressed.
Once dehydrated, you can roll up the leathers on the parchment paper and store in the refrigerator if you need extra time.
You can cut 1 inch strips and roll them up, use cotton food-grade string to tie them up and you can store either in a clean jar in a cool dry location for up to a month or freeze or refrigerate your jars of leathers for longer storage.

Serviceberry and pear pie
Ingredients:

Pie filling:
4 cups Frozen Saskatoon berries * If using fresh, use additional water (see next ingredient)
2 green pears
1 cup water * if using fresh berries, add an additional ¼ of water
¾ cup white granulated sugar
3 ½ tablespoon cornstarch
1 teaspoon of cinnamon
½ teaspoon of nutmeg
1 teaspoon almond extract
1 tsp. fresh lemon juice
½ teaspoon salt
1 tablespoon milk
For pie crust:
1 ½ tablespoon milk
1 teaspoon white granulated sugar

Instructions: Add all sauce ingredients to a medium saucepan and cook over medium- high heat, stirring frequently. * if using fresh berries, add an additional ¼ cup of water (*4 cups Frozen Saskatoon berries,1 cup water,¾ cup white granulated sugar,3 ½ tablespoon cornstarch,1 teaspoon almond extract,1 tsp. fresh lemon juice,½ teaspoon salt,1 tablespoon milk)* Let the berries simmer until soft and the mixture is thickened - about 15 minutes. The mixture will be as thick as jam when it's ready * you will be tempted to remove it too soon, but just keep stirring constantly so it doesn't burn to the bottom of the pan. Remove from heat and cool.

Pour into unbaked pie shell and cover with top crust (you can use a store-bought pie shell). Add top crust, then trim, using a paring knife or kitchen shears, Pleat with a fork to seal edges. Add some venting and brush top of pastry lightly with milk , using a pastry brush and sprinkle with a teaspoon of white granulated sugar. **1 ½ tablespoon milk,1 teaspoon white granulated sugar* Bake for a 2 crust fruit pie. *I bake it on 450 degrees F for the first 10 minutes, then reduce to 350 degrees F for the remainder (20 - 25 minutes or until cooked through.)

Lemony Quince jam

Ingredients:

2 pounds (about 5 quince) quince
4 1/4 cups water
1/4 cup lemon juice
1 tablespoon lemon zest
4 cups sugar

Instructions: Prep and grate the quince: Prepare the quince by washing and cutting them in half. Working around the core, grate the quince flesh (including the peel) with a cheese grater, until you have about 6 cups of grated quince.Simmer the grated quince with lemon juice and zest until soft: Put 4 1/4 cups of water in a large (6 to 8 quart), wide, thick-bottomed pan or pot and bring to a boil. Add the grated quince, lemon juice and lemon zest. Reduce heat and simmer until the quince is soft, about 10 minutes.
Add the sugar and simmer until thickened: Add the sugar and bring to a boil again. Stir to dissolve all of the sugar. Lower the heat to medium high.
Cook uncovered, stirring occasionally until quince jam turns pink and thickens to desired consistency, about 30 to 50 minutes. (If the jam has thickened but hasn't turned pink, add a little more water and cook a little longer.) Ladle into jars: Ladle into hot, sterilized canning jars, leaving 1/4 inch headspace. Wipe the rims of the jars clean before applying clean, dry lids

Poached Quince

Ingredients:

4 cups of water
½ Cup organic granulated sugar
Juice from 1 organic lemon (if lemony quince unnecessary)
1 cinnamon stick
3 ½ to 4 cups of quince, peeled and sliced

Instructions: Combine all of the ingredients in a medium or large saucepan.

Bring to a boil, dissolving the sugar. Reduce the heat to a simmer.
Cook for 60 to 75 minutes until the quince is tender and has turned a delicate shade of salmon pink.
Drain and reserve poaching liquid. Remove cinnamon stick.

Quince Gummy Bears

Ingredients:

2/3 cups of poached quince liquid (see above recipe)
2 envelopes of unflavored gelatin

Instructions: In a small saucepan, pour your liquid and whisk in the sugar until mostly dissolved. Sprinkle the gelatin over the top and let sit for at least 5 minutes. Not all of the gelatin will absorb the juice; that's okay.
After five minutes, heat the mixture over a low to medium heat until the gelatin is dissolved and the mixture is thick and clear. You can pour directly into the mold from the saucepan or use a liquid eye dropper.

Pour the mixture into the molds. You can pour to the very top. Place the mold on a flat tray and put in the freezer for 20 to 30 minutes. They should pop out easily. If they do not, put them back in the freezer for a few more minutes.

Gooseberry Cardamon Jam

Ingredients:

Gooseberries
Sugar
Cardamon

Gooseberry 'Ketchup' Sauce

Ingredients:

Gooseberries
Apple Cider Vinegar
Sugar
Salt
Shallots
Garlic
Thyme

Persimmon Pie

Ingredients:

1 9-inch unbaked pie crust (Made from Pillsbury rolled up pie dough, homemade, or frozen and thawed)
1 ¾ cups persimmon pulp- from 4 large very ripe Hiyacha or 5 to 6 large Fuyu persimmons (about 2 pounds) (For small American wild persimmons, up to 15)
2 large eggs
¾ cup sugar
½ teaspoon ground cinnamon optional
¼ teaspoon salt
1 (12 ounce) can evaporated milk (not sweetened condensed milk) (see variations to make with sweetened condensed milk)
2 teaspoons vanilla extract

Instructions: Preheat the oven to 400F. (You will reduce it to 350F later, so keep a timer close by.)If using a homemade crust or Pillsbury rolled up pie dough, arrange it in a 9-inch pie plate and crimp the edges. If using a thawed frozen pie crust, place it in the pie plate. Put the pie shell in the fridge until ready to fill with filling. For Hachiya and American wild persimmons, gently pull back part of the peel or skins and use a spoon to scoop out the very soft pulp. Discard the skins, and if they have seeds, discard those, too. These types of persimmons need to be VERY ripe or they will pucker your mouth.

For Fuyu persimmons, these persimmons can be eaten like an apple when firm. They are typically not astringent. If firm, just coarsely chop the flesh and puree the fruit in a blender or food processor or in a bowl using a hand-held immersion blender. If very soft and over-ripe, scoop out the pulp and discard the skins.

Place the persimmon pulp, or chopped Fuyu persimmon, in a blender or food processor.
TIP: The more ripe the persimmons are, the softer and darker the flesh will be.
Whisk the eggs in a medium size mixing bowl until blended together. If adding cinnamon or spices, stir into the sugar and salt, first. This will help incorporate it in the filling better.

Add the sugar mixture and persimmon pulp. Stir in the evaporated milk and vanilla.

Pour the filling into the prepared pie shell. Carefully place the pie plate on the center rack in the oven and bake, uncovered, 15 minutes at 400F. After baking 15 minutes at 400F, reduce the oven temperature (without opening the oven door), to 350F and bake an additional 35 minutes or until the center jiggles just slightly when gently shaken. Let cool on a wire rack until room temperature (about 1 hour), then loosely cover and refrigerate 2 hours or until chilled before serving. Store in the fridge up to 3 days to make ahead. You can freeze the persimmon pie, covered in heavy duty aluminum foil. Thaw in the fridge overnight.

Chickasaw Plum Jam

Ingredients:

1000 grams (2.2lbs) wild plum puree see method below
650 grams (23 oz) sugar
25 grams (4 teaspoons) powdered unsweetened apple pectin
15 grams (1 tablespoon) fresh lemon juice or ½ teaspoon citric acid
3powder

Instructions: Make a puree of wild plums by heating them on a baking sheet in an oven until hot, (325 F) for 15 minutes. You can also freeze very ripe plums, thaw and mush them around in a bowl.

Cool the plums until you can handle them, then mash them in a bowl, adding a cup or so of water to help release the puree. If you have really nice, large wild plums, you may not need all of the water, if your plums are small, you may need more.

Mush this puree through a colander over a bowl to catch the skins and stones, then reserve the puree that passes through the holes. Allow the puree to cool, then measure out what you need.
Mix the sugar and pectin, then puree with cool plum puree in a blender. Transfer the mixture to a stove and cook on medium, and then high heat, whisking occasionally until it comes to a rapid boil. Cook until the mixture hits 220 F on the thermometer.

Beat in the lemon juice, transfer to pint jars and can in a water bath for 10 minutes or the recommended time for the jars you're canning.

Appendix I References

Asmus, K. (n.d.). *Plant Description*. Oikos Tree Crops. https://oikostreecrops.com/

Bailey, R. (2021, March 8). *Quince - Maine Organic Farmers and Gardeners.* Maine Organic Farmers and Gardeners. https://www.mofga.org/resources/fruit/quince/

Bijelic, SM, BR Golosin, JI Ninic Todorovic, SB Cerovic and BM Popovic. 2011. "Physicochemical Fruit Characteristics of Cornelian Cherry (*Cornus mas L.*) Genotypes from Serbia." *HortScience* 46(6):849–853. http://hortsci.ashspublications.org/content/46/6/849.full.pdf.

Cornelian Cherry (CORNUS MAS) Plant facts. (n.d.). Retrieved March 5, 2026, from https://www.phillyorchards.org/wp-content/uploads/2019/12/Cornelian-Cherry-Plant-Info-Sheet-.pdf

Grant, A. (2016, October 27). *Harvesting Quince Fruit – How To Pick Quince Tree Fruit*. Gardening Know How. https://www.gardeningknowhow.com/edible/fruits/quince/harvesting-quince-fruit.htm

Hayhurst, S. (2012). *Passion for Persimmons: Grower Strives to Commercial ize Seasonal Fruit.* My Indiana Home. Available at: http:// www.my-indiana-home.com/food/passion-for-persimmons-grow er-strives-to-commercialize-the-seasonal-fruit/.

Hosseinian, F. S., & Beta, T. (2007). Saskatoon and Wild Blueberries Have Higher Anthocyanin Contents than Other Manitoba Berries. *Journal of Agricultural and Food Chemistry*, *55*(26), 10832–10838. https://doi.org/10.1021/jf072529m

Kansas Forest Service. (2010). Sand Hill plum. http://www.kansasforests.org/conservation/shrubs /sandhillplum.shtml [online: cited 28 June 2010]

Lehman, J. (2017). Commercial Persimmon Production.

Maughan, T., & Black, B. (2014, October). *How to Grow Gooseberries in Your Garden*. Extension.usu.edu. https://extension.usu.edu/yardandgarden/research/gooseberries-in-the-garden

McDaniel, J. C. (1973). *Persimmon cultivars for northern areas.* Fruit Varieties Journal 27(4):94-96.

Pioneer Cornelian Cherry Dogwood. (2025). *Edible Landscaping.* https://ediblelandscaping.com/products/pioneer-cornelian-cherry-dogwood

Raintree Nursery. (2025). *Growing a Persimmon Tree.* https://raintreenursery.com/pages/growing-fruit-trees-persimmon?srsltid=AfmBOooWwR8ClqCP3U04Z4 OjxW5oKadVYNehZLP-S-0JOV4GhoUKJMU6

Row, J. M. and W. A. Geyer. (2010). *Plant Guide for Chickasaw plum (Prunus angustifolia)*. USDA-Natural Resources Conservation Service, Manhattan Plant Materials Center, Manhattan, KS 66502.

Paradise Nursery. (2024). *Size & Spacing - Persimmon Trees* - Paradise Nursery. https://paradisenursery.com/pages/size-spacing-persimmon-trees

Quince growing. (2007, April 26). Www.dpi.nsw.gov.au. https://www.dpi.nsw.gov.au/agriculture/horticulture/pomes/other/quince-growing

Spencer, R., Matthews, L., Bors, B. & Peters, C. Saskatoon Berry Production Manual. (Alberta Agriculture and Rural Development, 2013). Saskatoon_Berry_Production_Manual.pdf

Wilson, M. H. (2017). *Perennial Pathways: Planning and Establishment Practices for Edible Agroforestry*.