An Introduction to Season Extension for High-Altitude, Short-Season Gardens

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YOU ARE A SHORT-SEASON, HIGH-ALTITUDE GARDENER IF:

You live in Idaho at an elevation above 4,500 feet, **OR**

Your USDA hardiness zone is 4 or lower, **OR**

You have a frost-free growing season of 110 days or less

University of Idaho Extension

Introduction

GARDENING IN HIGH-ALTITUDE REGIONS of the arid West can be challenging due to short growing seasons and extreme temperature swings. Season extension methods like cultural practices and physical infrastructure can increase gardening success in challenging climates. Cultural practices, including the identification and use of microclimates (in addition to planning for unpredictable adverse weather events), optimize the length of your growing season in high-altitude regions. Physical infrastructure involves either low- or high-technology constructions. Low-technology infrastructure is generally more affordable and requires less of a financial and labor investment to implement. High-technology infrastructure requires more financial capital and has permanence on the landscape. This bulletin provides an overview of these season extension methods and references additional Extension publications that offer more in-depth information on specific season extension methods and construction details. Growing a garden at elevations above 4,500 feet and in colder plant hardiness zones may be challenging, but it's doable if you plan appropriately, choose the most compatible infrastructure, and have persistence and grit.

Weather Considerations for Short Growing Seasons

Frost-Free Days and Warming Soil Temperature

Planning for unpredictable weather is the most important factor to gardening in short-season climates, since a season's arrival is unpredictable (first and last frost dates are always estimates). It is common to experience a frost midsummer, leaving no frost-free days during the summer growing season. Gardeners need to be ready to respond to unfavorable weather patterns or risk losing their garden to frost events. By minimizing plant stress and properly caring for your plants you'll create more resilient plants, particularly during harsh weather events. For a detailed consideration of cold-hardy plant varieties and site selection (including microclimates), refer to *Gardening Strategies for Short-Season, High-Altitude Zones* (University of Idaho Extension BUL 859, http://www.extension.uidaho.edu/publishing/pdf/BUL/BUL0859.pdf).

Artifically increased soil temperature is another primary factor contributing to plant success in short growing seasons. Warmer soil temperatures are needed for seed germination, root growth, and soil microbe activity. Microbe activity makes necessary nutrients available for plant growth. Using season extension methods artificially increases soil temperature by creating microclimates (warm pockets of air) to buffer your garden from the daily temperature swings common in mountainous regions.

Know Your United States Department of Agriculture (USDA) Plant Hardiness Zone

Idaho has a range of environmental conditions, altitudes, and USDA Plant Hardiness Zones. The USDA Plant Hardiness Zone Map delineates growing zones across the United States based on average minimum winter temperatures (https://planthardiness.ars.usda.gov/). If you plant appropriately according to your plant hardiness zone, your plants are more likely to thrive. The USDA Plant Hardiness Zone Map is a valuable resource to understand the growing potential of your county. When selecting plants, choose varieties that are optimal for your zone. The hardiness map does not show microclimates, an important caveat for successful growing on your unique property.

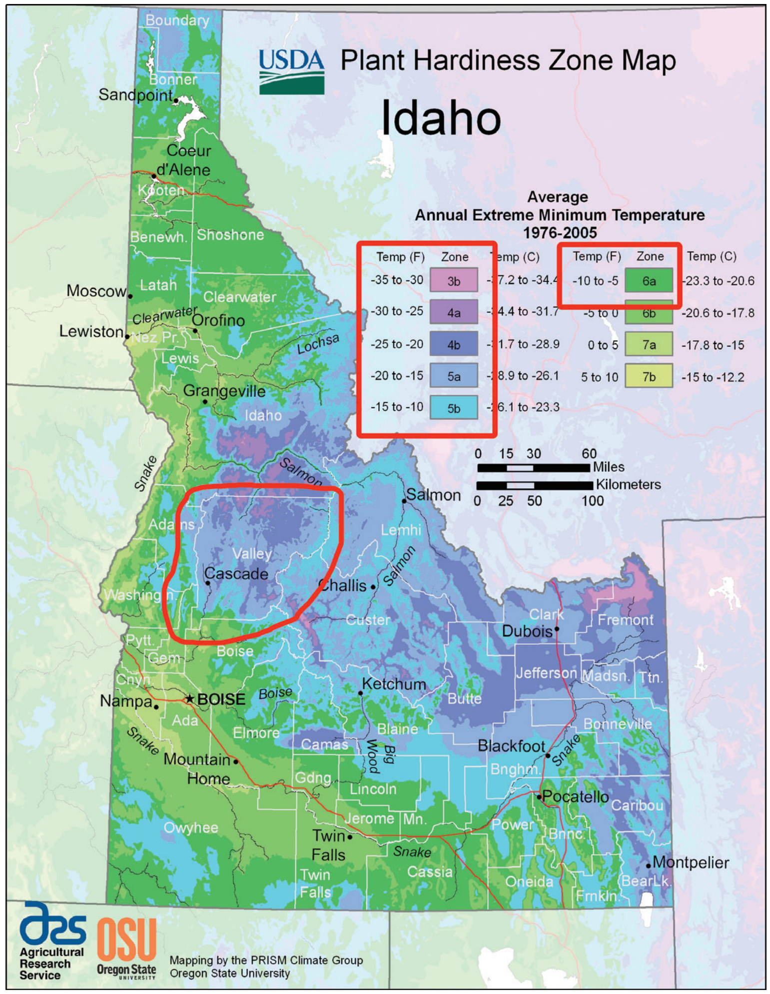

Figure 1. In high-altitude regions the plant hardiness zone can vary tremendously. For example, Valley County, Idaho, has zones 3–6 throughout the region. Each gardener needs to know their zone and microclimates within their zone.

Counties often host a range of zones. For example, Valley County, Idaho, ranges from zone 3b to 6a (Figure 1). Other mountain regions have multiple zones listed on the USDA map, so you'll need to do additional research to find the most appropriate hardiness zone for your property. Tap into the knowledge of experienced local gardeners, such as Master Gardeners, to learn about specific varieties suited to your local climate. Effective plant selection relies on a variety of characteristics, including quicker maturation rate, drought or cold resistance, and the availability of dwarf varieties. Knowing your USDA growing zone(s) and microclimates will thus help you when you're ready to purchase plants. Purchasing from local nurseries is highly encouraged; locally sourced plants endure less stress because they are already acclimated to the hardiness zone.

If you want to be conservative with plant selection to optimize success, select perennial plants suitable for a zone colder than your designated region. Be aware, however, that a harsh winter might kill plants, even those that withstand the average winter temperatures in your area. Having extra-hardy and healthy plants buffers unpredictable winters, increasing your chance of success. You can experiment with growing more sensitive annuals or perennials once you are familiar with your property's microclimates.

Figure 2. Microclimates play an important role in successfully gardening in short growing seasons. The tomato plants grown against this house tower over the plants in the raised bed at their feet (48 inches versus 12 inches, respectively). Both grew from seed and were planted at the same time.

Figure 3. The tomato plants in the raised bed grew to 12 inches (plant circled in red) and did not have as favorable of a microclimate as the tomatoes planted against the house. It is important to find the microclimates in your yard to optimize the growing potential of your landscape.

Observing Your Microclimates

Aspect and slope play an important role in determining the microclimates on your property. In the Northern Hemisphere, southern aspects optimize sunlight and are usually the warmest microclimates in your yard. An eastern aspect warms plants in the morning while the western aspect keeps them warm into the evening. Meanwhile, the slope of your property determines where cool or warm air might be present. Warm air rises and cool air sinks, so it's common to have pockets of cooler air at the bottom of a slope.

Bodies of water and irrigation, vegetative or man-made windbreaks, buildings, and natural formations such as boulders and rocks impact microclimates. Buildings and large rocks have thermal mass that retain heat, reduce wind, and regulate the temperature fluctuations of high-altitude areas. They also affect the solar resources available on your property. Knowing how to read the landscape will help determine the location of microclimates and assist with developing a plan to garden successfully. Observing where the snow melts earlier in the spring provides a wealth of insight in determining where microclimates are located. Record your observations for several years to understand the growing potential of your backyard garden.

Microclimates in Urban Landscapes

Microclimates are impacted by moisture, temperature, winds, vegetation, and thermal mass. Urban landscapes often have less evapotranspiration (water lost to the atmosphere) due to reduced vegetation and more impervious surfaces that collect heat from the sun. Hard surfaces in urban environments impact the temperature and moisture and can create wind barriers in a microclimate. More urbanized areas slowly release stored energy from hard surfaces into the atmosphere, which can act as an urban buffer to temperature swings (Figures 2 and 3). Observe the built environment of your location. Do you live in an urban or rural setting? Refer to *Introduction to Short-Season Gardening in Idaho* (University of Idaho Extension BUL 857, http://www.extension.uidaho.edu/publishing/pdf/BUL/BUL0857.pdf) for a detailed description of specific short-season areas in Idaho.

Figure 4. A homemade cloche creates a microclimate for basil to grow in a high-altitude garden.

Figure 5. A combination of low-technology season extension and interspersed plantings are utilized in this low tunnel in southeast Idaho.

Low-Technology Season Extension

Cloche (klōsh)

This term is French in origin, meaning "bell." A cloche is a bell-shaped glass or plastic dome that, like a greenhouse, increases the temperature around plants. To make sure that temperatures do not rise too much in their chamber during the day, devise some kind of ventilation. For example, if using jars, remove the tops (Figures 4 and 5).

Water Tubes/Water Wall (Wall O' Water)

Water tubes reduce temperature swings by capturing and retaining solar heat during the day (Figure 6). They create a warmer microclimate with water-filled UV-resistant plastic covers that encircle plants. Water tubes should last several years with proper winter storage. They are commonly used on less hardy plants like tomatoes or peppers. Research has proven that they effectively increase plant growth and reduce frost damage. Refer to *Early Season Extension Using Hotcaps* (University of Nebraska–Lincoln Extension, NebGuide GI745, https://extensionpublications.unl.edu/assets/pdf/g1745.pdf).

Figure 6. Water tubes and raised garden beds help keep the soil and tender plants warmer at a community garden in the Teton mountains.

Mulch

Mulching is the practice of covering the soil with organic or inorganic material. It creates an effect like a blanket covering, increasing soil temperature while buffering plants from the temperature swings of high-altitude environments. Mulch raises soil temperatures at the beginning and end of the growing season and assists in decreasing soil temperature during the peak of summer. It has the added benefit of increasing moisture retention and discouraging competition from weed growth and other pests. It is important to consider advantages and disadvantages when choosing a mulch—these may include material lifespan, cost, and accessibility.

Organic Mulch

There are several organic mulch choices, including straw, bark, newspaper, and cardboard. Germinated weed-free straw is often used by organic farms to reduce weeds and water evaporation. Straw and bark mulch degrade quickly over time, but also help add organic matter back into the soil. Cardboard and newspaper (e.g., “sheet mulching” or “lasagna gardening”) are also effective organic mulches that create weed barriers for pathways. When utilized effectively, sheet mulching also helps prepare soil for a new garden. One disadvantage is that cardboard can limit drainage and may decompose more slowly in our colder Idaho climates, so be sure to apply it to the garden bed well before planting and/or cut holes in the cardboard for transplants so that the plants can more effectively spread roots and uptake soil nutrients.

Inorganic Mulch

Covering your garden with a plastic mulch (polyethylene sheets) can melt snow earlier in the spring and increase soil temperatures for earlier planting and more rapid plant growth throughout the season (Figure 7). The plants grow more quickly due to a “chimney effect” of a higher concentration of carbon dioxide (CO_2) near the base of the plant and plastic opening. As plants grow, the roots emit CO_2 and the leaves oxygen. The released CO_2 accumulates under the plastic and subsequently increases plant growth. Refer to *Plasticulture for Commercial Vegetables* to learn more about this process (NC State Extension Publications, AG-489, https://content.ces.ncsu.edu/plasticulture-for-commercial-vegetables).

If you choose to use a plastic mulch, there are some disadvantages. Clear plastic mulch heats soil more rapidly, but it may increase and promote weed growth in cooler climates if temperatures do not rise enough to solarize the soil. In warmer areas, solarization is an organic weed management tool that kills vegetation and other weeds underneath the plastic. Plastic mulch also locks rainwater away from the soil and contributes to landfill waste. Thus if you use plastic mulch, use compatible irrigation. A drip system can be effective at targeting water to individual plants at openings in the plastic mulch. Learn more by reading *Biodegradable Plastic Mulch and Suitability for Organic Agriculture* (Washington State University Extension Fact Sheet FS103E, https://s3.wp.wsu.edu/uploads/sites/2181/2021/07/Biodegradable-Plastic-Mulch-And-Suitability-for-Sustainable-and-Organic-Agriculture.pdf.

Figure 7. Dark plastic mulch used around everbearing strawberries in Victor, Idaho.

Row Cover/Frost Cloth

Fabric covers can be referred to as floating row covers or frost cloth. Place them over your garden plants to trap heat; this will also allow sunlight and water to pass through the barrier. Different weights (thicknesses) of fabric covers have a different transparency and level of frost protection. Transparency and frost protection may also vary by brand, making comparisons across brands a challenge. Refer to the product instructions for its unique safe-from-frost temperature rating.

In general, lighter fabrics allow more sunlight to penetrate (~85%–90%) and can be left covering the garden throughout the day. A medium-weight fabric cloth will allow ~70% of light to transmit and should be removed during the day, as demonstrated in Figure 8. Frost cloth that lets less than 50% of light through should be used during a frost event. The heavier fabric needs to be removed from your plants as soon as the frost event passes to allow enough sunlight for optimal growth. If summer conditions are warmer than 85°F, remove the lightweight fabric covers during the day. When the forecast predicts a drop to 38°F or lower, it is a good practice to water your plants well and cover them with a frost cloth. Refer to *How to Install a Floating Row Cove*r (Washington State University Extension Fact Sheet FS089E, https://s3.wp.wsu.edu/uploads/sites/2071/2014/04/Install-a-Floating-Row-Cover-FS089E.pdf) for more information.

Figure 8. Early season in Valley County, plants are covered at night to protect them from frost and are uncovered during the day. The extra care provides them optimal sunlight and thus the best conditions for growth. Row cover is used frequently and is a low-cost tool that aids in season extension and pest control.

Container Gardening

Utilizing containers can be an affordable and simple option for growing tender plants. When weather events threaten your plants, depending on the size of your container, you may be able to relocate them indoors or to a warmer microclimate. By having a smaller surface area, the soil in the container heats up more easily. You can also control the soil pH, texture, and structure of the soil in your container to optimize plant growth. Dark containers heat up quickly but may also dry out more easily in arid Idaho climates. Choose a container size that is large and deep enough for your selected plant. When in doubt, choose larger ones. Since soil in containers can easily dry out and nutrients can be more quickly depleted, you will need to water and fertilize your container plants more frequently than in more traditional garden spaces.

Medium-Technology Season Extension

Raised Beds Gardening

Designing your garden to optimize the absorption of heat gives you a head start on your gardening season. Raised beds will warm the soil earlier in the spring and keep it warmer in the fall (Figure 9). It can extend your season by several weeks. Raised beds can reduce weed growth and allow you to provide the ideal soil pH, texture, fertility, and structure using a 1:1 mix of compost and topsoil. Some gardeners choose to add vermiculite to hold water, nutrients, and air in the soil. Raised beds provide excellent drainage for your garden and are a great option for areas that have poor soil characteristics such as compaction, rocky surfaces, and/or weeds.

Figure 9. Raised beds can be used in conjunction with other season extension techniques.

Cover the bottom of your raised bed with hardware cloth to limit burrowing mammals (voles, gophers, etc.). Adequate depth is an important factor to consider when building raised beds. Determine the root depth of desired garden plants and whether or not the barrier on the bottom of the bed (hardware cloth or weed fabric) will be permeable to root growth. Use cedar, redwood, or an untreated hardwood for long-lasting beds. Raised beds, although more expensive because of material costs, help make gardening easier and less time intensive. Refer to *Raised Bed Gardening* (Oregon State University Extension publication, FS 270, https://catalog.extension.oregonstate.edu/fs270/html) for a detailed description of raised-bed gardening and *Homemade Potting Media* (PennState Extension, https://extension.psu.edu/homemade-potting-media) for directions on creating a soil mixture for your raised beds.

Cold Frames

Cold frames are an easy and often more affordable season extension tool. Cold frames are mini-greenhouse structures (Figure 10) that are used for seed starts or to harden plants in the early spring. Hardening plants is the process of acquainting the seed starts to the outdoor environment and is critical for transplanting success. Cold frames are opened during the day and closed at night to protect young seedlings from early spring temperature swings.

Figure 10. Old windows and reused lumber were used to construct these cold frames at a small farm in Victor, Idaho.

Hotbeds

Hotbed gardening entails adding an additional heat source, such as compost or electric heating cables, to the soil. These methods are most commonly used inside a greenhouse or cold frame for starting and growing young seedlings that will eventually be transferred to the garden.

Traditional Manure Hotbed Garden

Manure compost was traditionally used for hotbed gardening. However, there are important considerations when using this method to reduce the risk of adding food pathogens to your vegetables. The direct application of raw manure to a garden as a top dressing is not recommended. The harvest times after an application of raw manure are 90–120 days, according to the USDA Agricultural Marketing Service National Organic Program.

In short growing seasons, allowing enough time between the application of raw manure and harvest is a challenge (some Idaho areas have growing seasons less than 90 days). Using manure as a hotbed creates less predictable temperatures and eventually the pile will cool, leaving your seedings vulnerable to temperature fluxuations. While the use of manure for hotbed gardening is possible, it requires a hands-on approach. More maintenance and monitoring are needed to ensure your plants will flourish and the food will be safe for consumption. Refer to *Guidelines for Using Manure on Vegetable Gardens* (University of Maine Cooperative Extension Bulletin #2510, https://extension.umaine.edu/publications/2510e/) for a detailed description of using fresh manure in your garden hotbed. Understanding the source of your fresh manure is another consideration. It is important to source manure that is herbicide-free, since some applications of herbicide are persistent in compost. Refer to *Herbicide Carryover in Hay, Manure, Compost, and Grass Clippings* (NC Cooperative Extension, https://lee.ces.ncsu.edu/2016/03/herbicide-carryover-in-hay-manure-compost-and-grass-clippings/).

Modern Hotbed Garden

Using electric cables can be a cost-efficient method that provides even heat with less maintenance and contamination risk than traditional manure hotbeds. A prefabricated electric hotbed can be purchased or constructed from readily available materials.

Refer to “Two Designs for Low Cost ‘Hot Beds’ for Small Scale Production” (PennState Extension, https://extension.psu.edu/two-designs-for-low-cost-hot-beds-for-small-scale-production) for a detailed description of hotbed (electric and organic) construction methods.

Hoop Houses (Low and High Tunnels)

The terms *hoop house*, *low tunnel*, *high tunnel*, and *greenhouse* can often be used interchangeably. This publication will delineate these structures based on their size, cost, and permanence. Low and high tunnels are designated as medium-tech solutions for season extension because they don’t require a foundation. Greenhouses qualify more as a high-tech solution, since they are more permanent structures (see High-Technology Season Extension).

Figure 11. Low tunnel directly on the ground. Courtesy of the USDA.

Low Tunnel

A low tunnel is achieved by placing covered ribbing structures over your garden. Low tunnels can be established directly in the ground (Figure 11) or built as an addition on top of a raised bed (Figures 9 and 12). Low-tunnel structures are usually built 3–4 feet off the ground and are not tall enough for a user to walk under. These structures are affordable and a highly effective way to extend your growing season. Refer to *How to Build Your Own Raised-Bed Cloche* (Oregon State Extension Service Publication EC 1627-E, https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/ec1627.pdf) for a detailed description of a low tunnel on a raised-bed (medium-tech version of a cloche) construction.

High Tunnel

High-tunnel structures are polyethelene-, plastic-, or fabric-covered hoop structures for season extension and winter sowing. They can be constructed at various sizes for plants to be grown directly in the ground or in raised beds. They are often used by small acreage farmers to grow a market garden. Most large high tunnels are not practical for home gardeners. They are usually more permanent structures on the landscape.

High tunnels for the home gardener are smaller in size, typically temporary structures, and are constructed similarly to low tunnels. The high-tunnel ribbing is usually covered and secured on a 2’ × 6’ foundation (Figure 13). Like a greenhouse, high-tunnel structures need ventilation. Many designs allow air flow at the

Figure 12. An Idaho Master Gardener utilized a variety of season extension techniques to build this low tunnel in Valley County, Idaho.

Figure 13. Hog-panel high-tunnel greenhouse, High Country Orchards, Idaho County, ID. Courtesy of Casie Carnes, University of Idaho Extension, Valley County.

Figure 14. This high tunnel in Victor, Idaho, is a high-technology season extension tool that offers a lot of space suitable for market gardens.

Figure 15. A homemade greenhouse that optimizes southern exposure and incorporates creative season extension techniques in Victor, Idaho.

base of the ribbing and many gardeners open and close doors and windows to create it. Unlike greenhouses, tunnels are unheated and have no fans, lights, or other electrical devices to condition the air. See Figure 13 for an inexpensive DIY high tunnel and Figure 14 for a high tunnel suitable for small-scale production.

If you live in areas that endure snow loads, you'll likely need to remove the polyethelene plastic during the winter months. If you don't remove the covering, make sure to have a plan for snow removal from the top and sides of the structure. For example, installing a gothic arch to a hoop house design allows the structure to more easily shed snow. Refer to *High-Tunnel Construction for the Mississippi Gardener* (Mississippi State University Extension Publication Number P2970, http://extension.msstate.edu/publications/high-tunnel-construction-for-the-mississippi-gardener) for a detailed description of a low-cost high tunnel for the backyard gardener.

High-Technology Season Extension

Overview of Greenhouse Structures

Greenhouses do not come in one size or shape. They can be custom built or constructed from a prefabricated kit. Before you establish this infrastructure, think about the orientation of the greenhouse to minimize wind damage and optimize sun exposure based on your plant's needs. South-facing greenhouses (ends pointing east and west) are optimal to increase sunlight exposure. If you plan on growing early in the spring or late into the fall, an additional heat source may be needed to provide suitable growing temperatures. Gas, electric, or wood heating options will increase costs but might be necessary in order to accomplish your gardening goals. See *Greenhouses: Heating, Cooling, and Ventilation* (University of Georgia Extension Bulletin 792, https://extension.uga.edu/publications/detail.html?number=B792&title=Greenhouses:%20Heating,%20%20Cooling%20and%20Ventilation).

Greenhouse Design

Greenhouses are permanent structures that are usually placed on a foundation and have metal or wooden frames holding glass or plastic panels. The structures need to withstand high-moisture environments and wind, snow load, and temperature extremes. The components of a greenhouse include glazing (windows or polyethylene sheets), ventilation, drainage, and access for the gardener, platforms or raised beds for growing, and any desired garden equipment (Figure 15).

When constructing a greenhouse, there are several design features to consider. Can you increase your production potential by adding an additional heat source? Do you plan to grow cold-hardy vegetables throughout the winter months or warm-loving tomatoes in the heat of the summer? Would you like to have a passive solar greenhouse with less productivity and no additional heating expense? Before you invest time, money, and energy into a greenhouse, it is important to have a plan.

Design features determine when your greenhouse is productive during the year. Understanding design principles of season extension infrastructure will help you modify and customize your greenhouse to your local climate. Refer to *Hobby Greenhouses* (University of Georgia Bulletin 910, http://extension.uga.edu/publications/detail.html?number=B910&title=Hobby%20) or *Hobby Greenhouses in Tennessee* (Agricultural Extension Services, University of Tennessee PB1068, https://www.shelbycountytn.gov/DocumentCenter/View/1129/Hobby-Greenhouses-in-Tennessee) for a general overview of hobby greenhouse design. Downloadable blueprint designs are available at Colorado State University Extension Blueprints—Greenhouse Plans (https://extension.colostate.edu/publications-2/blueprints-and-housingequipment-plans/blueprints-greenhouse-plans/).

Freestanding or Attached

Freestanding greenhouses usually cost more to construct and require additional heat (Figure 16). Attached greenhouses are built against an existing structure and tend to be more stable in high winds and require less heat (Figure 17).

Passive Solar Greenhouse

Passive solar greenhouses optimize the solar energy gained from the sun through careful design considerations. They are designed to be productive through the cold winter months and often become too warm in the summer for plant growth. The structures tend to incorporate a solid, insulated north-facing wall with a south-facing glazed surface. The slope of the glazed surface needs to optimize low-light conditions in the winter. The angle of incidence determines the greenhouse's slope of glazing. If you are in a northern latitude, the slope (angle of incidence) will be steep. This angle optimizes the amount of sunlight available when the sun is low on the horizon in the winter. It equally decreases sun exposure when the sun is overhead in the summer. Large rock surfaces or water tanks are used in passive solar designs for thermal mass and heat retention. Refer to *Passive Solar Greenhouse* (College of Agriculture, Food and Natural Resources, University of Missouri, Southwest Research Center, https://southwest.missouri.edu/passive-solar-greenhouse/) for information about this greenhouse design style.

Figure 16. Master Gardener freestanding greenhouse, Valley County, ID.

Figure 17. Master Gardener attached greenhouse, Valley County, ID.

Passive solar greenhouses are popular in Minnesota (Figures 18 and 19). If you would like to grow through the winter months and reduce associated heat costs, consider greenhouses that use passive solar design. Refer to “What Is a Deep Winter Greenhouse” (University of Minnesota Extension, https://extension.umn.edu/growing-systems/deep-winter-greenhouses) for more information on the greenhouse design.

Stegner Farm in Valley County, Idaho, has utilized a passive solar greenhouse design to enhance the growth of warm-loving vegetables in the summer and to provide cool-weather crops throughout the winter (Figures 20 and 21). In Idaho and other cold regions, a growing community of gardeners are experimenting with year-round production. There are opportunities to connect with this community through social media, particularly with the Deep Winter Producers Association on Facebook (https://www.facebook.com/DeepWinterProducers/).

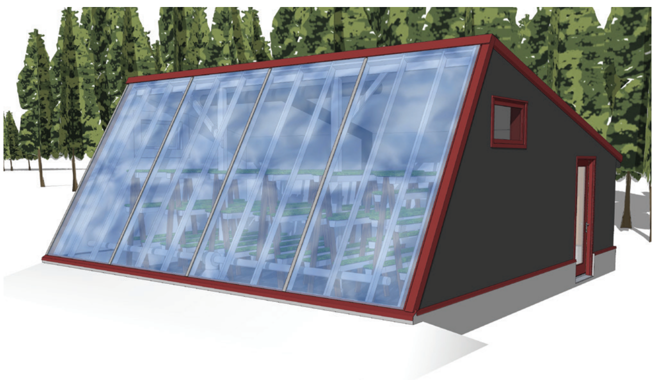

Figure 18. Minnesota deep winter greenhouse with passive solar design. Courtesy of Daniel Handeen, University of Minnesota, College of Design.

Figure 19. The *Cold-Climate Greenhouse Resource* is a useful guide that demonstates the importance of optimizing microclimates on your property. Courtesy of Greg Schweser, University of Minnesota, Agronomy and Plant Genetics.

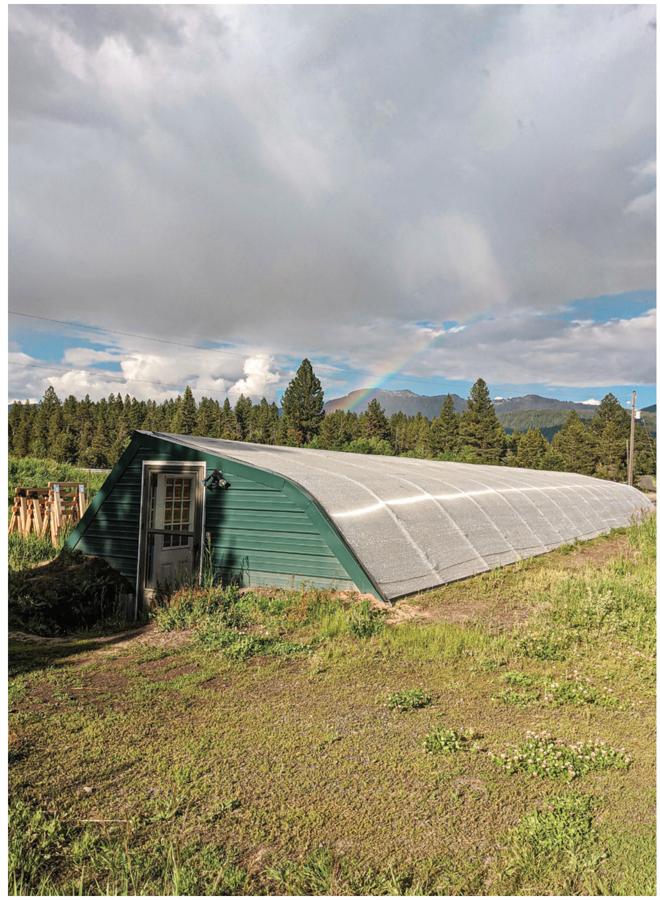

Figure 20. Geothermal greenhouse at Stegner Farm in Valley County, Idaho.

Figure 21. Inside view of passive solar geothermal greenhouse, Stegner Farm, Valley County, Idaho.

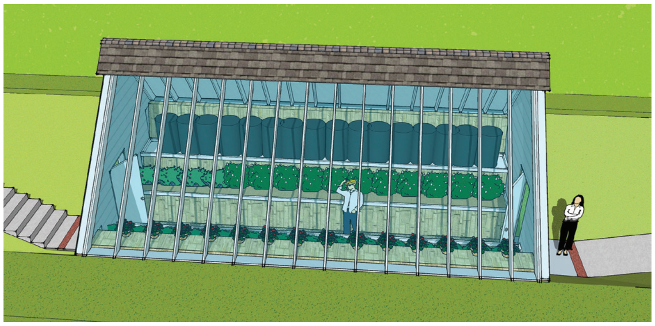

Figure 22. A walipini can have several designs and is similar to the south-facing geothermal design featured in Figure 19. Courtesy of Gary Austin, University of Idaho, Landscape Architecture program.

Walipini (Pit Greenhouse)

Originating from Bolivia, *walipini* means a "place of warmth." It refers to an underground greenhouse structure (demonstrated in Figure 22) whose design buffers extreme temperature swings and optimizes the even temperature of the ground throughout the year (approximately 55°F year-round). When paired with south-facing glazing, a walipini captures passive solar radiation during the winter months to create excellent growing conditions for cold-hardy, frost-tolerant crops. Some gardeners report success growing tender crops such as tomatoes and cucumbers; however, results can vary. Considerations need to be made for drainage and snow removal during the winter as well as radon levels in some areas of the state. There is limited research-based information on this method.

Conclusion

Season extension techniques vary from low-technology to high-technology solutions. When gardening in a short-season, high-altitude environment, one or more of these techniques will increase your garden's success. Observe your property before planting to identify microclimates. Utilize warmer areas on your property and season extension techniques to grow more frost-sensitive plants. Research and develop the season extension infrastructure needed to warm your soil and enjoy a longer harvest season. Consider establishing a plan and take incremental steps each season to achieve your garden goals.

Gardening is dependent on the weather, a variable which changes from season to season. Recommendations for achieving gardening success in colder Idaho climates include experimenting with the following cultural practices and physical infrastructure season extension methods:

- Implementation of appropriate season extension low-to-high-technology infrastructure solutions that are compatible with your goals and budget
- Understanding your typical growing season (USDA Plant Hardiness Zone, frost dates, average soil temperature and precipitation)
- Choosing plant varieties that are better suited for short growing seasons (hardy or semihardy varieties)
- Providing the best possible growing conditions for your plants (start seeds indoors, harden off healthy transplants, improve soil health, utilize appropriate irrigation, etc.)
- Optimizing microclimates (solar and water resources, aspect, slope, proximity to heat sinks)
- Watching the weather and planning for adverse weather events

There is no precise recipe for success in gardening because environmental and biological variables are dynamic and change annually. Be observant and keep good records of your garden successes and failures. Educated choices and experience will sharpen your garden skills so you can join the ranks of persistent and dedicated gardeners growing in adverse, high-altitude conditions.

Further Reading

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Figure 1: Idaho USDA Plant Hardiness Zone Map, 2012. Agricultural Research Service, U.S. Department of Agriculture. Accessed from https://planthardiness.ars.usda.gov/. **Melissa Hamilton** provided the photographs for Figures 2–4, 8, 12, 16, 17, 20, and 21 and **Jen Werlin** provided those for Figures 5–7, 9, 10, 14, and 15.

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