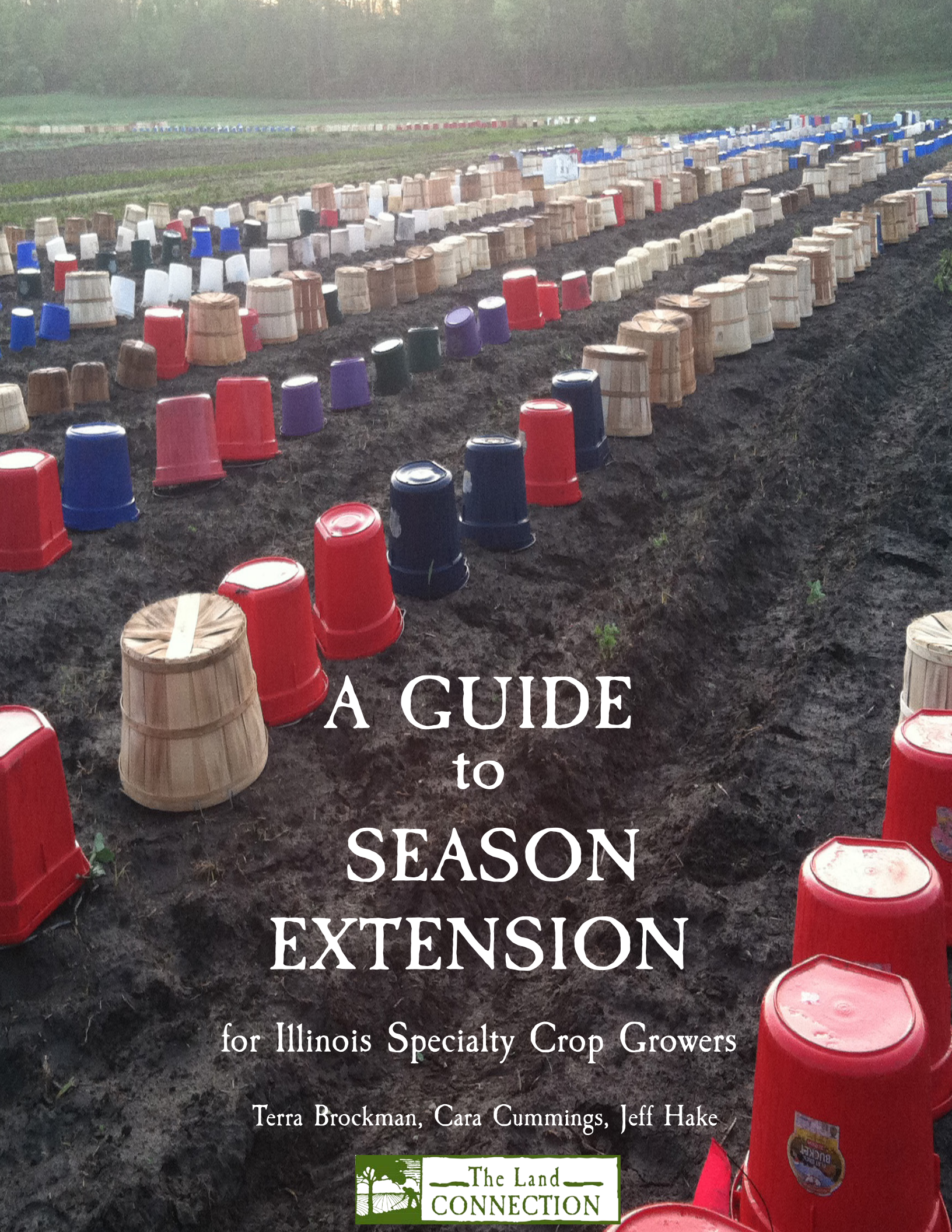

A GUIDE to SEASON EXTENSION

for Illinois Specialty Crop Growers

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The Land CONNECTION

Cover photo of Henry's Farm, Congerville, IL by Terra Brockman

Henry Brockman of Henry's Farm got creative with season extension, using every bucket and basket he could find to create warmer microclimates around each tender transplant. Because if you've invested in great cultivars, and a hoophouse to start them in, and then transplanted them all to the fields in mid-May, you need to make sure they won't all die when a late frost is predicted. And yes, they survived!

ACKNOWLEDGEMENTS

The Land Connection thanks the following people for their valuable contributions of time and expertise as we developed this guide:

Lorien Carsey of *Blue Moon Farm*, Urbana, Illinois
Alisa DeMarco of *Prairie Fruits Farm & Creamery*, Champaign, Illinois
Marty Gray of *Gray Farms,* Watseka, Illinois
Marnie Record of the *Illinois Organic Growers Association*
Clay Yapp of *Sola Gratia Farm,* Champaign, Illinois

We also thank Kira Santiago for her designing of this guide, and Tim Meyers for his excellent recording and editing of our three case-study videos.

Federal funds for this project were provided by the Specialty Crop Block Grant Program of the USDA Agricultural Marketing Service, through the Illinois Department of Agriculture.

TABLE OF CONTENTS

SEASON EXTENSION

Season extension practices can be as simple and inexpensive as selecting cold-tolerant varieties of crops that you already plant, or they may be as complicated and expensive as constructing a high tunnel, then laying a plastic mulch layer and using row covers over some of the crops inside.

While there are many detailed resources explaining how to implement various season extension practices, we've found little guidance to help farmers decide which are the most appropriate season extension practices for their unique farm situation and specific farm business goals. This guide provides that missing information, and includes a worksheet at the end to facilitate your decision-making process.

WHAT IS SEASON EXTENSION?

Season extension refers to a broad range of practices and techniques, some of which you are most likely already using, from identifying and utilizing micro-climates in your field, to choosing cold-hardy cultivars, to using mulch and row covers. Any practice or technique that allows you to produce and sell more of your products for more of the year, enabling your customers to purchase and enjoy those products over a longer period of time, is a form of season extension.

High tunnels and other plasticulture techniques such as row covers and sheet mulch are the most recognized forms of season extension, and are used by farmers around the world. Season extension, however, is more than just the use of plastic to capture solar energy. Solar energy can also be captured in the form of fruits or vegetables that can be stored and sold for months after the killing frost, or in the form of value-added processed foods. This guide will cover production and marketing topics for all these forms of season extension.

Because season extension practices often require increased inputs of land and time, and because you will need a market for your products, the worksheet at the end of this guide will help you evaluate various season extension practices, and decide which are most appropriate and desirable for your farm business.

Tender greens grow in marty gray's hoophouse while there is still snow outside. Photo credit: Cara Cummings

Blocking out seedlings for early-season outdoor transplanting. Photo credit: Terra Brockman

WHICH SEASON EXTENSION PRACTICES ARE BEST FOR YOU?

There are many paths you can take to reach your goal of extending the harvest season. The bulk of this guide provides the information, examples, advice, case studies, and resources that will assist you and other Illinois specialty crop growers in making informed decisions about which season extension practices to implement. As with most new farm activities, it's a good idea to start small, and invest your time and capital conservatively at first. As you learn what works for your farm, and develop your skills and markets, you will then be in a position to invest in more season extension infrastructure and techniques, and reap additional benefits.

Of course, success or failure in season extension depends on many factors, some under your control, and others not. The case studies starting on page 26 illustrate how three farmers in Central Illinois have incorporated a wide array of season extension practices, and expanded and improved their businesses as a result. The additional resources starting on page 47 provide in-depth information you need to research and then implement season extension infrastructure, techniques, and practices.

Once you have gained a broad knowledge of season extension principles and practices, you can delve deeper by answering the questions and filling out the chart in the worksheet on page 37. This culminating activity will help you think through the specifics of where you and your farm business are at, where you want to go, and the best way to get there.

RISKS AND BENEFITS OF SEASON EXTENSION

Direct Benefits

- Higher productivity and income
- Getting specific products to market earlier and later in the season, when prices are typically higher, resulting in higher profit margins
- Extended income, which creates positive cash-flow over more months of the year
- Extended marketing, which can develop customer loyalty to a brand
- Reduction in weather, pest, and disease damage, leading to lower pest-control costs, and improved quality of your fruits and vegetables

Indirect Benefits

- New infrastructure helps you develop equity, and provides opportunities to diversify revenue streams, and have positive cash flow throughout the year
- Year-round positions, which can help you develop a skilled and consistent labor force, and enable you to spread the workload more evenly over the entire year

EXTENDED SEASON, EXTENDED BENEFITS

The benefits of local food systems, such as viable farm incomes, year-round employment, and improved nutrition, are closely tied to the availability of local foods. Extending the growing season helps provide these larger societal benefits of local food systems all year-round.

Costs and Risks

- Cost of initial infrastructure and associated infrastructure, resulting in higher production costs
- Investment of time, often including increased management demands, and a steep learning curve
- No break in the physical and mental tasks of farming and marketing
- Plastic disposal problems

As we discuss later in this guide, the season extension infrastructure itself may be expensive, and some, such as passively ventilated greenhouses and hoop houses, require constant monitoring so that crops do not burn up or freeze. You may also find that new infrastructure requires a steep learning curve as field management and pest management strategies are often different, taking funds and personnel away from your main farm enterprises. Even after you invest in and are comfortable with managing season extension infrastructure, you may find costs snowballing as you now need to invest in drip irrigation under your plastic mulch, or in your high tunnel.

That said, there are many season extension techniques that are simple and inexpensive. It's best to consider the low-investment alternatives first, and to enter into any season extension with as much information and practical experience as possible.

PRINCIPLES OF SEASON EXTENSION

There are a few principles that apply to all forms of season extension. Specific information on many of these are found later in this guide.

Energy capture

When you extend the season, you are in effect capturing and storing solar energy. This energy capture and storage can happen over various time frames:

- Short-term, such as under a row cover or in a hoophouse, which captures solar energy in the form of heat and creates a microclimate suitable for plant production earlier and later in the season
- Mid-term, by plants such as apples and pumpkins, which capture solar energy in the form of complex sugars and can be stored easily for many months
- Long-term, such as in a jar of jam. See the Prairie Fruits Farm & Creamery case study for discussion of value-added products made with harvest surplus

Timing

Most season extension practices require you to time your farming practices differently than in your normal field production, for example:

- You will plant, cultivate, harvest, and process at different times of the season, and in addition to time already devoted to your field crops during the regular growing season
- Growing crops in the winter, when temperatures are low and daylight is limited, can cause crop growth to slow or even cease
- Marketing throughout the year requires a host of new considerations, from knowing where to sell off-season products, to preventing freezing during transportation. See the Gray Farms case study and the Blue Moon Farm case study for specific examples of the complexities and hazards of processing, transporting, and marketing in the winter.

Crop choices

You will most likely choose different crops for your season extension farming than those in your regular fields. Your choices will depend upon the extension practices employed and the demands of the market. Common crop choices are:

- Hardy greens such as kale, spinach, cabbage, chop, and salad mixes that can overwinter
- High-value summer crops such as heirloom tomatoes and colored peppers that can be brought to market both earlier and later in the season and sold for a premium
- Perennial fruits such as strawberries, raspberries, blueberries, and even dwarf peaches, which are high-value and may be grown in high tunnels
- Perennial herbs such as rosemary, lavender, and tarragon can often be grown and marketed year round with season extension techniques

If your farm business is going to focus on using season extension to grow a few select crops, your other farming decisions will revolve around those crop choices. Some common reasons to choose certain crops for season extension include:

- Market demand
- Ability to "cold sweeten"
- Natural ability to store well
- Potential for value-added processing
- Available season extension infrastructure
- Cold hardiness—see the Blue Moon Farm case study for discussion of the importance of selecting cultivars for this trait

Early and late season kale cultivars.
Photo credit: Terra Brockman

SEASON EXTENSION PRACTICES

This guide divides season extension practices into practical categories of no/low, medium, and high investment. The information and examples presented will broaden and deepen your knowledge, and help you make informed decisions about season extension practices for your farm. You can then use the worksheets, references, and resources at the end of this guide to get ready to take concrete steps toward implementing season extension practices that are right for you.

USING MICROCLIMATES

Low-cost: Exploiting what you have

There are many no- or low-cost season extension practices, and many of them involve finding or creating microclimates. Even the smallest farm landscape has climate variations that can be exploited. This section will help you identify and modify microclimates on your farm in order to extend your season. Working with microclimates will also provide clues that point you toward next steps for season extension on your farm, such as sites for high tunnels or crop storage facilities.

Site selection. Even slight gradients can make a big difference in climatic conditions. South-facing slopes enjoy the most solar gain, staying warmer longer in autumn, and heating up faster in the spring. These slopes are great for stone fruits, brambles, and other perennials that require few mechanical tasks.

You may also construct berms or Hugelkultur beds to artificially create beneficial southern slope microclimates. Cold air collects in low-lying areas, so these are best avoided for tender specialty crops.

Example 1: A farmhouse is located on top of a small hill facing south, and the land slopes down from there to the road. The farmer decides to plant raspberries and blackberries on the slope. The southern exposure warms the area earlier in the spring, allowing the farmer to bring those berries to market earlier than other area farmers, and charge a premium price.

Example 2: A farmer takes fallen branches and brush from his woodlot to create a Hugelkultur bed that runs from east to west. The south-facing slope on one side of the bed, plus the warmth from the decomposition of the plant matter in the mound, allows the farmer to plant cucurbits and other crops that are normally at risk in that climate.

Rebecca Fisher builds Hugelkultur beds with brush and tree branches from her wooded land near Quincy, IL.
Photo credit: Terra Brockman

HIGHLY ERODIBLE?

Be sure to consult a soils map before planting on slopes, to ensure the soil is not particularly prone to erosion. (USDA Natural Resources Conservation Service, 2015)

HUGELKULTUR BEDS are a permaculture technique in which you pile up organic matter such as brush, logs, or leaves. These then slowly decompose, leaving behind a raised bed of rich soil. (Miles, 2010)

Windbreaks. Vertical structures, such as buildings, trees, fences, and trellises can reduce wind and hold warm air near your crops. Small grains, perennial grasses, or fast-growing trees make good windbreaks and improve early plant growth and crop production, particularly with melons, cucumbers, squash, peppers, eggplant, tomatoes, and okra. You may also select windbreak trees that will do double-duty, such as cedar for posts, or mulberries for fruit.

When you situate barns, sheds, and other structures on your farm, consider how they might create useful microclimates for your crops. Bear in mind, however, that structures and windbreaks can also create negative microclimates, such as shaded areas and wind tunnels. Be sure to thoroughly evaluate how light and air move around these structures and how they change temperatures, solar exposure, and wind speed before planting your crops near them.

Example 1: A farm experiences consistent westerly winds, and so the farmer decides to plant a windbreak of fast-growing trees at the western edge of the property. Until that windbreak is tall and substantial enough to protect sensitive peach trees, the farmer will plant the fruit trees in a row set 30 feet off the eastern side of the farm's large barn, with will function as a windbreak and also reflect solar heat onto the trees.

Example 2: The same farmer wants to install a high tunnel and sees an opportunity to use her growing windbreak to protect the tunnel. She chooses a spot for the tunnel but then decides to spend some time observing how the shade falls and looks up how tall the trees in the windbreak will get. Based on this information, she decides to move her high tunnel an additional 40 feet away from the windbreak to keep it out of the shade.

The corn crib and tree line at Gray Farms in Watseka, IL help create a windbreak protected microclimates. Photo credit: Cara Cummings

Choosing early, mid, and late season cultivars helps you extend your season and deal with unpredictable weather. Photo credit: Terra Brockman

Soil and moisture management. Soil that dries out quickly will warm faster than heavy, wet, high-clay soils, so you can create warmer microclimates by adding organic matter, doing strategic tillage, creating raised beds, and improving drainage. Increasing or decreasing soil water content can enable tillage operations, prevent waterlogging of the root zone, and aid germination. Overhead irrigation can be used to protect crops from frost, and micro-sprinklers can be used to cool them. Soil in raised beds will dry and warm faster than soil that is flat in the field. Home gardeners often use frames to contain the soil of their raised beds, but no-frame raised beds are more practical for commercial production.

Cultivar selection. You can extend your harvest season by choosing varieties that are more heat- or cold-tolerant. A heat-tolerant lettuce cultivar, for example, will allow you to bring lettuce to market when other farmers' lettuce has all bolted. The number of days from planting to maturity varies from cultivar to cultivar, and some cultivars will germinate better in cool soil than others. Many seed catalogs recommend specific varieties for season extension or for growing in high tunnels. Succession planting, along with the use of cultivars spanning a large range of maturity dates, will allow you to significantly extend your harvest season.

Transplants. You can get a three or four week jump on the season by germinating seeds in a hoophouse or other warm place, potting them out, and then transplanting the young plants into your field as soon as the danger of frost has passed.

Putting in bare-root brassica transplants in early April. Photo credit: Terra Brockman

USING PLASTICULTURE

When most people think about season extension, they think about plastic sheet mulch, row covers, hoop houses, and other forms of plasticulture. Plastic is the most common material used to create microclimates and extend the season, with glass a distant second. Plastic, in conjunction with other technologies, offers you the flexibility of adding just a few weeks on to your growing season, or going to full 12-month farming.

Sheet mulch. Sheets of plastic are held tight to the soil surface by mounded soil or, less often, by stakes or staples driven into the ground. Sheet mulch offers many benefits to the farmer, but the most important is that it captures solar energy, warming the soil and then retaining that heat. This can extend your season from a few days to one to two weeks. There are many types of sheet mulch, with black polyethylene being the most popular.

In addition to capturing and retaining heat, sheet mulch is useful for retaining soil moisture. However, it sheds rain, so a drip irrigation system must be used under the plastic, and you need to keep those materials and labor in mind when considering using sheet mulch.

In field production, sheet mulch is usually spread by a mechanical mulch layer, typically mounted on your tractor's three-point hitch. This specialized implement requires a substantial investment of time to master. It is also generally unsuitable for soils with a lot of clods, rocks, or residue. Most mulch layers include a reel that dispenses drip irrigation under the plastic as it is being laid. Also bear in mind that laying plastic mulch is one more step to be taken in spring field preparation. It may warm the soil more quickly, but making the time to install it can also cause delays.

MULTIPLE BENEFITS OF MULCH

Other benefits of sheet mulch include uniform bed-making, weed suppression, erosion control, and moisture retention.

In high tunnel production, sheet mulch is often spread by hand because it's impossible to get a tractor into every row of most high tunnels. This requires a dedicated and skilled crew. See the Blue Moon case study for discussion of this topic.

Many crops, such as brassicas, are suited for sheet mulch only in the late summer and fall, because they would otherwise suffer from the added heat. The crops that are most likely to benefit from sheet mulch are members of the nightshade family (tomatoes, peppers, eggplant) and cucurbit family (squashes, melons, and cucumbers). (Penn State Extension, 2015)

Example 1: A farmer's cut flower enterprise is booming and he wants to start marketing flowers for June weddings. However, he is not able to produce enough stems that early in the season, so he arranges to borrow a neighbor farmer's plastic mulch layer and installs sheet mulch on a few beds in his field. The increased soil warmth allows the flowers to be planted, germinate, and grow earlier than they normally would. The farmer harvests more stems of more varieties than in years past, enabling him to provide flowers for a June wedding. The added springtime effort to lay the plastic mulch also reduces his weeding time later in the season.

Example 2: Later in the season, the farmer's vegetable CSA is doing well, but he wants to offer more vegetables in the end-of-season shares. The flowers from earlier in the season have died, so at the end of July he seeds broccoli, cauliflower, radicchio, and other moderately hardy crops in the hoophouse. In early September, he transplants the starts into the holes in the black plastic left vacant by the spent flowers. These vegetable crops are able to mature an extra two weeks, thereby extending his CSA offerings and giving him extra produce at the market that other farmers don't have available.

Low tunnels and row covers. While plastic sheet mulch goes under the leafy part of plants and warms the soil, low tunnels and row covers go over the plants, and warm both the soil and the air around the plants. Low tunnels are supported by wire hoops (or sometimes PVC or other materials), whereas row covers have no support structure and simply "float" over the plants. Managed properly, row covers or low tunnels can add two to three weeks onto the beginning and end of a growing season. The most common material for both is spun-bonded plastic, a thin mesh of plastic fiber that comes in various thicknesses and looks like a thin white blanket over the row.

Compared to sheet mulch, installing row covers and low tunnels requires less skill and no specialized equipment. This technique is also more amenable to rocky soils or those with residue. It is, however, a labor-intensive task that requires you to purchase and manage a lot of extra materials. The good news is that, with proper care, you can reuse the materials for a number of years, and also in multiple locations within a season. The bad news is that even a tiny hole can be an entry point for pests like flea beetles, one of the most aggressive pests for brassica production. Then the tunnel becomes a liability, trapping a breeding pest inside with plenty to eat. Once a hole appears, it either must be repaired quickly, or the section must be disposed of. Damage can substantially reduce the lifespan of these materials.

It's important to monitor the crops you have under row covers or low tunnels because they can overheat on sunny days, outgrow the covered space, or develop fungal diseases with little warning. Removing covers and tunnels in order to cultivate or harvest provides a good opportunity to check the status of the crops, but it's good to monitor more often than that.

Covers and tunnels can protect crops from wind damage on Illinois farms. However, they can become a liability if any corner is left uncovered or if there is a hole in the fabric. Wind can pull or tear at these openings, exposing the crop and causing further damage, so it's important to secure these materials, even using stakes in addition to well-mounded soil holding down the edges of the sheet.

Light penetration and insulation are determined by the thickness of the plastic. Agribon, a popular brand, offers a variety of thicknesses for their spun-bonded plastic material. Their AG-30 is an industry standard, which offers a balance of heat retention and around 70% light transmittance. Growers needing serious frost protection will look for heavier weights, as high as AG-70, which only allows about 30% of light to pass through. Some farmers will also use multiple layers of plastic, especially inside high tunnels, to maximize heat retention on the coldest winter days, even at the expense of light transmittance. (Penn State Extension, 2015) (Agribon, 2015)

Example 1: A farmer wants to be the first to market with summer squash, so she plants them two weeks ahead of her normal planting schedule into black plastic sheet mulch and then covers them with AG-30 row cover. However, a week after the seedlings emerge, a 30° low is predicted one night. The morning before, she removes the lightweight cover and, while she has it off, does a quick hand-weeding in the planting holes of the sheet mulch. She then replaces the AG-30 with an AG-70 cover. This allows heat to accumulate under the new cover over the course of the day, retaining enough to keep the inside above 32° overnight. After a few days, when the threat of frost has passed, she switches back to the AG-30 cover.

Example 2: Two weeks later, even though the danger of frost is over, the row cover is still useful as it protects the crop from squash beetles, vine borers, and other pests. She removes the cover to do a second weeding and then quickly replaces it to keep pests out. Another two weeks later, the squash plants are straining against the inside of the row cover. With the plants large enough to stave off pest attacks, she removes the cover, inspects it for any damage, rolls it back up, and plans to use it next on a late lettuce crop.

High tunnels. High tunnels are the most recognizable form of season extension. They are useful on almost any specialty crop farm and are often viewed not as an "if" investment, but "when." Farmers who are serious about season extension usually have more than one, and significant portions of some specialty crop farms are under plastic at any given point in time.

High tunnels offer many of the same benefits as a standard greenhouse, but they differ in that they are semi-permanent structures, sometimes even mobile. This allows them to be constructed at lower cost and with less skill, and to be moved, expanded, or adjusted according to the needs of the farm.

High tunnels still are, however, a substantial investment, incurring both one-time and ongoing costs. Their installation can cause a significant shift in the operation of your farm, possibly calling for the expansion of your labor force, a reduction in time off over the winter, new marketing strategies, new infrastructure, and more.

Much has been written about high tunnel installation and maintenance, and some of the best resources are listed on page 47.

An industry standard high tunnel (30 feet by 96 feet) can be purchased as a kit for under $2.20/square foot as of September 2015. Some farmers erecting high tunnels for the first time may spend an inordinate amount of time constructing the tunnel, or spend a lot of money hiring someone to install it. If you are considering a high tunnel, keep figures of $12,000–$15,000 in mind to cover costs of materials, labor, and additional site preparation. (FarmTek, 2015)

Although there are some less expensive high tunnel options, beginners should not cut corners or improvise. There are many sources for high tunnel kits and supplies, and even experienced growers often buy kits when constructing new tunnels. High tunnels are only a good investment if you do your research, buy one suited to your situation, and commit to utilizing the high tunnel for producing and marketing more crops.

High tunnels can function well as simple passive solar structures if they are monitored for climatic changes and are ventilated on sunny days. However, they can add significantly greater benefits to your farm with a few basic additions, which may include:

- Fans hung from the ceiling that can be of benefit in both summer and winter for moving air and circulating heat
- Automated vents on end walls
- Sensors for monitoring temperature and humidity
- Blower for double layers of plastic, creating an insulating layer of air between the two layers of plastic
- Propane, kerosene, pellet, or wood stove as a heat source in the high tunnel

A simple high tunnel can extend the season from a few weeks to 1 to 2 months and enable not only production of cold-tolerant crops, but also earlier planting and harvesting of tender crops like tomatoes that can fetch premium prices when you're the first farmer in your area to market them.

Double-layered tunnels with a blower reduce the risks from severely cold nights and can add even more time onto the beginning and end of the season. For true year-round farming, however, heat will have to be added. See the Blue Moon Farm and Gray Farms case studies for examples of different ways to add heat to high tunnels.

The biggest concern for Illinois farmers using high tunnels is wind, with a close second in some areas being freezing rain leading to a heavy coating of ice. Constant winds throughout the season, coupled with strong thunderstorms that can bring hail and tornadoes, put high amounts of stress on plastic-covered hoop houses. This reduces their lifespan and can also cause catastrophic tears or blow-offs. While these events cannot be 100% avoided, mitigating risk is certainly possible. For instance, if your farm has a prevailing wind (generally from the west or southwest), orienting your end walls to face the prevailing wind will reduce the risk of wind damage. You might also equip your tunnels with two layers of plastic, kept separated by a blower fan, as mentioned above. In addition to providing better insulation, a double-layer of plastic on a high tunnel can improve the endurance of the plastic due to the rigidity

it creates. See the Gray Farms case study for more discussion on this topic.

In general, don't consider high tunnels to be a structure that you can put in an "odd space" on your farm. High tunnels should be carefully placed near your home or work buildings to facilitate the frequent monitoring and adjustment they require. They should never be located on slopes, because the designs of almost all high tunnels require flat ground. Also avoid low-lying areas prone to flooding. Lastly, while gaining some wind protection from a building and keeping it close to the center of the farm is important, putting it too close to buildings can block sunlight, limit your ability to do work on the high tunnel, and increase the risk of equipment puncturing the plastic on the tunnel. (Frisch, 2007)

High tunnels can do more for you and your farm than help you extend your crop season, providing additional benefits that many farmers do not recognize until they have one. They can serve as short-term storage for tools, drying space for storage crops, staging for seeding trays, or a meeting place for employees and farm tour groups. Some farmers also use them as housing for their laying hens during the winter. The hens appreciate the heat, and the soil appreciates the fertilizer. While these ancillary benefits are hard to quantify, they do provide additional benefits to many specialty crop growers.

As useful as they are, however, high tunnels can disrupt your existing practices and record-keeping. Their beds might be narrower, planting and cultivation will more often be done by hand, many tasks will be completely new to you and your labor force, and seeding, transplanting, mulching, trellising and other activities will be happening at different times of the year than you are used to in your regular field work. Be sure your books are ready for the new information, that your staff are trained on the new tasks, and that you keep a log in each high tunnel to keep close track of temperature, maintenance, and plant material moving in and out.

Mobile tunnels, high tunnels on a simple rail system, can be slid along the rails to an adjacent location. Photo credit: Terra Brockman

Example 1: After years of field production, a farmer decides to install a high tunnel. The field closest to his house is flat and comes up to the edge of the driveway. This seems like a good location, but he realizes that this part of the driveway is where he also sometimes piles gravel and other materials. Vehicles maneuvering near a high tunnel make him nervous, so he decides to site the high tunnel an additional 30 feet into the field. This allows him to still easily access the tunnel, while also giving him room for three tractor passes in the 30-foot gap between the tunnel and his driveway.

Example 2: Years later, the same farmer has installed several more high tunnels and is becoming known for his salad mixes, available until late in November and starting again in April. He decides he wants to take the plunge and begin selling some produce year-round. He has one double-layered tunnel in which he installs a corn burning stove. The first year, he fails to stay on top of feeding the stove and loses some crops of tender greens. The next year, he writes a work plan for himself and his crew that outlines who is in charge of monitoring temperatures in the houses and, if necessary, feeding the stove. He also puts a log sheet in each of his tunnels so he and his crew can keep track of temperatures and who is doing what in each tunnel.

STORING CROPS

Producing storage crops, and then storing them at proper temperature and humidity, is one of the easiest form of season extension. Many specialty crop growers already grow crops that do well in storage, or could easily add other crops and cultivars suited for storage. Some farmers simply pull root crops and store them in plastic bins in basements or coolers.

The main challenge lies in marketing the stored crops. Fresh greens and value-added products have instant shelf appeal, while stored fruits and roots may appear dull. Successful marketing of storage crops relies less on one-off retail sales and more on wholesale channels or on selling in tandem with the products of other forms of season extension.

There are a few themes common to successful crop storage:

Environmental conditions. All storage crops are best kept in as little light as possible, benefit from good airflow, and should never be kept in completely sealed conditions. In other words, they need to continue "breathing." There are many online resources giving optimum temperature and humidity for storing various crops, but generally speaking, storage crops need low temperatures, in the 35-55 degree range, and high humidity, between 70% and 95%. (Nock, 2012)

Damage. Injury to some crops prior to storage, whether from human hands, pests, or other factors, can compromise their storability, even if the damage seems minor. For instance, pests like squash bugs are not easily controlled, but the plants can withstand a certain level of damage and be brought to harvest with moderate pest pressure. However, if the bugs are allowed to dwell on the fruits, their chewing will create micro-abrasions that will not become apparent until later, when rot will begin at those points. This can shorten their storage life from months to weeks.

It's also important to prevent injury and loss while crops are in storage. As the saying goes, it only takes one bad apple to ruin the whole barrel. This is one way that investing in more serious storage infrastructure can pay off: basements and root cellars increase the risk of damage from mold, insects, and rodents far more than sealed environments like coolers. Different means of storage are discussed later in this section.

> *Example:* The weather report indicates that a hail storm is likely overnight. Knowing there is not much time but unwilling to lose the storage onions still maturing in his field, the farmer hurries out and covers as much of the field as he can with Reemay, blankets, tarps, and any other materials he can find. Surveying the damage the next day, he sees that the uncovered onions are slightly bruised, so he decides he will sell those first because the bruises will lead to rot in storage. The covered, undamaged onions become his storage crop.

Curing. To reduce water loss and decay during storage of root, tuber, and bulb crops, they need to be cured in ways appropriate for each crop, which can be readily researched online and in print resources. During the curing process of roots and tubers, surface wounds heal with new epidermal tissue called wound periderm. In bulb crops, curing dries the neck tissue, which prevents the bulbs from rotting.

> *Example:* A farmer wants to offer her customers potatoes for as long as possible in her CSA. She begins by harvesting new potatoes in July, choosing a section of each variety that she will dig for the small tubers. She continues to do this every week through mid-September, at which point 1/3 of the potato plants have been removed. By now, the plants have completely died back and the tubers are mature, with thick skins suitable for storage. She has her whole crew spend one day digging all the remaining potatoes, places them in a dark storage room with good air circulation at 40-45F and 95% humidity and stores them for the next six months in order to offer them to her winter CSA members.

Crops for storage

The following crops and crop families are appropriate for storage. Specific information on optimum temperature and humidity may be found in many online sources, as well as Extension and other publications.

Alliums: Cured garlic and onions, as well as large leeks harvested late in the season, will store well. Garlic and onions should be stored by themselves, because their smell can affect nearby crops. Leeks can be stored similarly to root crops such as carrots and parsnips, by keeping them in-ground under protection, or in bins of wet sand. See the "Roots" section below for more information.

The only substantial difference between producing alliums for immediate sale and for storage is the choice of cultivars. Hardneck garlic varieties keep well for only 3–4 months, and so should be sold first. Softneck varieties will store well for up to a year under optimal conditions. (Byczynski, n.d.) Similarly, many onion cultivars will keep for only a few months, while others will store well for a year or more.

Cucurbits: Many varieties of pumpkins and winter squashes, if properly harvested and cured, will last six months or more in storage, and the taste and nutrition of some varieties improve with age. Again, cultivar selection is important if you decide to grow cucurbits for storage. Acorn squash have the shortest storage life, followed by spaghetti squash, buttercup, butternut, and blue hubbard. (Ontario Ministry of Agriculture, Food, and Rural Affairs, 2000)

Apples: While most fruits are highly perishable, many varieties of apples and some pears can last for months in storage. They do not need to undergo a curing process, but extra care must be taken in harvest not to bruise or cut their skins, as this will hasten rot. (Willenberg, 2010)

Roots: Carrots, parsnips, beets, turnips, and similar root crops, as well as leeks, all store well. Some farmers simply harvest them, and then place them in plastic bins with the lids slightly ajar. These crops like very high and consistent humidity and low temperatures, which can be provided in some basements and root cellars, and also with sand storage and in-ground storage. In sand storage, roots are kept in damp sand inside bins such as Rubbermaid boxes, which are then kept in a cool, dark place. Root crops may also be left in the ground and kept insulated from sub-freezing air temperatures with straw, blankets, plastic, and other materials so that they remain just above freezing and can still be pulled when needed for sale. This will only work if the crops were covered when the ground was still relatively warm, and if the winter temperatures are not brutally cold for long periods of time. Planting some root crops in high tunnels will allow them to be kept in the ground and dug as needed through most of the winter. As mentioned previously, roots that are exposed to moderate freezing temperatures will go through a cold-sweetening process that improves the flavor of those crops. (Royal Horticultural Society, 2015)

Softneck garlic hangs from the barn rafters to cure.
Photo credit: Terra Brockman

Tubers: Potatoes and sweet potatoes have very different curing protocols, and very different storage temperatures.

Sweet potatoes are a tropical plant, and are cured at close to 90 degrees and 90% humidity, which causes the periderm to thicken and reform, healing any bruises or cuts, and triggering the development of enzymes that convert some of the starch in the roots to sugar. Once the sweet potatoes are cured, they are very shelf stable. The only thing to be careful about is that they do not go below 55 degrees, which will lead to the same problems caused by cool, wet autumn soil, namely, rot. When stored at 55-60 degrees, and medium high humidity, sweet potatoes will not only keep well until spring, but their maltose sugar-creating enzymes will continue to work, and your sweet potatoes will get sweeter and sweeter. (Lerner, 2006)

Potatoes should be stored at cooler temperatures, about 45-55 degrees, and high humidity, and must be kept dark to prevent them from turning green and sprouting. Be careful not to let the temperature in your potato storage area drop below 40 degrees. Low temperatures cause the starch to turn to sugar and negatively affect the taste, texture, and color of the potatoes. (The Ohio State University Extension, 2002)

Dry crops: A number of other crops, such as legumes and specialty grains, are easily stored and make excellent offerings to the right chef or store. Once dried, they can store for many months, or even years, in very simple dry, dark storage conditions such as in bags that can be sealed to prevent damage from insects or rodents.

Leafy crops: A handful of leafy crops are suitable for storage. Certain cabbages store extremely well in high humidity conditions, and Belgian endives may offer a novel treat for retail and CSA customers. In general, having an assured market for these crops is critical before spending the time producing and storing them, as the market may be limited.

Marty Gray of Gray Farms in Watseka, IL storing onions in his corncrib. Photo credit: Cara Cummings

How and where to store crops

There are many simple, low-cost ways to store vegetables, and many farmers adapt existing infrastructure can to meet basic crop storage needs.

Basements tend to stay cool and have high relative humidity, especially when they are unfinished. With simple shelving or container space, farmhouse basements make good crop storage spaces, but it's a good idea to monitor your basement for fluctuations in temperature and humidity for up to a year before using it for crop storage. Then you'll know if you need to add heaters, air conditioners, or humidifiers to maintain optimal storage conditions. Once you've put crops in your basement, continue to monitor temperature and humidity, and run a fan for air circulation to avoid mold development. Crops should always be placed on pallets or shelves for good air circulation.

Attics and dark loft spaces are often suitable for storing crops like onions and garlic, since they tend to be dryer than basements. Windows may need to be boarded over to block sunlight, and uninsulated attics may need to be heated to avoid freezing. Monitoring equipment will also be valuable in these spaces.

Walk-in coolers, whether commercial refrigeration units or rooms with air conditioners modified with CoolBots, are standard infrastructure on many specialty crop farms. They are valued because you can precisely control temperature and humidity precisely, and pest concerns are relatively low. (Northeast SARE, 2010)

High tunnels and greenhouses, particularly those used for starting seeds, tend to be empty in early winter and so can serve as interim crop storage. This may require some insulation or added heat to avoid freezing, as well as the use of blankets, tarps, and other materials to reduce light exposure as much as possible.

You can create other effective crop storage spaces on your farm as well, often with only modest expense.

Root cellars utilize the relatively constant 55 degree temperature of the earth below the frost line. They can be constructed either by digging and reinforcing spaces underground, or by constructing and reinforcing mounds of earth with storage space inside. These spaces offer temperature and humidity conditions similar to basements. (Wixson, n.d.)

Reefer units and storage containers may be adapted for use as walk-in coolers. Such units come in handy when large amounts of different crops (potatoes, carrots, beets, turnips, and winter squashes, for example) are all harvested around the same time. See the Gray Farms case study for discussion of the use of old reefer units.

Example: A farming couple grows a diverse array of specialty crops, many of which they store to sell at winter markets and to local restaurants. Their restaurant buyers told them that they love cold-sweetened carrots and fresh leeks in the winter. The couple planted Bolero carrots in their high tunnel, a variety well-suited to storage, and they planted Bandit leeks, a frost-hardy variety, outside. As temperatures begin to fall in early winter, they put an extra layer of row cover over the carrots inside the high tunnel, and then begin to harvest them as needed. They cover the field bed of leeks with layers of burlap and leaves, which they pull back periodically to harvest the leeks.

The couple also grew pumpkins, and in the fall when the vines died back, they let the pumpkins cure in the field. Though they would have preferred to leave them out a few days more, a hard frost advisory prompted them to bring all the pumpkins in from the field. They stored the good winter keepers in the basement, and put the ones with shorter shelf lives in their walk-in cooler until the first winter markets.

COOLBOTS are very popular with small-scale specialty crop growers. They are computers that attach to and override the control systems on off-the-shelf air conditioners. This allows a farmer to install the modified air conditioner and turn any small room into a walk-in cooler. (CoolBot, 2015)

PROCESSING TO ADD VALUE

The method that extends the season the longest also requires the most "non-farming" time and can be quite expense. Although preserving the surplus of the summer months can be costly, the resulting value-added products are relatively easy to market due to their appeal and stability, and the payoff on the investment can be substantial.

If you are just starting to experiment with some value-added products, you will benefit from short-term or single-day courses put on by community colleges, Extension offices, and nonprofit community organizations. You can take these courses during the winter to learn more about value-added production and the time, skills, and investment it entails. If you're looking to add a few pickled vegetables or dried herbs to your farm offerings, a short winter course may be all you need to be ready to make and market value-added products at a small scale the next season.

Although there are simple ways to get into value-added processing that will make your farm offerings stand out from everyone else's, you will need to invest more time and expense than with most other forms of season extension if you want to make these shelf-stable products a larger portion of your farm income.

If you are able to make the investment, an on-farm kitchen can be a tremendous boon for your business, one that goes far beyond crop preservation. A licensed commercial kitchen will allow you to invite chefs to the farm to cook on-farm dinners and allow you to host weddings and other events. In addition, value-added products are valuable to your business at any time, inviting customers to both the winter and summer farmers' market booths.

Before you start

These are some of the factors that make value-added processing expensive and time-consuming:

Skill set: Many people do canning and preserving at home, which is a relatively simple undertaking. But to follow food safety standards and legally can and preserve large amounts of produce is not easy. Purchasing the right equipment, getting the right certifications, and then doing the work when the harvest surplus is coming in is time-consuming and sometimes nearly impossible to fit in. This means that you may need to hire someone to take over your other farm work, or hire a culinary expert to manage the value-added processing.

Commercial kitchens: Constructing, outfitting, and running a kitchen that can efficiently produce safe value-added products can be very expensive. If you're not ready to make that kind of investment yet, you can usually find commercial kitchen rentals where you can make small to medium size batches of your value-added product.

Before you invest in your own on-farm commercial kitchen, examine the existing assets of your farm and ask yourself:

- Does a building for the commercial kitchen exist, or does it need to be constructed?
- Is existing plumbing, heating, cooling, and ventilation sufficient?
- Will I use the kitchen consistently enough to make up my investment?

Answers to these and other questions will vary widely from farm to farm. Depending on your answers, a commercial kitchen may be a non-starter or the best investment you've ever made.

If you do decide to jump in and construct and outfit a commercial kitchen, a useful rule of thumb is to plan for everything to take twice as long, and to cost twice as much, as your projections show. Small farms often struggle to secure loans or other funding for capital expenses, but a well-budgeted and well-planned proposal for the construction of a commercial kitchen to support a specific new enterprise may be more likely to receive funding. (University of Minnesota Extension, 2015)

COTTAGE FOOD LAWS, AS OF SEPTEMBER 2015

In Wisconsin, producers with less than $5,000 in gross annual sales may produce homemade canned goods with a pH under 4.6, but baked goods are not allowed, and they can only sell directly to the consumer. (Forrager, 2014)

In Illinois, producers with less than $25,000 in gross annual sales may produce both homemade baked goods and canned goods with a pH under 4.6. (King, 2012)

Regulations: Meeting state, local, and other standards is the elephant in the room regarding value addition. Before making any major investments of time or money into a value addition enterprise, be sure to investigate all your local regulations, even at the county or village level. It is easy for a promising project to be stymied by food safety and other regulations. Ask other farmers or chefs in your area what they went through to meet those standards, and contact your local health department very early in your planning process.

Note that many states have passed "cottage food" exemptions for small-scale value-added food processing. See the sidebar for examples of these regulations in the Midwest, and call your local health department to see what paperwork you may have to fill out, or courses you may need to take, to qualify as a cottage food producer.

Ways to preserve the harvest

Canning and pickling are the most recognizable ways of preserving foods and adding value, but there are a few other important ways as well. When you are ready to take the next steps in these practices, see the resource section on page 47 for books and on-line resources to help you begin processing and adding value to your produce.

Canning, pickling, and fermenting are ways that many specialty crop growers preserve foods in a shelf-stable form. Jams, jellies, preserves, sauces, and pickled and fermented produce have great customer appeal, and can fetch premium prices if they can be differentiated from other goods on the market through good branding and high quality. (National Center for Home Food Preservation, 2009)

Fermentation, an ancient form of food preservation, has been experiencing a renaissance, as more people are aware of the importance of the gut microbiome. Making fermented products such as sauerkraut and kimchi tends to be cheaper and safer than canning or pickling, and has the added benefit of improving the nutritional value of whatever is being fermented. (United Nations Food and Agriculture Organization)

The production of canned and pickled goods is a substantial undertaking in the height of the harvest season. Many farmers do it only as a last resort, preferring to sell as much of their fresh product as possible and preserving only the excess for their own use. This mindset of preserving only what is necessary lends itself well to enterprises falling under a small-scale, "cottage food" exemption, requiring both minimal investment and minimum income. However, if you want value-added goods to be a significant part of your production and marketing, you will most likely need to hire more staff. See the Prairie Fruits Farm & Creamery case study for more perspective on canning and value addition as part of a farm business.

Freezing, by contrast, is a relatively simple way to preserve many products. Some produce can be frozen whole in bags with very little preparation, while others require a brief blanching period before being placed in plastic bags and frozen as quickly as possible.

Marketing your frozen goods, however, is generally not as easy as marketing canned and pickled goods. They do not offer the customer a lot to look at, they cannot be sold off a shelf, they are difficult to add flavor or uniqueness to, and they sometimes give customers the impression that a food has been cheapened, rather than that value has been added. As a result, the market for frozen goods may be limited to restaurants who are willing to work with them (remember that anything "local" can still sell) and CSA customers who are told upfront that they will be receiving frozen foods in their share.

Drying is simpler than canning and pickling and offers some market appeal when done with the right crops. Many farms make use of home drying equipment to handle the small amount of foods they intend to sell as dry goods, but electric and solar dehydrators appropriate for commercial scale are a better option if you plan to dry large quantities of herbs, garlic, hot peppers, fruit, or other produce. (Scanlin, 2014)

Chocolate adds a lot of value to raw aronia berries at Sunny Lane Farm in Eureka, IL. Photo credit: Terra Brockman

The dried product can be sold as salad toppers, snacks, or as ingredients to be ground or used whole in the kitchen. They can make a good addition to CSAs and winter market stands, and storing them is relatively simple, as long as they are kept in tightly closed plastic bags or tightly lidded jars after being thoroughly dried. Note that most health departments consider drying to be "processing," and you will need to go through the same procedures as you would to make jams and other canned goods.

Example: A farmer wants to start making salsa based on a recipe she grew up with. She already grows most of the ingredients and feels confident in her cooking and canning abilities, so she begins making the product on her own in small batches. She hires a friend to make labels, and after two years, her salsa has a small customer base that is asking for more. Her home kitchen is being taken over by the salsa enterprise, and she finds herself torn between her field work and her kitchen work. She decides to hire a part-time field worker so that she can concentrate on making and marketing the salsa and a few related products.

After another two years, she is approaching the sales ceiling for her state's exemptions for small-scale "cottage food" producers. She had already considered installing a commercial kitchen on her property by building an addition to her home kitchen, and decides that the project will be possible with a loan from her bank. She writes a business plan for the salsa operation and applies for the loan. The bank approve her loan, but not for as much as she was asking for. She decides to wait another two years to begin the addition, continuing to save money from her salsa sales and strengthening the enterprise so she can reapply. This waiting period winds up giving her more time to explore and experiment with new value-added products, such as dried tomatoes and pickled jalapeño peppers, and she prepares to add those products to her next loan application. In the meantime, she stays under the state's gross sales exemption for small-scale producers.

MARKETING FOR SEASON EXTENSION

Marketing the fruits of season extension carries multiple benefits. A winter farmer can charge premium prices because of the rarity and desirability of the product. In addition, being that rare farm with available product will set a farmer apart from the pack. Farmers who keep their customers happy and well-fed through the off-season also strengthen customer loyalty.

However, even an experienced farmer with a well-developed marketing strategy may find that marketing in the off-season has challenges. Opportunities for direct marketing are generally harder to find, the farm's product line and availability will be more limited, and customers might not even think to look for products from local farms after winter sets in. The climatic challenges of winter can also interrupt the logistics of getting products to market, as they may freeze during harvest, packing and distribution. Dangerous travel conditions can also limit farmers' ability to get product to their customers.

You can take advantage of many of the same marketing channels as in the summer time, but you will likely encounter significant differences in how they are managed in the cold months:

Winter CSA: A CSA requires a high level of understanding and coordination between farmers and customers. The challenges of a winter CSA can add extra strain to this relationship and will require heightened communication and flexibility in order for the relationship to be maintained.

Weather is the primary troublemaker in winter, and can interrupt harvest and packing of product in a variety of ways. Heaters may break down, water lines in the packing house may freeze, and rural roads can become impassable. Even if a farmer is able to successfully harvest and pack all shares, the farmer's ability to leave the farm, or the customer's ability to get to the pick-up point, can still be hindered by dangerous roads.

As a result, delivery may need to be delayed or canceled, and those disturbances must be understood as the risk of buying into a winter CSA. Alternatively, the farmer might offer to return payment for up to a certain number of undeliverable shares, if winters are predictably bad enough.

In addition, the winter CSA will not be able to offer the same product line as a regular season CSA, unless the farm is adding a substantial amount of heat to greenhouses or is buying in product to supplement the shares (which arguably stretches the definition and mission of a CSA). In addition, a weekly CSA share might not be possible, and farmers may choose to offer bi-weekly or monthly winter shares.

It's important to be up front when marketing winter CSA shares, so customers are not surprised at how different the winter shares are compared to their summer shares. However, winter shares are a good opportunity to incorporate value-added products and storage crops. In this way, you are not offering a CSA of limited crops, but a re-branded CSA with a unique product line. It is uncommon for CSA farmers to put a jar of jam into the share box, so those kinds of additions increase the value of the share and may keep customers coming back season after season.

Winter farmers' markets: Farmers' markets are strongly associated with people strolling through sun-dappled streets and parks, selecting from field-grown produce. A market in the winter turns this scene on its head in a number of ways. First, winter markets are usually held indoors. No matter how nice the space is, it may negatively impact the "farmers' market experience," straining the mental and emotional association that customers make with products at the farmers' market.

Second, farmers selling at winter markets have to put even greater effort into the aesthetics of their stands in order to recapture that "farm fresh" feeling. This can be done in several ways, from including cut flowers in the high tunnel production plan to eye-catching labels on value-added products or colorful storage crops like squashes, gourds, and garlic braids. In addition, the market display may change significantly with the loss of the summer tent. You will have to plan ahead for this, as it is easy to forget how much of the display hinges on use of the tent's structure.

Third, the products available at the farmers' market will shift in the winter, with a noticeable reduction in fresh produce and an increase in processed goods, shelf-stable products, and, depending on the market, arts and crafts. This affords a major opportunity to farmers who can offer fresh product. Market managers will often offer those growers premium spaces at the market, and customers will gravitate towards that product and be willing to pay premium prices.

Finally, although the prevalence of winter farmers' markets is on the rise, customers are still less likely to expect a market in the off-season. Therefore, attendance may be lower, and both managers and vendors may struggle to promote the market. Photos and simple written explanations of the process of harvest, storage, and processing on local farms can be used by both vendors and managers to show how the winter farmers' market has product and what farmers do to bring it to the customer.

Winter restaurant and store sales: A farm that can supply product directly to restaurants and stores is a rare thing. Rarer still is the farm that can supply product during the winter, meaning that the prices a winter farmer might fetch from a cafe for fresh local salad greens will be much higher than during the regular season. However, the winter can cause that restaurant relationship to sour quickly, in two ways:

TRANSPARENCY IN LABELING

A farm that offers canned fruit preserves as one of its major products takes on a big risk: in some years, there is simply no fruit. Late frosts and pest infestations can wipe out whole crops. In order to maintain product line consistency and make the best use of a commercial kitchen, farmers may choose to buy fruit from other farms. It is important to make sure that labeling and advertising reflects that the fruit is from another farm, to avoid leaving customers feeling duped.

Consistency: Restaurants need deliveries to be timely and consistent. Chefs run a tight ship, and it's easy for farmers to lose accounts if they don't stick to the chef's schedule. Winter can make this more difficult with interrupted harvests, crop losses, and dangerous driving conditions. This means you will need to 1) do everything possible to reduce the risks of winter production, and 2) have a strong relationship with the chef, making sure from the outset that he/she knows what your challenges are during the winter. A chef who already works with farmers is more likely to be sensitive to these risks and interruptions and therefore will not need the same amount of education as a chef who is new to using fresh, local foods.

Freezing temperatures: Restaurant drop-offs are usually brisk. The produce is dropped at the back door or swiftly placed in the walk-in, and then the farmer is on his/her way. In the winter there is the risk that the delivery truck was exposed to freezing temperatures en route, and boxed produce will have been damaged. This will most likely not be discovered until the moment the kitchen crew or store stockers opens the box and discover brown lettuce or soupy tomatoes. While this is a preventable risk and the chances are low, the likelihood of a furious customer is high.

There are also some innovative ways of marketing products in the off-season beyond the usual marketing channels:

Online ordering: Farmers may choose to set up online ordering systems on their websites. An online marketplace can be helpful for a winter grower because it can fill in gaps between markets, retaining the attention and income of loyal customers. In some ways online markets are more manageable than summer markets, since the product is limited and much of it can be storage crops that are easily pulled with no additional processing needed.

There are of course the usual production and processing problems associated with winter weather, and you will want to inform your customers of potential interruptions in availability. See the Gray Farm case study on page 30 and the Blue Moon Farm case study on page 33 for their experience with online ordering in the winter months.

Bulk sales: The availability of storage crops and value-added products opens the possibility for regular bulk sales to restaurants, stores, and schools. This could include anything from potatoes and onions to jams and pickles, delivered on weekly, monthly, or other schedules. Bulk sales in the winter can be a simple and reliable means of maintaining cash flow and relationships with solid wholesale accounts. The risks of this are relatively low, and come almost exclusively from the inherent risks of storing crops, such as temperature, moisture fluctuations, and pests.

Most of the investment to maintain bulk sales is up front, in infrastructure, processing, and marketing. A farmer must be willing to set themselves up at the beginning of the growing season for successful bulk sales later in the year. Bulk storage crops and processed goods tend to not fit neatly into field plans that are otherwise designed around fresh, direct-market sales. They can differ in the following ways:

Bulk harvests: Crops like garlic, onions, squashes, and potatoes will be harvested all at once, causing a sudden need for a large amount of labor, equipment, and storage space on the farm.

Processing time: Crops intended for value added processing (jams, pickles) must have their harvest time carefully coordinated with the processing team, and shelf space must be available.

In-ground storage: Crops like carrots, parsnips, and leeks may stay in the ground long after all other crops are removed, yet if the farmer wants to have them available for winter sales, the ground must be kept warm enough to harvest from. This is often done with a combination of plastic layers in unheated tunnels or even out in the field. Alternatively, these crops can be stored in buckets or bins of cool, moist sand.

CASE STUDY #1

GRAY FARMS

Both Marty and Crystal Gray grew up on farms, but it wasn't until they were living and working in the Chicago suburbs that they realized they wanted to be closer to their family, and to try farming as a business. After attending Central Illinois Farm Beginnings and interning with Jon Cherniss of Blue Moon Farm, Marty and Crystal Gray started farming in 2008.

They moved to their current farm in 2011, and now raise vegetables on eight acres using vegan and certified organic practices. They sell their produce through a CSA, and at the Kankakee farmers market and Division Street farmers market in Chicago. They also serve their customers through an online ordering system.

PLASTICULTURE PRACTICES AND EQUIPMENT

The Grays have been using season extension techniques on their farm from the beginning. They started with just one hoophouse that they heated and used for seedling production. As they grew their business, they saw that the most successful vegetable farms around them had multiple high tunnels so they began making investments. Now they have the heated seedling hoophouse and three double-layered high tunnels with 90,000 BTU corn-burning stoves in them. Marty says that in keeping with both their strong environmental ethic and need for keeping input costs low, they only use the stoves when they absolutely have to. "Our take on winter production is mainly passive solar," he says. "We focus on varieties that are cold hardy and will last using only the AG-50 row cover."

In their high tunnels, the Grays keep a fairly simple rotation from year to year, growing mostly vegetables such as kale, beets, Swiss chard, green onions, and spinach. Marty says that their tunnels "mirror" each other, with each tunnel laid out in a similar pattern but planted in succession for staggered harvests. This makes it easier for Marty to predict yields, to delegate and track tasks, and to have a back-up plan in case of a crop failure in one of the tunnels. All of their beds are hand-planted and hand-weeded. Marty has been experimenting with the use of sheet mulch inside his tunnels. Although he has seen the benefits of weed control from the sheet mulch, it has added too much heat for the brassica crop roots, so he plans to only use it on his tomatoes and cucumbers.

WIND

Marty's high tunnels have been subject to wind damage. "We completely lost two or three 96-foot coverings, and that's a real heartbreaker." Those coverings were single layers of plastic. Since the loss of the single sheets, all of the Gray's high tunnels are two layers of plastic inflated with a blower fan, which has made a huge difference in protecting his high tunnels from wind. The inflation makes the hoophouse stronger, and the outer layer of plastic protects the inner layer. Marty says, "I wish I had double-covered from the start. I'm getting three to four years out of the double-layered plastic as opposed to three to four months out of the single layers. If you do have to do it single, you have to make sure to watch your wear points, and make sure the thing is properly fastened down."

Marty has also made use of fast-growing eastern white pines, and the strategic placement of buildings to block wind and hold warm air near the tunnels, which he says has made a big difference.

CROP STORAGE PRACTICES AND EQUIPMENT

In addition to high tunnels, the Grays grow and market storage crops. They use two different types of containers for winter crop storage. One is a four-inch-thick polyurethane box with a CoolBot that usually stores roots. The other is a small insulated trailer, which currently contains all of their potatoes, carrots, and many other crops. The trailer is kept outside under a shelter, and its only use of power is a fan to keep air circulating in the dark, humid space, and Marty monitors temperature and humidity.

MARKETING

When we interviewed Marty Gray in early February, he was just seeing new growth on the kale and other greens in his high tunnels, spurred by the lengthening daylight. He was very excited about this because it meant he could start bunching fresh greens for his winter farmers markets. These farmers markets are his primary off-season marketing venue, which he says is easy because you simply bring whatever you have available.

Marty also does online sales: "On our website, you can do custom orders that get delivered to four or five places around Chicago. Thursday through Tuesday I see orders come in, and it's a little scary at first. Inventory management is such a huge thing, especially in the winter. But I think it's made me a better gardener because I can look at my beds and be able to tell what I've got to sell. You're working with square feet, not acres, so you've got to make everything count."

PROCESSING AND TRANSPORTATION

Processing and transporting produce to market in the winter has its own set of difficulties.

Marty said he was caught off-guard by the many issues of dealing with produce in the bitter cold when he began extending the season on his farm. "We've had days where it's zero degrees, -20 degrees, and the wash table has a layer of ice on it when we're ready to go. You have to have some kind of mechanism to get it to at least 33 or 34 degrees, and that's not taking into consideration your own comfort. We charge a premium for these products because every harvest requires a winterization process."

Marty Gray with a baby carrot that he'll be marketing locally before the ground has thawed.
Photo credit: Cara Cummings

Marty explains his crop storage trailer, parked under the barn at his farm.
Photo credit: Cara Cummings

After processing the vegetables, Marty notes that transportation then presents its own difficulties. "You get out to the box truck and it's zero degrees, what do you do? One time I ended up with everything in the cab of the truck and it looked ridiculous. That's a panic moment we're trying to avoid. These aren't super complicated things, but they are things you need to think through before you get started. Just spend a minute or two penciling it out and figuring out how you're going to deal with these rough conditions. Having an insulated truck, having a thermometer, having an extra sheet of greenhouse plastic can help. All of those can help, but you can't avoid the rough weather."

Swiss chard coming back to life in a high tunnel at Gray Farms.
Photo credit: Cara Cummings

EMPLOYEE RETENTION

Gray Farms has two employees "that we strive to give nine months of work to, and we are shooting for ten." This means that there is a gap of just two months in the winter when there is no work on the farm for anyone other than Marty. He says that his employees deal with that gap, but the more he can close it, the better, and he is slowly working toward year-round employment. "They're great guys for sticking around, but closing that gap is paramount for us to keep them around year to year. They're scrambling around looking for work in the wintertime and that doesn't make me feel good either."

PROFITABILITY

Marty and his wife Crystal have definitely seen the value of season extension for their farm business. "When we jumped into this thing, it was absolutely critical for us to stand out at the farmers market. It [season extension] has helped us broaden the range

Marty Gray, co-owner and operator of Gray Farms in Watseka, IL.
Photo credit: Cara Cummings

of people we serve. You can't go to the farmers' market and hold up a flag saying 'notice me!' It has to be something on the table that is really nice or really early."

Bulk onions in storage at Gray Farms in Watseka, IL.
Photo credit: Cara Cummings

Marty also notes that being able to get started with premium-priced early tomatoes helps bring in much-needed cash just at the time when seasonal employees are beginning to arrive on the farm. Then the late-season tomatoes from the high tunnel bring in a little extra income for the family at the end of the year. "In terms of the farm's sustainability, we don't make a windfall, but extending the season definitely helps us keep this all going."

CASE STUDY #2

BLUE MOON FARM

Blue Moon Farm is a 20-acre certified organic vegetable farm in Urbana, Illinois, founded in 1995 by Jon Cherniss and Michelle Wander. Blue Moon Farm capitalizes on local wholesale and retail markets by offering a large volume of high-quality produce all year long.

Lorien Carsey is the winter farmer at Blue Moon. She helps manage production year-round, but takes the lead role every winter while the farm owners step back and prepare for the coming summer season.

PLASTICULTURE PRACTICES AND EQUIPMENT

For winter production, Blue Moon uses ten high tunnels, ranging from 48 to 96 feet long. Three of the 10 tunnels are 60-foot long moveable high tunnels on rails. Blue Moon staff use tractors to move the tunnels every spring. "If I moved them every spring and fall like some people do, and put tomatoes in them in spring every year," Lorien says, "my tomatoes would always end up in the same spot, which isn't a good rotation."

Two of the high tunnels utilize a unique heating mechanism, an oil-burning heater inside the box of an old truck that no longer runs. The truck is positioned at one end of a tunnel with the box open so that heat from the oil burner flows into the tunnel. The burner in the truck heats one tunnel at a time. Once a year, the truck is pulled off of the overwintered greens hoophouse, and pulled to the early tomato hoophouse. Even though there is additional labor and money needed to heat the tunnels, Lorien says it's worth it because the heat allows her to get more cuttings of greens from the first hoophouse, and earlier tomatoes from the second. Lorien uses plastic sheet mulch in Blue Moon's tomato hoophouses. She is able to lay the mulch smoothly and precisely by getting the greenhouse very hot so that the plastic can stretch tight over the beds, and by working with an experienced team of farmhands.

Lorien Carsey, winter farmer at Blue Moon Farm in Urbana, IL. Photo credit: Cara Cummings

Some of the many high tunnels at Blue Moon Farm. Photo credit: Cara Cummings

Blue Moon Farm uses two types of monitoring equipment in their high tunnels. The Sensaphone takes temperature readings in their most critical tunnels, and also monitors their coolers. If the temperature enters the danger zone, the device calls them. The other monitoring device is the Kumostat, an online system utilizing tags that are installed in the greenhouses and coolers. The Kumostat tags collect data that help Lorien make management decisions about, for example, when to cover and uncover crops, and whether double layers are necessary in all of their tunnels.

After a couple of years of frustration with freezing temperatures, and because of the increased demand for their produce, Blue Moon Farm made a substantial investment in a large wash-pack area that is insulated and

heated by a propane burner. Even with the heating and insulation, they must completely drain the pipes and wipe water from all surfaces after each use because the temperature drops below freezing on the coldest nights, which could cause the pipes to burst.

CROP SELECTION

While infrastructure is important to Blue Moon Farm's season extension and winter farming, Lorien emphasizes careful crop and cultivar selection. She swears by White Russian Kale, saying "I've tried lots of different kales and this is the most flexible variety. It grows well all winter and like gangbusters in the spring. And in another month [from March], we'll start harvesting napini [kale flower shoots] from it for about three months." The lesson she's learned from the White Russian Kale is that "you really want to find the varieties that can survive anything and plant a lot of that, versus trying to find the varieties that do ok, because 'ok' in -14 degree F is going to be dead. For instance, I won't plant chard anymore in a moveable tunnel, because they can't take the wind when we move the tunnel."

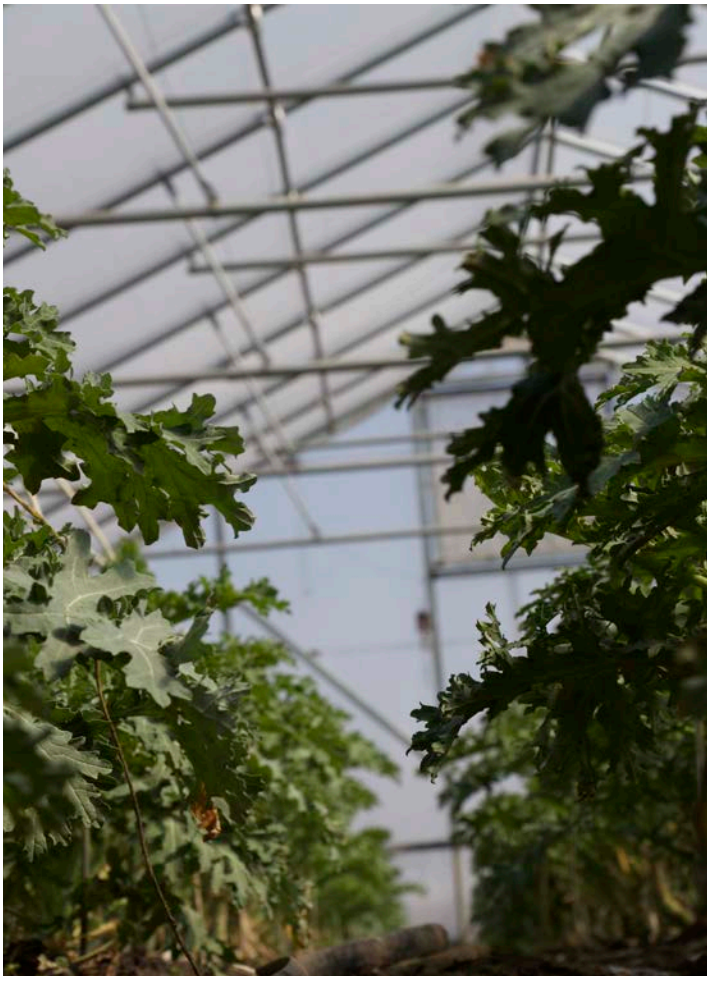
PEST CONTROL

When asked about pest challenges they've had over the years, Lorien quickly replies "aphids." But she adds, "We're finally figuring out how to use beneficials to our benefit." Lorien was happy to note that the ladybugs were starting to make a measurable difference in keeping the aphids at bay.

MARKETING

Blue Moon's main sources of revenue are the summer and winter farmers' markets in Urbana. During the winter months, they continue to sell to a number of restaurants and stores in the Champaign-Urbana area, and they also serve individual consumers through an "on-line CSA." People can see what produce is available and order it on the Blue Moon Farm website, then pick it up at a designated time and place.

These seedlings will be Blue Moon Farm's first field succession of lettuce. Photo credit: Cara Cummings



White Russian Kale at Blue Moon Farm, which Lorien says has performed very well for them and also has great flavor that customers love.
Photo credit: Cara Cummings

But finding safe and convenient places to sell their winter produce to consumers has not been easy. After the winter market ends in December, a "Middle Market" runs from January to April, from 8am to 1pm. Blue Moon Farm wanted to participate in that market, but knew that being there at 8am in January and February could damage or destroy their produce. "Because winter production is new, few traditional winter markets are set up to handle the special needs of fresh produce," Lorien says. "We are in the process of negotiating with market managers about more flexibility in their rules for produce vendors, which would insure safe transport of the crop."

For the past few years, Blue Moon Farm has hosted their own market in various places at the Lincoln Mall, while hoping to develop an official winter market space that would suit the needs of winter farmers and their customers. "Customers love having fresh produce in the winter," says Lorien. "They go nuts for it!"

CONSISTENT EMPLOYMENT THROUGH WINTER FARMING

Having high quality produce consistently available throughout the year is important to Blue Moon Farm, Lorien, and the other farm staff. Lorien draws a distinction between season extension and her work, which she calls winter farming. "Season extension is being able to start earlier in the spring and have earlier tomatoes, early peppers, early squash. Winter farming is when you can produce fresh products consistently all winter. We've always done season extension here, but we really went into winter farming with the goal to be profitable, explore that niche, and have more consistent employment. Winter farming means we can employ one person full-time, one person maybe three-quarters time, and a couple of part-timers throughout the winter. Even for those part-timers, we've extended how long they can work here through winter farming. It's definitely been a benefit for our employees, including me."

PROFITABILITY

Blue Moon Farm's winter farming, January to March, is still in a beginner stage, according to Lorien, who wants to keep tweaking and investing until it is truly profitable. But it has already brought benefits to the farm through more consistent employment, and by keeping Blue Moon produce on store shelves and customers' tables year-round, strengthening their already large and loyal customer base. "Everything about winter farming takes much longer," Lorien explains, "so much so that I can't say we're making a big profit in the winter. I can say we're working more and keeping more people employed. We still have a long way to go in terms of profitability, but it's definitely overall a benefit."

CASE STUDY #3

PRAIRIE FRUITS FARM & CREAMERY

Prairie Fruits Farm & Creamery was founded by Wes Jarrell and Leslie Cooperband in 2003. The first year they planted 350 fruit trees, which now bear apples, peaches, and cherries. They also have a herd of over 80 dairy goats, whose milk is used to make many kinds of cheeses, gelato, and other value-added products. In addition to the orchard and the goat herd and on-farm creamery, Prairie Fruits Farm runs an active agritourism operation, serving on-farm dinners and hosting many other events.

Central to all of the farm's enterprises is their commercial kitchen and its executive chef, Alisa DeMarco. Part of Alisa's work is to extend the season by preserving the farm's excess produce which, in 2015, meant dealing with an abundant harvest of organically grown peaches.

VALUE-ADDED PRODUCTS, PRACTICES, AND EQUIPMENT

Wes Jarrell and Leslie Cooperband invested in their commercial kitchen in 2008 in order to meet health department regulations and be able to legally invite the public out to their farm for evening dinners in a beautiful setting. They secured a grant from the Frontera Farmer Foundation, which helped pay for the expensive ventilation system the kitchen required.

Prairie Fruits Farm & Creamery had been preserving the excess of its harvests since its first years, but the kitchen allowed them to do more, and to have a convenient marketing channel for those value-added products, many of which are used for on-farm dinners and other events.

Alisa DeMarco has broad and deep knowledge of all aspects of value-added processing, which she learned through her own research and hands-on experience. "We didn't learn this at culinary school," she laughs. She adds that, as local foods have become more prevalent and desired, food preservation has become part of the curriculum in many culinary schools.

In addition to preserving peaches, Alisa has put up raspberries, cherries, currants, aronia berries, and many other fruits. She also pickles cucumbers, peppers, pumpkins, and other produce, not all of which is grown at the farm. Prairie Fruits likes to support other local farms, and having a diverse array of preserved fruits and vegetables to offer during its farm dinners and at its markets makes the farm more profitable.

PEACHES AS AN EXAMPLE

Although Alisa preserves a variety of fruits and vegetables, 2015 was the year of the peach. The heavily laden trees kept the farm very busy during peach season, and the farm opened the orchard for U-Pick. "We let our customers come out and choose the peaches that look best to them," Alisa explained. "Then we come through the orchard after and pick the 'second' fruit, which is what we use for

preserves, jams, and in our gelato [made from the farm's goat's milk]. I'm looking for the ones that cosmetically don't look so good but that will make great jam."

The peaches at the farm are not "free-stone" peaches, which slows down the manual process of preparing the fruit. Alisa says that if making peach preserves were the primary enterprise of a farm, she would recommend that the farmer plant free-stone varieties.

When Alisa has enough to make a batch, she brings the fruit into the kitchen, where the 25 pounds of "seconds" become about 15 pounds of value-added processed peaches.

MARKETING

The primary marketing channel for Prairie Fruits Farm & Creamery products is internal. The fruits, cheeses, pickles, and many other value-added products are used in gelato, at on-farm dinners, and cheese boards served at events. Excess produce is canned in eight-ounce jars. The farm has created special labels for their jams, preserves, and pickles.

While people may buy them at any time, Prairie Fruits Farm sets some aside for around the holidays because people like to purchase them as gifts. In addition, Alisa says that using the preserves as part of the meals and then telling guests that they can buy their own jar to take home "almost always works. Someone always picks up a jar because of that."

Alisa DeMarco makes a batch of 12 8-ounce jars of peach jam in the licensed commercial kitchen at Prairie Fruits Farm & Creamery.
Photo credit: Cara Cummings

Chef Alisa DeMarco of Prairie Fruits Farm & Creamery in Champaign, IL.
Photo credit: Cara Cummings

PROFITABILITY AND CONSISTENT EMPLOYMENT

Alisa's budgets shows that turning "second" peaches into high-quality jam, sold at $8.00 per eight-ounce jar, adds economic value to a product that only sell for $1.00/pound, if they're salable at all. Furthermore, she says "having these products into the late summer and fall at market, you can tell our customers are excited to have something new. Our cheese production also drops off at that time, so it really keeps our market stand active and drawing customers over when they can see these colorful jams and jellies. They are really excited, they know we do a limited amount, and they want to share them with their families. For us, it helps us stay busy and keep people employed when work in the cheesery is slow. And in the fall, it keeps people's interest in the farm."

WORKSHEET

WHICH SEASON EXTENSION TECHNIQUES ARE RIGHT FOR YOU?

Season extension techniques can be as simple and inexpensive as selecting cold-tolerant varieties of crops you already plant, or they can be as expensive and complex as constructing a half-dozen high tunnels with heat and ventilation. You might even be ready to launch a complex combination of season extension practices, including windbreaks, row covers, high tunnels, value-added processing, and refrigerated storage rooms with sophisticated temperature and humidity controls.

There are many paths you can take to reach your goals of extending the harvest season, which will increase the number and amount of products you sell and the months you are able to sell them. The questions below, and the links to more detailed information and worksheets, will help you think through where you're at, where you want to go, and the best way to get there.

Your choice of season extension technique(s) will depend on your answers to these four basic questions. Sub-questions, and space to write your answers, are provided below. If you have a farm partner, each of you should write your answers alone, and then discuss them together.

1. What do I want to achieve?

2. What markets are available, and what prices can I charge?

3. Am I currently ready and able to incorporate something new on my farm?

4. What are the time, labor, land, skill, and monetary requirements of the season extension technique I'm considering?

FINDING THE RIGHT FIT

1. Start with the end in mind. Imagine your farm operation in five or ten years, with your season extension practices fully functional. Sketch a picture of what this looks like in the space below. Include any physical infrastructure, value added products, and marketing outlets you will need.

2. What is the primary goal of your season extension? Start by checking any goals that apply from this list, and then add any of your goals that don't appear here.

   - ☐ Make more money
   - ☐ Diversify the farm's revenue streams
   - ☐ Maintain more constant cashflow throughout the year
   - ☐ Access more markets
   - ☐ Grow better quality produce
   - ☐ Employ skilled labor year-round

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3. After you think about all your different goals, circle the one that is your primary goal. Be sure to consult with any farming partners and jointly agree on this goal.

4. Keeping that primary goal in mind, answer the following questions:

What new crops do you want to grow?

What crops are you currently growing that you want to grow differently, or for more months of the year?

What crops would you like to store for selling over the winter?

Where will you store the crops?

What crops would you like to process for year-round value-added sales?

How much will you charge for the crops mentioned above, and/or for the value added items made from them?

When do you project that you will be able to recoup the higher cost of production incurred by the season extension infrastructure, labor, and other expenses?

Where will you sell the crops mentioned above?

- ☐ Roadside stands
- ☐ Farmers' markets (are there year-round markets?)
- ☐ U-pick
- ☐ Restaurants
- ☐ Locally-owned grocers
- ☐ CSA subscribers
- ☐ Produce auctions
- ☐ Wholesale markets

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5. Look at the list of Season Extension Options to Consider, below. Write down the ones you are considering in the chart below. Then research (online and with neighboring farmers using similar practices) what the time, money, labor, and technology requirements are for each of the practices. Fill in the chart.

Season Extension Technique	Crops	Size/Cost	Time Requirements	Labor Requirements

- **Growing Under Cover** is an excellent resource listing all the different high and low tunnel options, their benefits, challenges, size, cost, and suitable crops for each. This chart of poly tunnel options may be particularly useful: http://kansasruralcenter.org/wp-content/uploads/2014/12/Growing-Under-Cover-2-Pollytunnel-Options.pdf

- **Four Season Production Planning Worksheets** from West Virginia's Value Chain Cluster are a useful tool to use as you prepare to turn your season extension plans into reality: http://vc2.org/wp-content/uploads/2014/09/BLANK-WORKSHEET-PACKET-Lewisburg-aug.-25.pdf

6. Considering the financial, time, and labor requirements, are you ready and able to launch the season extension practice(s) in the chart? Consider concrete things such as your land, labor, and financial situations, as well as less tangible, but often more important things, such as your need for down time.

If so, what will you need in order to implement this season extension technology successfully? Check all that apply, and add others:

- ☐ A bank loan
- ☐ New management structure and activities
- ☐ Additional time
- ☐ Additional training
- ☐ Additional work space
- ☐ Additional employees
- ☐ A water source
- ☐ Drip irrigation
- ☐ Health department or other certifications

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KEYS TO SUCCESS

No matter which season extension practice you decide on, you will be more likely to succeed if you:

START SMALL. Try out simpler and less expensive techniques on a small scale, and you will risk little beyond your own time, energy, some plant material, and perhaps a small amount of money.

WEIGH BENEFITS AGAINST RISKS AND COSTS. Before investing in expensive infrastructure such as a high tunnel or cooler, carefully weigh the value of the technology and its costs. In addition to the monetary cost, consider the mental and emotional strain that may occur as you learn how to implement the new infrastructure and practices. Consider that critical personnel or funds may be taken away from other parts of your farm. Also consider worst-case scenarios: an ice storm collapses your expensive new high tunnel and the insurance company refuses to pay because it's an "act of god", or you suffer a complete crop loss because temperatures in your passively ventilated hoophouse suddenly soared and cooked all your plants. These things happen! While none of these risks are necessarily deal-breakers, it is important to keep them in mind, and to realize that while new undertakings can move a business forward, they can also strain an already-struggling or even a successful business. On the other hand, keep in mind all of the benefits of season extension, including ones that are more difficult to quantify. For example, you may be able to create year-round positions and attract skilled labor, and some items that will not result in high profit margins will serve to draw customers to your farm stand and increase overall income.

PLAN FOR SUCCESS. As with most farm activities, success or failure will depend on many things, some of which you have control over (materials, management) and some of which you don't (weather, physical ailments). But careful research, planning, and consultation with other farmers, Extension and nonprofit personnel, and vendors will most likely lead to successful season extension and a more successful farm business.

SEASON EXTENSION OPTIONS TO CONSIDER

NO-COST OR VERY LOW-COST

There are many free and low-cost methods of season extension. Most cultural practices for modifying micro-climates require little time, but some, such as planting windbreaks, require long-term planning.

FIELD SELECTION. South-facing slopes stay warmer in the late autumn, and warm up faster in the spring. Avoid planting your earliest, most tender crops in low areas, since this is where the cold air will collect.

SOIL AND MOISTURE MANAGEMENT. Add organic matter, do strategic tillage, utilize raised beds, and improve drainage. Soil that dries out quickly will warm faster than heavy, wet, clayey soils.

CULTIVAR SELECTION AND PLANTING DATES. Choose varieties that are more heat- or cold-tolerant to extend your harvest season. The number of days from planting to maturity varies from cultivar to cultivar, and some cultivars will germinate better in cool soil than others. Many seed catalogs, such as Johnny's Selected Seeds based in central Maine, now recommend certain varieties for cold climates and growing in high tunnels. Succession planting, along with the use of cultivars spanning a large range of maturity dates, will extend your harvest season for any one crop a great deal.

TRANSPLANTS. You can get a three- or four-week jump on the season by germinating seeds in a hoophouse, and transplanting the seedlings so that they grow to transplant size early in the season. By the time the soil and weather warms sufficiently for outdoor growth, you will be setting out a small plant, not a seed.

IRRIGATION. Increasing or decreasing soil water content can enable tillage operations, prevent waterlogging of the root zone and/or aid germination. Overhead irrigation can be used to protect crops from frost, and micro-sprinklers can be used to cool them.

WINDBREAKS. Windbreaks create small areas with warmer growing conditions. Small grains, perennial grasses, trees, or a fence may help protect crops, and improve early plant growth and earlier crop production, particularly with melons, cucumbers, squash, peppers, eggplant, tomatoes, and okra.

RAISED BEDS. Soil in raised beds will dry and warm faster than soil that is flat in the field. Home gardeners often use frames to contain the soil of their raised beds, but no-frame raised beds are more practical and economical for commercial production. Bed heights of six to eight inches are common.

STORAGE CROPS IN EXISTING FACILITIES. Many crops are well-suited for storage, and many farmers already grow them. In addition, many crops can be stored in existing spaces on farms, such as basements, attics, and walk-in coolers.

MEDIUM LEVEL OF INVESTMENT

PLASTIC MULCH. There are many kinds of mulch products, but all are used to cover planting beds in order to raise the temperature of the soil beneath them. Much of the temperature increase occurs when the plastic is in direct contact with the soil, so it is important that the plastic is laid tightly against the soil. Plants are placed into holes cut in the plastic. Plastic mulch suppresses weeds and conserves water, but many growers use drip irrigation under the plastic. Biodegradable mulch is also available, but it tends to be more expensive and more fragile.

ADDITIONAL COSTS

For effective use of plastic mulch, row covers, and low tunnels, additional costs are likely for drip irrigation, supports, staples or pins to secure material, etc. When planning, remember that the amount of row cover or plastic cover needed will generally be greater than the square footage covered, since the material will be raised over plants or supports.

ROW COVERS are translucent spun-bonded materials that protect plants while allowing light and water to pass through. Lighter weight row covers are often used as physical barriers to insects. The thicker the row cover is, the more heat it will retain, and the less light it will transmit.

LOW TUNNELS are built from short (usually less than three feet high) arched supports that hold row covers above the plants, protecting them from pests and from frost.

WALK-IN OR CATERPILLAR TUNNELS use taller hoop-style supports. These tunnels are typically between eight and eighteen feet wide, around six feet tall, and twenty-four to three hundred feet long. Most people can walk into these tunnels, but they can be difficult to work inside of.

ROOT CELLARS AND STORAGE COOLERS. Costs for storage crops can increase if a farmer has to construct additional facilities, such as root cellars or a new cooler, in order to store them. Still, there are low-cost versions of both root cellars and storage coolers, making them only a modest investment.

VALUE ADDITION IN EXISTING FACILITIES. Many crops can be preserved and sold year-round. Depending on local and state regulations, farmers can process and sell up to a certain gross income threshold and in certain markets without having to follow the regulations that pertain to larger commercial kitchens.

HIGHER LEVEL OF INVESTMENT

HIGH TUNNELS (also known as hoophouses) consist of hoop-style, gothic, or other more rigid supports covered with plastic. The structures are tall, typically six feet or higher at the center. Compared to caterpillar tunnels, they have more internal supports and bracing along their length, making them structurally stronger. In addition, peaked designs will be better at sloughing off mounding snow. Many of these structures have no heat or electricity, but these can be added if needed. Inside a high tunnel, you may use additional season extension techniques such as plastic mulch, row covers, or low tunnels.

CONVENTIONAL GREENHOUSES are very expensive to set up and maintain, and generally include electricity, heat, vents, and large fans. Plant growth in a greenhouse is rapid, and pest development can also be rapid. Carefully evaluate the needs of your crops to be certain a conventional greenhouse is warranted. You should also develop a good marketing and business plan to make sure you can recoup your costs.

COMMERCIAL KITCHENS. Farmers may also decide to make a larger investment into their value addition and processing enterprises. If the sales from this enterprise pass a certain threshold or are taking place at certain markets, the processing kitchen will need to meet all local and state regulations for commercial kitchens. This will require investment of both time and money, and also substantial research to be sure that all regulations are being carefully followed.

REFERENCES

Agribon. (2015). *Agribon*. Retrieved from Agribon: http://agribon.com/?lang=en

Byczynski, Lynn. *Growing for Market*. Retrieved from The Scientific Truth about Garlic Varieties: http://www.growingformarket.com/articles/garlic-varieties

CoolBot. (2015). *CoolBot*. Retrieved from CoolBot: http://storeitcold.com/

FarmTek. (2015). *FarmTek*. Retrieved from Economy Round Style High Tunnels: http://www.farmtek.com/farm/supplies/prod1;ft_high_tunnels_cold_frames;pgpb01680r6c.html

Forrager. (2014, April). *Forrager*. Retrieved from Wisconsin: http://forrager.com/law/wisconsin/

Frisch, T. B. (2007, May). *University of Vermont Sustainable Agriculture*. Retrieved from High Tunnels: http://www.uvm.edu/sustainableagriculture/Documents/HighTunnels.pdf

King, W. (2012). *Illinois Stewardship Alliance*. Retrieved from Cottage Food Operation - Q & A: http://www.ilstewards.org/wp-content/uploads/2013/06/Cottage-Food-Operation-Law-Facts_Updated.pdf

Lerner, Rosie. (2011). *Purdue University Consumer Horticulture*. Retrieved from Dig Those Sweet Potatoes: https://www.hort.purdue.edu/ext/sweetpotatoes.html

Miles, M. (2010, August 3). *The Permaculture Research Institute*. Retrieved from The Art and Science of Making a Hugelkultur Bed – Transforming Woody Debris into a Garden Resource: http://permaculturenews.org/2010/08/03/the-art-and-science-of-making-a-hugelkultur-bed-transforming-woody-debris-into-a-garden-resource/

National Center for Home Food Preservation. (2009). *National Center for Home Food Preservation*. Retrieved from USDA Complete Guide to Home Canning: http://nchfp.uga.edu/publications/publications_usda.html

Nock, C. B. (2012). *Cornell University*. Retrieved from Production Guide for Storage of Organic Fruits and Vegetables: http://nysipm.cornell.edu/organic_guide/stored_fruit_veg.pdf

Northeast SARE. (2010). *Northeast SARE*. Retrieved from Walk-in coolers for winter storage: http://www.sare.org/Learning-Center/SARE-Project-Products/Northeast-SARE-Project-Products/Walk-In-Coolers-for-Winter-Storage

Ontario Ministry of Agriculture, Food, and Rural Affairs. (2000). *Ontario Ministry of Agriculture, Food, and Rural Affairs*. Retrieved from Pumpkin and Squash Production: http://www.omafra.gov.on.ca/english/crops/facts/00-031.htm#growth

Penn State Extension. (2015). *Penn State Extension*. Retrieved from Plastic Mulches: http://extension.psu.edu/plants/plasticulture/technologies/plastic-mulches

Penn State Extension. (2015). *Penn State Extension.* Retrieved from Plasticulture technologies: http://extension.psu.edu/plants/plasticulture/technologies

Royal Horticultural Society. (2015). *Royal Horticultural Society.* Retrieved from Root vegetables: storing: https://www.rhs.org.uk/advice/profile?PID=666

Scanlin, D. (2014, July). *Mother Earth News.* Retrieved from Best-Ever Solar Food Dehydrator Plans: http://www.motherearthnews.com/diy/tools/solar-food-dehydrator-plans-zm0z14jjzmar.aspx

The Ohio State University Extension. (2002). *The Ohio State University Extension.* Retrieved from Recommended Storage Temperature and Relative: http://ohioline.osu.edu/fresh/Storage.pdf

United Nations Food and Agriculture Organization. *Food and Agriculture Organization.* Retrieved from The Benefits of Fermenting Fruits and Vegetables: http://www.fao.org/docrep/x0560e/x0560e06.htm

University of Minnesota Extension. (2015). *University of Minnesota Extension.* Retrieved from Food Safety - Preserving and Preparing: http://www.extension.umn.edu/food/food-safety/preserving/

USDA Natural Resources Conservation Service. (2015). *USDA Natural Resources Conservation Service.* Retrieved from Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

West, Joseph. *SF Home Gate, Home Guides.* Retrieved from Reasons Leafy Vegetables Taste Better After Frost: http://homeguides.sfgate.com/reason-leafy-vegetables-taste-better-after-frost-91999.html

Willenberg, B. (2010, December). *University of Missouri Extension.* Retrieved from Home Storage of Fruits and Vegetables in Root Cellars: http://extension.missouri.edu/p/MP562

Wixson, C. (n.d.). *Maine Organic Farmers and Gardeners Association.* Retrieved from An introduction to root cellars: http://mofga.org/Publications/MaineOrganicFarmerGardener/Fall2008/RootCellars/tabid/984/Default.aspx

ADDITIONAL RESOURCES

HIGH TUNNELS, LOW TUNNELS, AND GREENHOUSES

ONLINE GUIDES AND RESOURCES:

Four Season Production Planning worksheet. Value Chain Cluster Initiative, a program of Natural Capital Investment Fund, 2012. http://vc2.org/wp-content/uploads/2014/09/BLANK-WORKSHEET-PACKET-Lewisburg-aug.-25.pdf

Growing Under Cover. Dan Phelps, Kansas Rural Center, 2015. http://kansasruralcenter.org/growing-under-cover/

Growing Under High Tunnels in Illinois and the Midwest, Zachary Grant, University of Illinois Extension, 2014. https://pubsplus.illinois.edu/CS01.html

High Tunnel Construction Demonstration, A.J. Both, Steve Garrison, and Wes Kline, Rutgers University, 2015. http://sustainable-farming.rutgers.edu/high-tunnel-construction-demonstration/

Hightunnels.org, various authors, 2015. http://hightunnels.org/

Michigan State University Hoophouse Website, 2015. https://hoophouse.msu.edu/index.php?q=resources

Midwest Winter Production Conference, various authors, 2014. http://www.webbcityfarmersmarket.com/winter-production.html

Mother of a Hubbard, Cathy Rehmeyer, 2015. http://www.motherofahubbard.com/

Polytunnel Options: A Comparative Chart, Dan Phelps, Kansas Rural Center. http://kansasruralcenter.org/wp-content/uploads/2014/12/Growing-Under-Cover-2-Pollytunnel-Options.pdf

Season Extension Resources Database, Midwest Organic and Sustainable Education Service, 2015. http://mosesorganic.org/farming/farming-topics/season-extension/

Season Extension: Variety Trials and Selection, SARE, 2012. http://www.sare.org/Learning-Center/Topic-Rooms/High-Tunnels-and-Other-Season-Extension-Techniques/Season-Extension-Variety-Trials-and-Selection

Tools and Calculators, Johnny's Selected Seeds, 2015. http://www.johnnyseeds.com/t-online-tools-calculators.aspx

University of Kentucky High Tunnel Research Facility, 2015. http://ukhtrf.webs.com/

VIDEOS:

Lincoln Land Community College (Springfield, IL). LLCC Garden High Tunnel Research Project, 2015: http://www.llcc.edu/career-training/green-center/llcc-garden/

High Tunnels: Using Low-Cost Technology to Increase Yields, Improve Quality, and Extend the Season, DVD available from the University of Vermont Center for Sustainable Agriculture.

Building a Hoop House video series, Adam Montri, Michigan State University, 2008. https://www.youtube.com/watch?v=z5dyGHurXdA

BOOKS:

The Hoophouse Handbook: Growing Produce and Flowers in Hoophouses and High Tunnels, 2nd edition, Lynn Byczynski, ed. 2014. Lawrence, KS: Growing for Market

The Market Gardener, Jean-Martin Fortier, 2014. Vancouver, Canada: New Society Publishers

The Northlands Winter Greenhouse Manual, Carol Ford and Chuck Waibel, 2009. Milan, MN: Garden Goddess Publications

Season Extension Techniques for Market Gardeners. Janet Bachman, 2005.Butte, MT: ATTRA/NCAT

The Winter Harvest Handbook, Eliot Coleman, 2006. White River Junction, VT: Chelsea Green Publishing

CROP STORAGE

BOOKS:

Build Your Own Underground Root Cellar, Phyllis Hobson, 1983. North Adams, MA: Storey Publishing

The Complete Root Cellar Book, Steve Maxwell and Jennifer McKenzie, 2010. New York, NY: Robert Rose

VALUE-ADDED PROCESSING

ONLINE GUIDES AND RESOURCES:

Fermenting for Value Added Vegetables, North Central SARE, 2010: http://www.sare.org/Learning-Center/From-the-Field/North-Central-SARE-From-the-Field/Value-Added-Vegetables

BOOKS:

The Art of Fermentation, Sandor Ellix Katz, 2012. White River Junction, VT: Chelsea Green Publishing

The Joy of Pickling: 250 Flavor-Packed Recipes for Vegetables and More from Garden or Market, Linda Ziedrich, 2009. Cambridge, MA: Harvard Common Press

Ball Complete Book of Home Preserving, Judi Kingry and Lauren Devine, 2006. New York, NY: Robert Rose

Preserving Summer's Bounty: A Quick and Easy Guide to Freezing, Canning, and Preserving, and Drying What You Grow, Rodale Food Center, 1995. Emmaus, PA: Rodale Press