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XII – Choosing the Best Site and Orientation for a Passive Solar Greenhouse

The success of a passive solar greenhouse begins long before construction - it starts with the determination of a good site. A beautifully designed SunCatcher will not perform as intended if placed in the wrong location. In this chapter, we outline how to evaluate potential sites, ensure adequate solar access, and account for local conditions like drainage, wind, trees, and nearby structures. With careful planning and proper orientation, your greenhouse can take full advantage of the sun's energy and natural surroundings.

Practical Considerations

When choosing a site, the location of related spaces (i.e., garden, tool shed, sidewalk, house, barn) should be taken into consideration. Will it be convenient to access the greenhouse from the house, barn, or garden? Can you bring in building materials easily? Is there enough room for walkways and equipment like wheelbarrows? Positioning the greenhouse near related uses, such as gardens or tool sheds, saves time and effort in daily use.



Figure XII.1. SunCatcher located next to the fenced garden and across a small courtyard from the main house.

Solar Access

The single most important factor is good solar access. A PSG requires uninterrupted sunlight, especially in winter when days are short and the sun is low in the sky. A great way to start is to explore potential sites during the winter months before you begin to build, one to two weeks on either side of the winter solstice - between early December and mid-January. Because the sun is lowest in the sky during this period, shadows are longest. This will be a great opportunity to observe and photograph shading from nearby trees, buildings, or hills. From these observations, select the best site with a clear *true southern* exposure (*not* magnetic south) to orient your greenhouse correctly. A neat way to determine true south is the “Local Solar Noon” method explained in the text box.

Local solar noon is the time of day when the sun is due south at a particular location on Winter or Summer Solstice. In the Northern Hemisphere, the sun is always in the southern portion of the sky as it makes its journey east to west every day. While the sun rises and sets at different times each day (depending on the date, the location and daylight-saving time), the sun is due south at that particular location at exactly halfway between sunrise and sunset on the two solstices. At local solar noon on the solstices, the shadow of objects that are perfectly straight and vertical (tool handles, a weight hanging on a string, etc.) points due north and can help you properly orient your SunCatcher.

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The glazing of the passive solar greenhouse needs to be clear of any obstacles causing shade in the cone between 45^0 to the east and west of the structure (Figure XII.2). Evergreen trees within the cone are particularly problematic, as they block winter sun. As a rule of thumb, any obstruction should be at least as far away from the greenhouse as its height. For example, a 25-foot tree, house or barn should be at least 25 feet south of the structure. Keep in mind that trees grow, so base your calculations on average *mature size* of species (Table XII.1) rather then their present height. Figure XII.3 illustrates how the shade cone of a 50-foot evergreen differs from that of a deciduous tree across the seasons. Deciduous trees can sometimes be an asset: their bare branches let in sunlight in winter but provide shade in summer to reduce overheating.



Figure XII.2. Area to the south to be kept free of any obstructions (left). In the example of the Laurel Ridge SunCatcher (right) you can see the site has very good solar access.

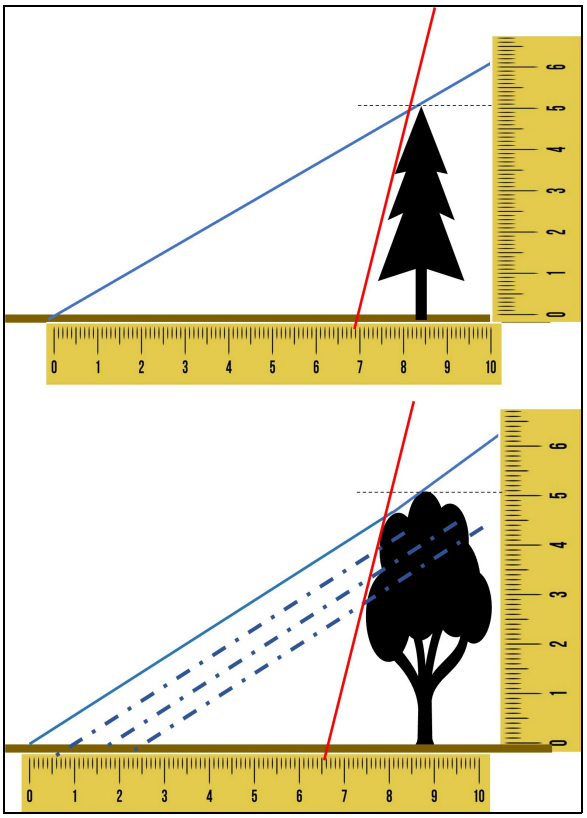


Figure XII.3 In Boone, NC (latitude 36^0 N), the angle of the sun to the horizon on summer Solstice is 77.5^0 (red line), and 30.5^0 (blue line) on winter Solstice. The shade thrown by a 50 ft tall evergreen tree in summer is about 12 ft long, but 87 ft in winter (measured from the base of the tree). For a deciduous tree of the same height, the shade cone in summer will be slightly larger due to the wider crown (22 ft), whereas in the winter, it will throw dabbled shade depending on branch pattern and density over a length of 88 ft.

Table XII.1. Average mature height of small, medium and large trees at maturity, giving examples of each.

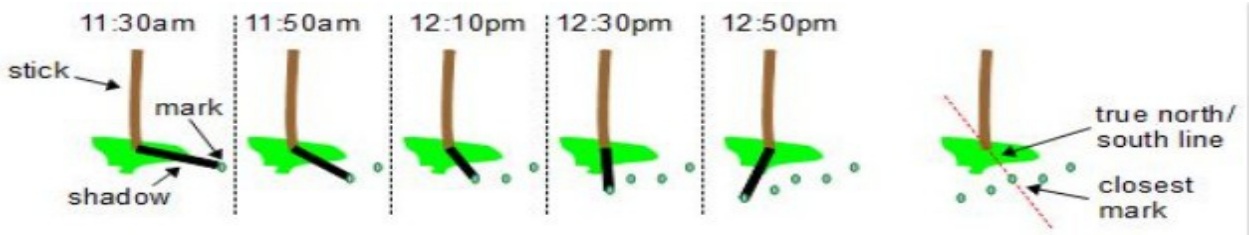
Size class	Average mature height	Examples of species
small	≤ 33 ft (10m)	Japanese tree lilac; eastern redbud; flowering dogwood; service berry; dwarf and semi-dwarf apples; hazelnuts.
medium	33-50 ft (10-15m)	Hophornbeam; crap apple; golden rain tree; standard apple and pear.
tall	50-100 ft (15 -30m)	Oaks; beech; sycamore; basswood; maples; sweetgum; eastern white pine; eastern juniper; hemlock; spruce.

Based on the presence of trees or other obstacles, adjust the location of your planned SunCatcher as needed to maximize solar access.

An easy way to calculate solar angles to the horizon at the solstices:
- For the winter solstice: 90 - (your latitude + 23.5)
- For the summer solstice: 90 - (your latitude - 23.5)

Using Tools and Apps

An easy, low-cost method is using a perfectly vertical stick in the ground and measuring the shortest shadow around solar noon on the solstices, as shown in the diagram below. In the example shown, solar noon is 12:10pm.



The shortest shadow method.

Source: https://rimstar.org/renewnrg/finding_true_south_pole.htm

There are, however, several modern smart phone tools that make site determination easier:
- Sun Seeker and Sun Surveyor apps help visualize sun paths and shadows (Figure XII.4).
- Lumo Sun and Moon Tracker app adds detailed solar timing.
- Online calculators can adjust compass readings for magnetic declination in your area.
- Websites like Enkonn Solar and Solaripedia explain methods for finding true south.

Microclimate Factor and Site Conditions

Geography creates microclimates that affect temperature and air movement. South-facing slopes receive more sun and tend to be warmer than adjacent flat terrain. North-facing slopes are cooler as they receive no direct sunlight. Mountain tops (more exposed to wind plus lower temperature

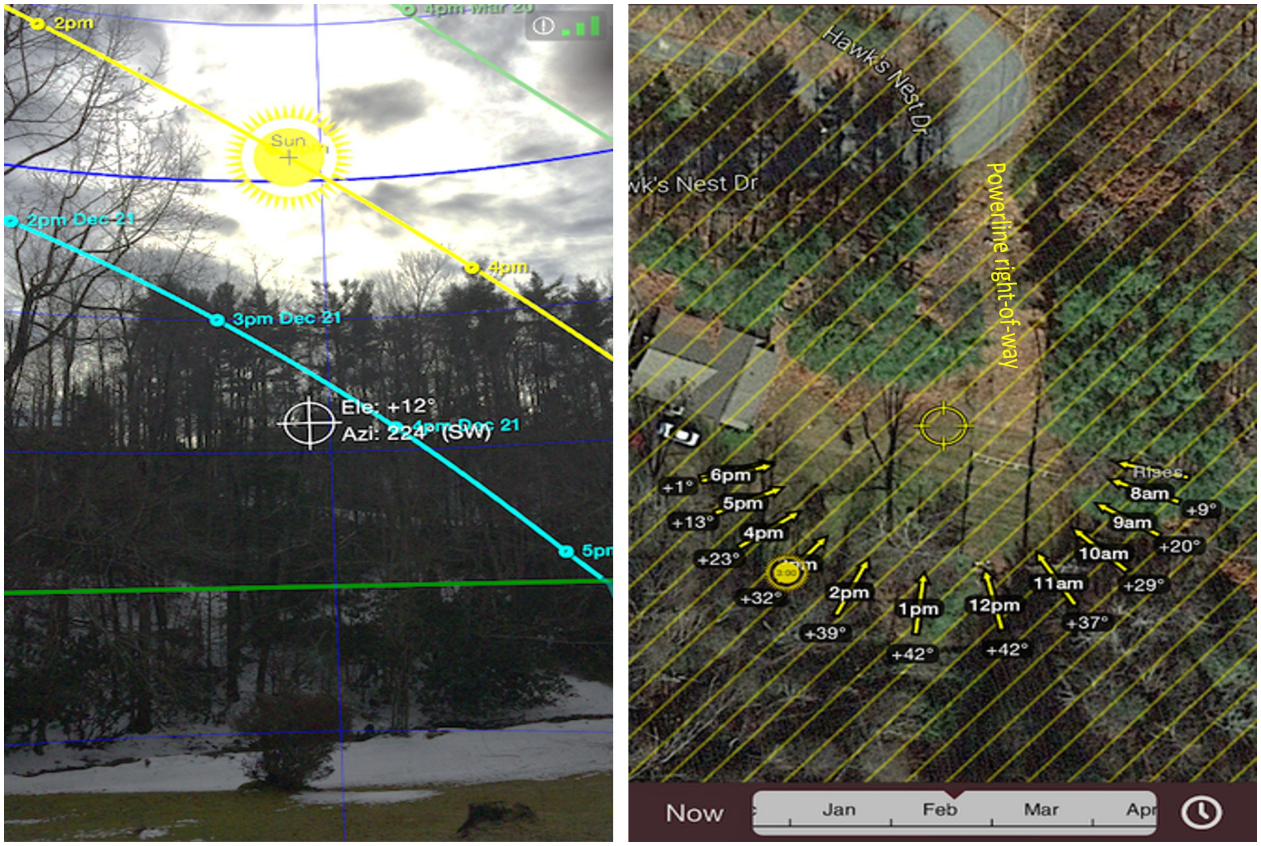


Figure XII.4. Results of SunSeeker app scouting for a potential site for the Hawk's Nest SunCatcher PSG. In the left picture, the blue line represents the sun's track during the winter; yellow line spring and fall, and the green line the summer sun track. The right picture shows the position of the sun during a day in mid-February (assessed at 4pm).

based on elevation) and valleys are cooler (as cold air drains downhill settling in valleys at night, pushing warmer air mid-slope). Large bodies of water moderate nearby temperatures, releasing heat in winter and cooling surroundings in summer. In urban areas, paved surfaces and buildings create "heat islands," raising temperatures compared to the surrounding countryside.

Good drainage is critical to ensure your foundation remains dry and stable. Avoid low-lying sites where water collects or where snow lingers late into spring.

Staking Out the Site

Once you have chosen a potential site, stake it out. Begin by marking the south wall, oriented east-west and perpendicular to your solar noon line. Then lay out the east and west walls running north from the corners, and finally mark the north wall parallel to the south side. With the footprint marked, spend time observing where shadows fall between 9 am and 3 pm (local solar time) in the winter months. Photographs taken every hour on clear days are especially useful for reviewing conditions. If any shadows fall within the footprint, move it slightly east or west to avoid these shadows. Figures XII.4 and XII.5 show the process of determining the best sites for the Parkway School and Hawk's Nest SunCatchers, respectively. The website shademap.app may be useful to find shade patterns for your specific location throughout the year and day.



Figure XII.4. Future Parkway school SunCatcher site is marked with a yellow ribbon at local solar noon (left) and at 3:00pm local solar time (right). The arrow points to the location of the southwest corner of the future PSG. The initial desired site was moved slightly east to avoid shading before 3 pm during the winter period.



Figure XII.5. Different views of the staked out site for the future Hawk's Nest SunCatcher.

Orienting the greenhouse

After determining the best site for your PSG, the orientation of the PSG is critical for optimizing the amount of sunlight and when during the day it is available.

As we touched on in chapter IV, many greenhouse operators do not pay attention to the orientation of a greenhouse. In most research and extension publications the recommendation is to orient a greenhouse with the long axis pointing roughly North-South so that the east and west facing sides of the greenhouse will receive about the same amount of sunlight during the day. This is good if the primary purpose for the greenhouse is season extension. However, this orientation limits the amount of sunlight entering the structure during the winter months, making crop production during this period dependent on fossil energy for heating and lighting (Figure XII.6).

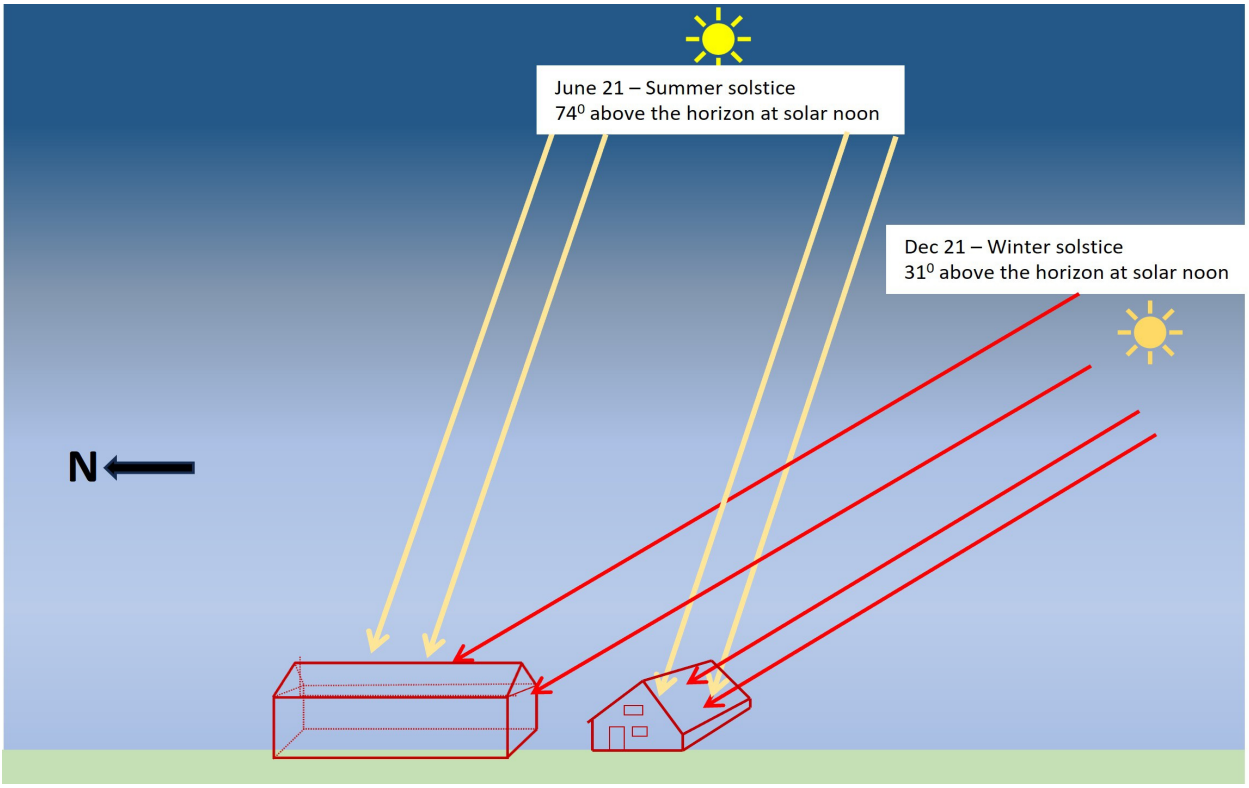


Figure XII.6. The orientation of a SunCatcher PSG (right) and the angle of its glazing allows it to capture most of the low angle winter sun, while reflecting most of the high angle summer sun. A N-S oriented conventional greenhouse or high tunnel (left) will overheat in summer, while in winter the sun hits the narrow south end wall. With the low angle of the winter sun, most of the light will reflect off that end wall as well as the roof glazing.

A Passive Solar Greenhouse intended for year-round production should, however, be oriented with the long axis roughly in an East-West direction. This orientation works with the sun's low angle during the winter months by having the glazing face south while the north wall and roof are well insulated. It is estimated that changing the long axis of a conventional greenhouse from a north-south to an east-west axis orientation requires (on average) 25% less energy to heat during the winter period (McCullagh:13). However, research by Papadakis et al. (1998) and Soriano et

al. (2004a, b) found that an E-W orientation generated light transmission differences between the growing zones of the greenhouse: the west side will receive more light in the (still cool) morning hours, whereas the east side will receive more light in the (already warmer) afternoon. These transmission differences can be mitigated with greenhouses of higher roof slopes; narrower spans (width) to reduce the shade thrown by the east and west walls in the morning and evening, respectively; and the utilization of light-diffusing covering materials (Castilla, 2007).

The earth turns on its axis 360º every 24 hours; therefore, it turns 15º on its axis in one hour (four minutes per degree) as the sun appears to move from east to west. The coldest time of the day during the winter is about 30 minutes after sunrise as the air and soil surface continue to cool until the sun is high enough in the sky to start warming them. So, in order to capture more of the early sunlight to warm up the greenhouse on a winter morning to get your plants growing, the optimum orientation, when you have clear solar access, is 15º east of south. During the winter period, the south facing angled glazing is set up to capture direct sunlight light for as much as six hours per day. If the SunCatcher's glazing is facing due south, sunlight entering will be most direct from about 9 am-3 pm local solar time. A 15º turn to the east allows the sun to start heating the SunCatcher about an hour earlier than glazing facing due south (Figure XII.7). What is given up is the extra heat that would be gained from 2pm-3pm, but the extra heat may not be needed and as useful then. However, you can orient your passive solar greenhouse's long glazing side anywhere within 30° east to 30° west of due south provided you have clear solar access. However, the latter may overheat the greenhouse.

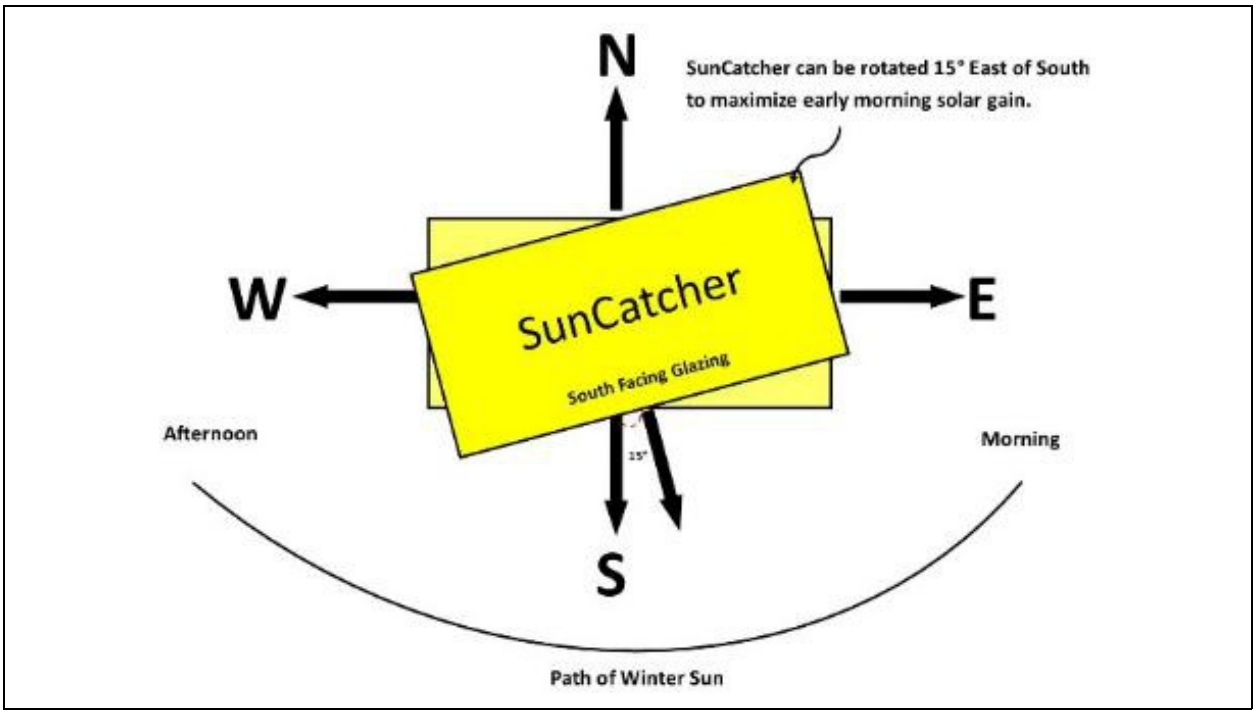


Figure XII.7 Optimum orientation is 15º east of due south.

In order for a greenhouse to have enough light throughout the year for adequate plant growth, it needs some sunlight from the east and/or west sides as well – south light alone is not enough. Without some lighting from the east and west sides, plants will be missing the beneficial effect of

longer daylight hours and blossom development will suffer. Clear or partly clear eastern walls are preferable to clear western ones because the eastern glazing allows the greenhouse to warm up earlier in the morning after a cold winter night; the western sun in summer, combined with higher afternoon temperatures may contribute to overheating problems of the greenhouse (Yanda & Fisher p. 32, East & West walls).



Figure XII.8. Morning sun on the west wall of the Hawk's Nest SunCatcher, February 22, 2025. No thermal mass was in place at that date (barrels painted but not filled).

Six hours of direct sunlight in the winter may, however, not be sufficient for good plant growth even though greenhouse temperature may be good. Additional lighting may be needed as plants require a minimum of 12-14 hours of sunlight a day for good production. There are several options available for artificial lighting, and, depending on the type you choose (LED, HPS, MH, HID or any other[1]), they all generate heat. How much is easy to calculate by taking the total amount of watts used (i.e., watts used by the bulb plus watts used by the ballast) and multiply it by 3.41 to get the total British thermal units (BTUs) produced per hour. BTUs are a standard heat measurement within the HVAC industry and one BTU is roughly equal to the heat produced by one 4-inch long match.[2] Therefore, a 1,000W HPS grow light (1,060W with ballast loss) generates 3,617 BTU of heat per hour. A 400W LED producing an equivalent number of lumens (440W with driver loss) generates approximately 1,500 BTU of heat per hour. A good website explaining different types of grow lights and their pros and cons for different growing operations is https://growace.com/blogs/learning-center/hid-vs-led-grow-lights. Note that flowering and fruiting plants need different kind of light than leafy greens, which also changes based on the crop's life stage.

The color of the interior walls, rafters and ceiling also plays a role in the amount of light available to plants. We will discuss this in more detail in Chapter XV.

Further Reading

Mazria, E. The Passive Solar Energy Book, pp. 312-325.
Clegg & Watkins. The Complete Greenhouse Book, pp. 19-20.
Yanda & Fisher. The Food and Heat Producing Solar Greenhouse.
Carter, V. Climate and Site Considerations for Passive Design.

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[1] HID=high intensity discharge; HPS=high pressure sodium; MH=metal halide; CMH=ceramic metal halide; LED=light emitting diode.

[2] Adapted from https://chilledgrowlights.com/education/do-led-grow-lights-produce-heat