Review of experiences growing containerized fruit trees in Northern climates:

Observations from local growers

Report completed on behalf of the Alaska Food Policy Council
& the Stickleback Farm Orchard, Anchorage, Alaska

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Introduction

Stickleback Farm is a community project on a long-neglected urban lot in downtown Anchorage. The goal of this project is to revitalize the space and demonstrate how urban food production can beautify, bring the community together, and increase the availability of healthy foods. One part of the food production area is a cold-hardy orchard. This part of the project is especially meaningful as it is a highly visible early step in developing the farm site and was installed in the middle of the COVID-19 pandemic. In the fall of 2021, 28 apple trees and five sour cherry trees were planted into recycled fish totes. Fish totes are portable using heavy equipment, so the site setup is flexible. Other sites across the state of Alaska may face challenges avoided by growing in containers, such as permafrost, contaminated soil, or temporary land use arrangements. The Stickleback Farm orchard serves as a community experiment with the potential to increase community food security across the state.

This report reviews literature in the field of growing fruit trees in containers in northern climates. Similar projects are scarce in the existing literature, a situation that highlights the importance of the work being done at the Stickleback Farm orchard. The information from this report came from websites, recorded webinars, and publications, and personal communication with individual growers. Photos provided by local orchardists are included in Appendix 1.

This report begins with information based on observations and experiences of people who have been growing containerized trees in Alaska and Canada. The fruit tree orchardists in northern climates were enthusiastic and generous with their time and information, and several have expressed their desire to help with the project. Next is a section of observations from the first spring after planting the orchard at Stickleback Farm (April 2022). The final section summarizes recommendations for long-term maintenance of the orchard at Stickleback Farm. Additional information on early experiences growing containerized urban trees, much of which focuses on growing urban street trees, is included in Appendix 2.

Experience Growing Fruit Trees and Containerized Trees in Alaska and Canada

The University of Alaska Cooperative Extension Service has one publication with tips for planting fruit trees in the ground in Alaska, including site selections and preparation, recommended cold-hardy varieties, and maintenance. Dr. Pat Holloway, UAF Professor Emeritus of Horticulture, shared that "at least since the late 1960s there has been no research on fruit trees in containers at UAF or the [Georgeson Botanical Garden] and also at the MatSu station" (personal communication, April 22, 2022).

Karlsson and Calhoun (2010) presented the results of a feasibility study funded by the Western SARE. They looked at growing fruit trees (including 39 varieties of apples) in high tunnels from 2007 to 2010 but not in containers. Information was collected to develop publications about variety selection, production procedures, maintenance, winter management, high tunnel technology, and the cost of growing fruit in the Interior. The trials were conducted on the Fairbanks Experiment Farm at UAF. Trees had a higher survival rate in high tunnels (60% versus 40%). No cherry, pear, or plum trees survived. High tunnels were consistently 10-15 degrees warmer inside in the winter. Trees in high tunnels flowered and fruited more and sooner, and the study concludes that high tunnels are beneficial to fruit production, though the trial was short (3 years, given that most fruit tree trials run a minimum of 10 years).

River Bean of Arctic Organics in Palmer confirms the findings above that containerized fruit tree information comes from nurseries. He keeps the trees in containers for three Alaskan winters so that he can "assure buyers that the trees are hardy and have survived and adapted to our changing winters" and then encourages them to get the trees into the ground quickly (personal communication, April 23, 2022). He doesn't keep trees in pots beyond the 3- to 4-year mark, but by then there is hardly any winter kill. Given the size of the containers used at Stickleback Farm, which are much larger than anything he has used before, he believes "that the roots have enough space to allow for growth and be fully functional" (personal communication, April 23, 2022).

Other northern research focuses on variety trials. John Lenart and Kim Melton have a nursery outside of Dawson City in the Yukon Territory. The goal of their 2020 report was to generate "comprehensive, regionally-reliable descriptions of a subset of hard fruit cultivars being trialed at Klondike Valley Nursery" (p. 2). The report begins with an introduction to the nursery (6000 sqft of sheltered growing and 2 acres of field). Lenart has been experimenting with fruit trees on site since the 1980s and collaborating with the University of Saskatchewan's Fruit Breeding Program since 2002. The project includes 150 apple trees, 100 haskap bushes, and small numbers of pears, cherries, and other berries. The goal of the project is to provide relevant information and plant material for northern growers, both ornamental and for food, grown with a light footprint and without synthetic fertilizers, pesticides, or herbicides. Having more fruit trees and berry plants in the territory minimizes imports from elsewhere and risk of pest and disease introduction as well as providing economic benefits. Page 4 shows a selection of photos from the site, one of which includes trees in boxes. Some trees are containerized and move with the seasons while others are permanently sheltered or receive seasonal coverings for freeze protection and season extension. Their main model is growing in-ground in permanent cold frames. This report combines all growing methods for each variety, so there is no specific information on containerized trees. Additional sections include information about bloom time for coordinating pollination, harvest, yield, and cold hardiness. Fertilization instructions, including additional fertilization for containerized trees, and instructions for dealing with cold damage could be useful.

The 2017 study focuses on structures and shelters. They have four structures; the site selection, construction, insulating properties, and dimensions are detailed in the report. They use data-loggers to track interior and exterior temperatures on an hourly basis. "We have increased our sample size of fruit tree cultivars by thirty percent, and look forward to being able to provide more rigorous data on relative productivity, survivability and transplanting success of long-containerised trees in the future." Some trees have been grown in containers for 25 years.

In a personal communication with Lenart and Melton, they explain that they have not published anything detailing the 30+ years of containerized work at their nursery. However, they have established a record of success. They avoid the need for heavy equipment by growing in "wooden boxes with wire mesh bottoms so that the trees can root into the ground during the growing season, then cut them away in the fall to move them into storage" (personal communication, April 25, 2022). They grow apples, pears, cherries, grapes and figs in containers.

Lenart and Melton recommend careful watering and remind that containerized trees need a lot of nutrients. They also recommend letting branches grow low to compensate for being so high up in the fish totes.

Burl Sheldon, project manager of the Chilkat Valley Orchard Project, provided a draft of their project report for the USDA Specialty Crop Block Grant. The report consists of a section on site selection, choosing trees, planting trees, nutrition and soil, preparing for winter, protecting trees from wildlife, and additional local recommendations. The report contains limited advice for planting in pots and provides a few photos (p. 13-14). The report recommends attempting growing in pots cautiously, testing a few trees at a time to see how they adjust. Limitations and challenges with growing in pots are higher nutrient and water needs and vulnerability to cold damage. Moving pots to winter in a shelter is heavy and impractical. Most apples adapt well to 30-gallon air pots grown in greenhouses. Dwarf or semi-dwarf rootstock are recommended. Plums and sweet cherries are more challenging in pots because of being less cold hardy. They "stunt out" and stop growing but can still produce fruit provided their high nutritional requirements are met.

The report provides extensive instructions for winter preparation. Directions for protection for moose, voles, and bears are also included. Winter staking and tying is crucial to protect from wind and snow loads. Painting the trunk can help with sunscald and thaw/freeze of cambium layers from winter sunlight.

The last orchard is the Alaska Apple Farms in Hoonah, part of the Chilkat Valley orchard project. Robert Bishop participated in a recorded workshop for the Chilkat Valley orchard project, describing his set up with apple trees in 30-gallon pots inside a hoop house. He specifically emphasized living soil, adding mycorrhizal fungi and earthworms. Most interestingly, at minute eight of the video, the image shows fish totes filled with soil outside of the hoop house.

In a phone call, Bishop explains that he has been growing in fish totes for six to eight years. The totes are readily available in Hoonah and other fishing communities, though they get taken quickly when left at the dump. He grows in whatever he can: fish totes, boxes, and 30-gallon pots. He grows in hoop houses, outdoors in pots, and outdoors in a field site. His biggest constraint is time and the cost of building materials as he also runs a construction company and is very busy in the summer season. (Personal communication, April 23, 2022)

Bishop explains the positive aspects of growing in fish totes. They are high enough to be out of range of voles and have good insulation, though sometimes that holds the cold in and there is a delay in the spring thaw. The biggest issue he sees with the totes is the freeze-thaw-refreeze cycle and associated ice damage. To avoid this, Bishop recommends hilling the tree, planting the tree onto a mound approximately a foot high in the center of the fish tote. This method allows the trunk to remain above any water or melting snow that pools in the tote and could refreeze causing damage. Hilling also helps keep the tree at a higher level over time because soil in the totes. Additionally, trees in containers need a lot of feeding and careful watering.

Early Observations of the Orchard at Stickleback Farm

The Alaska Food Policy Council, the University of Alaska Anchorage, and Alaska Seeds of Change held the first orchard pruning workshop at Stickleback Farm on April 13, 2022. The workshop provided a chance to check on the trees after their first winter in the totes.

Ben Tietge, horticulturist and member of the Alaska Pioneer Fruit Growers Association, assessed the trees and found no signs of mortality after their first winter in the location. He concludes that “it’s tough to know for sure until they start to leaf out, but there’s no indication right now that the containers or any of the other planting conditions did them harm this winter” (personal communication, April 21, 2022).

Two main concerns for containerized trees are winter damage to roots and water stress. During the workshop, it was observed that although winter snow accumulation remained on the ground, no snow remained around the fish totes to about a foot away. This could be due to the dark-colored totes warming in the spring sunlight and melting the surrounding snow which could be helpful for the trees. Alternatively, the position of the totes and the strong winter winds in the area could have created wind tunnels and drifting that kept snow from accumulating next to the totes which could reduce winter insulation. Solutions to observe and manage this issue next winter could be to add foam insulation around the totes and add snow fencing into the moose fence to cut down on wind through the site. Regarding water stress, the totes were watered heartily in the fall, and the heavy snow from the winter provides snowmelt for water in the spring. It is still unknown how the containers will perform over a dry summer season.

Recommendations for Long-term Maintenance of the Orchard at Stickleback Farm

- Water stress is mentioned across the research, so great care should be given to develop a watering schedule appropriate to site weather conditions. Microclimates within urban areas can be higher than reported average temperature in an area and, along with transpiration from wind, it causes a surprising amount of water loss. One suggestion is to plant small annual flowers in the fish totes which would give visible signs of water stress sooner than the trees as well as installing an on-site thermometer.
- The Stickleback Farm orchard should be continually observed for signs of winter stress during the summer season in order to plan for additional insulation or other adaptations for the following winter.
- Many of the local growers who contributed information for this report are eager to follow along with this project, so connecting the groups responsible for Stickleback Farm orchard maintenance with this support may provide a helpful support network.

Appendix 1: Photos

Klondike Valley Nursery, Dawson City, YT

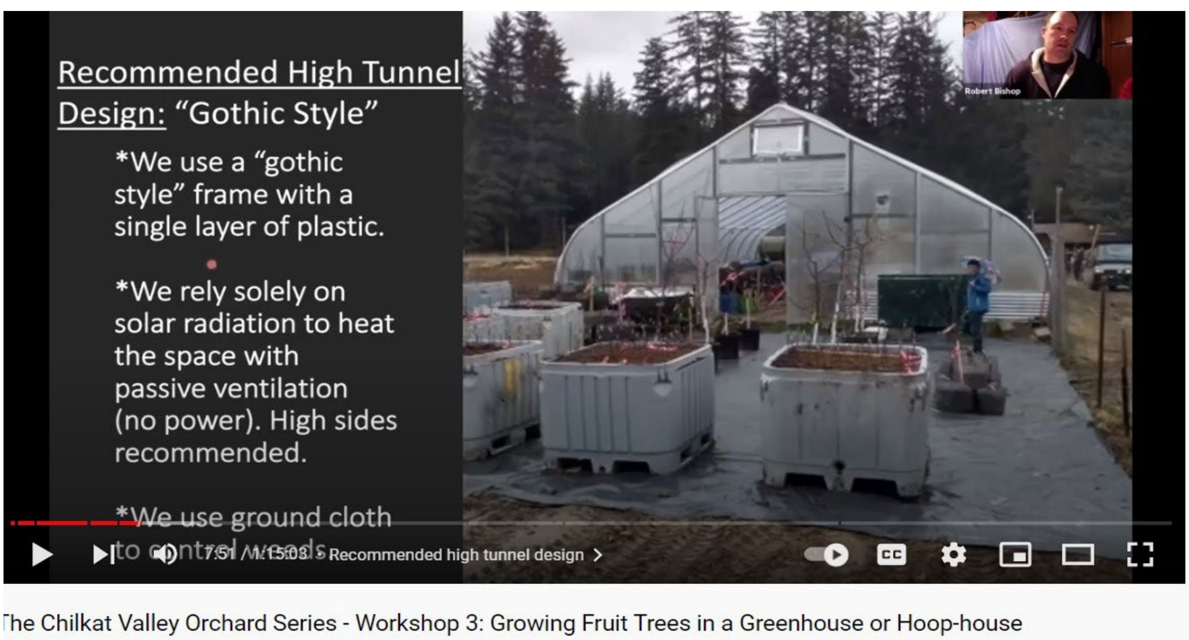
(15 y.o. Norland apple, photo by John Lenart, 2016)

(Crated apple with background crate showing wire mesh bottom, photo by John Lenart, 2016)

(27 y.o. Ure pear just before sheltering for winter, photo by John Lenart, 2016)

Alaska Apple Farms, Hoonah, AK

(Planting trees in fish totes, photo by Rob Bishop, April 23, 2022)



(Trees in fish totes at Alaska Apple Farms, screenshot from Chilkat Valley Historical Society Youtube video, March 3, 2022)

Appendix 2

Early Experiences Growing Containerized Urban Trees

Due to the dearth of information about growing containerized fruit trees in northern climates, this review begins with a summary of research about growing containerized trees, in general. The first relevant research comes from urban revitalization efforts of the 1960s and 1970s. Above-ground planters measuring approximately 4'x4'x4' were used to bring green spaces to downtown spaces. Cervelli (1984) calls this the free-standing container tree and later research names them street trees. This research is relevant due to the size of the container being comparable to Stickleback Farm's fish totes. First Cervelli highlights problems with the planter. "Continued use has shown surface planters to be notorious tree killers" in Midwestern and Northeastern states (p. 83). The planters freeze from the outside inward which exposes roots to the same temperatures as aerial parts of the tree, while roots are generally less temperature hardy than aerial parts. Another limitation is horizontal root spread and nutrient uptake. Tree "feeder roots" are generally in the upper 30" of soil, so an increase in depth does not compensate for the horizontal restriction. Trees also suffer from water restriction as well as overwatering, poor drainage, and reduced soil aeration. The problems listed here reduce the tree's natural resistance to disease and insect infestation, reduce its size, and shorten its lifespan. While these challenges can be addressed with proper planting and maintenance, that is often expensive and a key reason that such urban programs fail. The author is critical of the aesthetic characteristics of these containerized trees and recommends their use only where insufficient soil depth leaves no other option. The largest container possible should be chosen to maximize insulation and room for root development, including partially burying the container which "eliminates its awkward bulkiness" (p. 86).

Street trees are expensive to install and maintain, they often die off early, and their longevity is shorter than trees planted into the ground. Botanical research from the 1970s and 1980s reflects this concern. For example, the USDA Forest Service Northeastern Forest

Experiment Station's 1976 symposium titled "Better Trees for Metropolitan Landscapes" yields at least two relevant papers that are referenced continually in this time period. Gouin's "Winter Injury to Container-Grown Plants" focuses on root health and development, often overlooked in container plant choices. Flemer's "Container Trees for Use in Landscaping" stresses proper soil mix and container size; "the larger the containers, the better the survival and life expectancy" (p. 186). Flemer includes extensive lists of potential urban container trees for different hardiness zones, some of which are currently problematic (*Prunus padus,* European birdcherry).

Lindsey and Bassuk contribute an experiment on soil volume requirements for street trees (1992-a, 1992-b). The authors describe a typical situation where street trees get inadequate water and fail to develop, thus more accurate methods to predict whole tree water loss in a variety of climates are needed. The study finds existing recommendations for soil volumes are too high for reasonable use in street tree planting, up to 7,000 square feet, and widely variable to the point of being unusable. The authors describe difficulties measuring and estimating water and soil amounts. "Heat islands" in cities cause greater whole tree water loss. Demand for water generally exceeds precipitation rates, especially in containers, because not all precipitation increases soil moisture (evaporating before hitting the ground, being deflected by canopy foliage, lost by surface runoff, or drains beyond root zone). It is also difficult to estimate soil water retention in urban areas. The study looks at existing research for estimating whole tree water demand and loss and ways to directly measure water loss with complex formulas. The authors develop a (somewhat) simpler weather-based methodology using evaporation pans. The round metal pans are 47.5" across by 10" deep and filled with water and a gauge to measure on-site water loss. The study concludes with the recommendation of 1.6 to 2 cubic feet of soil for every 1 cubic foot of crown projection (crown projection is the area of a circle under the trees' dripline) with instructions on how to make adjustments for different climates. They also recommend mulching but not cover-cropping. The methodology can work in the other direction as well, starting with the estimated volume of soil and working backward to see the potential tree size. They conclude that "when urban soils are totally unsuitable as a growing medium, planters or raised beds can be used just as effectively if realistic soil volumes for a given tree size at maturity are specified" (1992-a, p. 36). The authors feel their methodology for estimating soil volume is effective and can also calculate the period of time between irrigation events to coordinate with maintenance staff availability. "The use of this methodology has important implications for ensuring better survivability and development of trees growing in urban areas and hopefully will greatly enhance attempts to 'green' cities and make them more humane, livable and aesthetically pleasing environments (1992-a, p. 37).

Myers and Harrison (1988) evaluated the use of two mulches (shredded bark, hardwood chunk bark) on the health and winter survival of two shrubs, highbush cranberry (*Viburnum opulus* 'Nanum') and juniper (*Juniperus chinensis procumbens*). Data collected include soil temperatures, soil moisture levels, plant growth, winter kill, and subjective evaluations of plant appearances. The bare soil cooled faster in the fall and warmed slower in the spring, and both shrubs performed best with the hardwood mulch. (Sidenote: shredded bark mulch caught fire from a cigarette butt.) Mulch treatments did not have an effect on plant growth and equal amounts of winter dieback were found on all treatment after winter temperatures reached -25.6 F (-32 C). One limitation was that mulching contributed to overwatering and may have reduced winter hardiness.

The study acknowledges that above ground planters were growing in popularity in urban landscapes where a lack of viable soil makes them the only option. Generally, plant selections and maintenance recommendations were based on the successes and failures of past programs and this was not effective. Montreal's program was unsuccessfully duplicated by Cincinnati (the same program referenced above). The authors note that various urban stresses (wind, shade, pollution, traffic, temperature, vandalism) make it difficult to replicate programs and predict plant survival. In addition, limited soil mass, water holding capacity, and root insulation make container culture difficult. Due to the high investment cost of these programs, the authors find it important to develop suitable local cultural practices. Milwaukee's program provided the opportunity for this mulch study. The authors conclude that site evaluations are important. Variables can change depending on sun and shade patterns, wind tunneling effects, soil mix, and container design.

The ecophysiology of urban trees is a topic that centers the biological needs of plants instead of the desires of humans in urban design and how plants are impacted by the urban environments (Whitlow & Bassuk, 1988; Sonti, 2020). Whitlow and Bassuk (1988) provide an overview of research in this field in "Ecophysiology of Urban Trees and Their Management - The North American Experience", and the field continues to develop. Whitlow and Bassuk acknowledge the consensus that urban habitats place numerous constraints on tree growth (soil compaction, waterlogging, lack of water, air pollution, vandalism, etc.) resulting in drastically shortened life spans compared to trees in natural stands. The authors approach the topic with curiosity, given that "serious investigation of these environmental limits is frequently dismissed, ironically either by viewing it as too complex to unravel or by assuming that the science is complete" (p. 543). The authors lament a lack of quantitative studies and empirical observations on street trees. After describing a case study focusing on the water demand of twenty newly planted street trees in Manhattan, the authors provide some suggestions for further research and for supporting street trees. They caution against generalizing weather data because urban microclimates can vary dramatically from what is expected. Street trees exist outside of the typical forest canopy, so adjustments to standard biological requirements for urban areas are necessary. Though the stressors facing urban street trees are numerous and complex, tackling one at a time (water demand) leads to useful results.

Eventually, containerized street trees fell out of favor in urban design, and the research turns to new cultivation methods instead of containers, such as growing trees in structural soil (a mix that can safely support pavement while allowing gaps for tree root growth) at the street level (Grabosky & Bassuk, 2016; Koeser et al, 2013; Mullaney et al, 2015). These studies draw upon thirty years of urban street tree research, some of which is referenced above. However, this research diverges too far from Stickleback's containerized fruit trees.

Current research on trees in containers is limited to short-term nursery-grown trees sold in containers but planted into the ground. One good example is "Differential Environments Influence Initial Transplant Establishment Among Tree Species Produced in Five Container Sizes" (Garcia-Chance et al, 2016). Different sizes have different merits. Larger sizes provide the greater aesthetic value of larger trees and are more able to withstand environmental challenges. However they are difficult to move and take up more nursery space, thus are priced higher for consumers. This study measures the first-year post-transplant growth of three tree varieties in a variety of pot sizes transplanted into two contrasting locations. It concludes unsurprisingly that trees in smaller pots present a greater percent change in growth when planted in the ground. The authors write that container-grown trees are gaining momentum in the industry, and additional research will allow homeowners, landscapers and arborists to select appropriate container sizes for the transplant stressors of their region and to predict growth responses.

Research on urban trees is limited to ornamental trees and shrubs. Fruit trees are not widely used in pedestrian areas due to the inconvenience of messes made by fallen fruits and the birds, animals, and insects attracted to them. Fruit trees are grown in containers by nurseries and then transplanted by landowners. Extensive research exists for the planting, fertilization, maintenance, and stressors of containerized fruit trees at the seedling stage, as well as containerized citrus orchard trees, but that is not included in this report.

Some academic research about fruit trees in northern climates addresses stressors such as winter injury, dormancy periods, and climate change (Rochette et al, 2004; Yu & Lee, 2020). Yu and Lee carefully evaluate freezing injury to tree tissue using a wide variety of methods. Freezing is a major limit to the distribution and production of fruit trees. Injuries include sunscald, frost splitting, blackheart, roots freezing, death of cambium, and damage to buds, flowers, and fruit. Field conditions are complex and unreliable, so in addition to field observations, they use artificial conditions, mainly containerizing trees or tree parts. However, these conditions often do not reflect the true cold hardiness of a species or predict its performance in the field. The authors conclude that freezing patterns are species- and tissue-specific but difficult to analyze and predict, suggesting that “freezing injury should not be evaluated based on a single method but rather on at least a couple of methods under both field and artificial conditions” (p. 792). They call this the “integrated evaluation of freezing injury”, in which they recommend collecting data from multi-year projects, to better predict survival and guide the selection of temperature fruit trees (p. 792).

Rochette et al (2004) used agroclimactic data for eastern Canada to predict temperature changes and explore the impact on fruit production especially as production moves north. Although winter damage to fruit trees is likely to decrease, more frequent winter thaw events would reduce plant hardiness. Lower snow cover would leave the tree vulnerable to extreme freezing temperatures.

Additionally, the research broadens sociologically to include ecosystem services and food security. In “Stewardship matters: Case Studies in Establishment Success of Urban Trees”, the authors note that when the aim is to provide ecosystem services that show up long after planting, understanding tree survivability is an important component of program evaluation (Roman et al, 2015). The authors propose that “programs with particularly high establishment survival can indicate best management practices for other programs to emulate” (p. 1174). Their case study presented two programs (in California and Pennsylvania) run by nonprofit organizations and did not include fruit trees. Stewardship in this case refers to community tree care practices and is determined to play a vital role in the success of both sites. The authors conclude with four recommendations: “Some urban tree losses are inevitable”; “Neighborhood-scale operations are well-suited to stewardship”; “Data management strategies facilitated monitoring”; and “Planting programs prioritized substantial time for tree care” (p. 1180-81).

Clark and Nicholas (2013) present a broad analysis of 37 urban food forestry programs and an extensive literature review of the topic. Then they explain how food provisioning and other ecosystem services provided by urban food forests can be maximized. The authors conclude that urban forestry will require public-private and transdisciplinary collaboration and that there is a need for additional qualitative and quantitative research in the form of case studies. Finally, the authors of “Community Orchards for Food Sovereignty, Human Health, and Climate Resilience: Indigenous Roots and Contemporary Applications” include Indigenous voices and community resilience (Lovell et al, 2021).

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