Creating a Compost-Heated Greenhouse

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In the City!

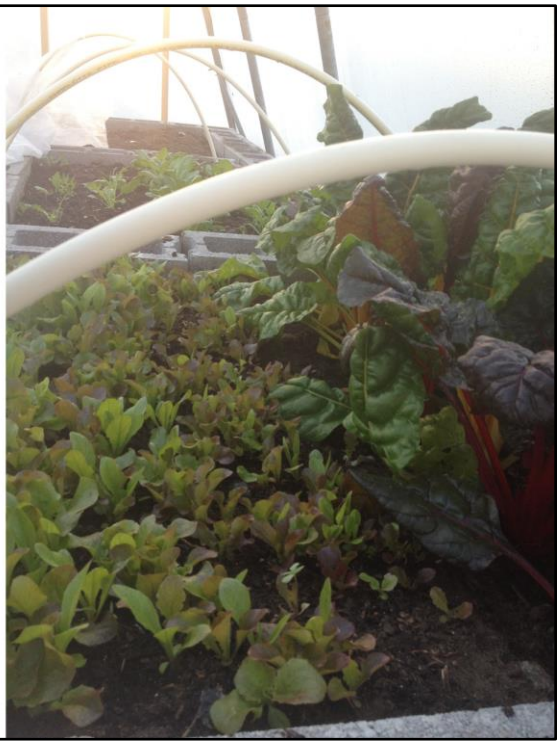
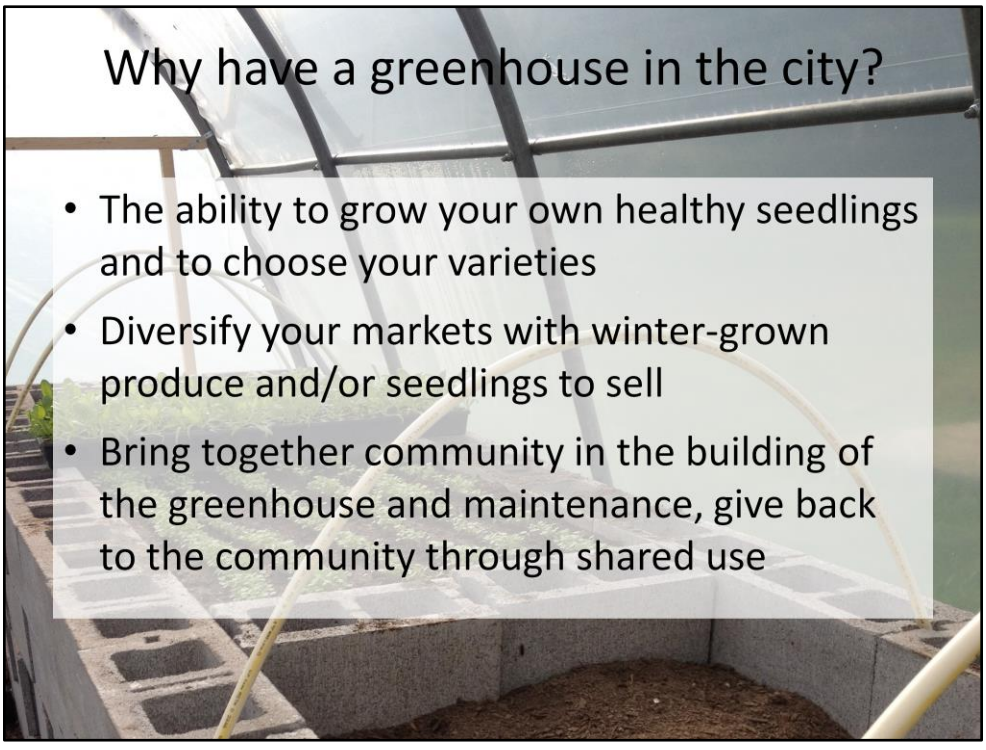


Photo shows crops being grown in the greenhouse in mid-December: Chard and lettuce in Bay 3 in the foreground, spinach in Bay 2 in the background


Why have a greenhouse in the city?
• The ability to grow your own healthy seedlings and to choose your varieties
• Diversify your markets with winter-grown produce and/or seedlings to sell
• Bring together community in the building of the greenhouse and maintenance, give back to the community through shared use


Why have a *compost-heated* greenhouse in the city?
• Remove materials from the waste stream
• Be able to heat your greenhouse without connecting to a power source or fossil fuels
• Create usable, nutritious compost
• Make friends with your local coffee houses!

Photo shows uncovered greenhouse in its new location inside a fenced area. You can see the design of the end walls with placement of the window for ventilation and door at the other end.

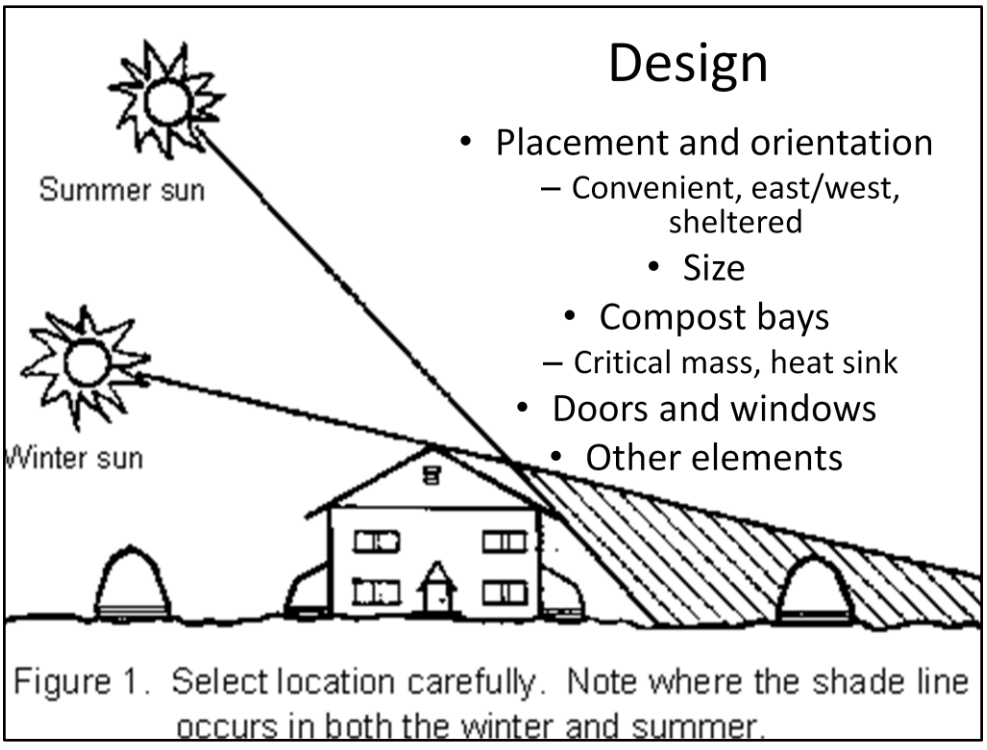


Figure 1. Select location carefully. Note where the shade line occurs in both the winter and summer.

When designing a greenhouse there are several things to consider and you have to compromise the optimum situation with your reality. Ideally, the greenhouse will have an east-west orientation for maximum heat gain or a north-south orientation for even sun and heat distribution. The area should have full sun and be in a sheltered location.

When designing the compost bays, remember that they must hold enough compost materials to stimulate an active compost, about a cubic yard for each bay worked for me. To help retain the solar and compost heat, try to incorporate good heat-sinks into your bays.

Don't forget to have good placement of your door and vents to allow good air circulation. Include fans and blowers to ensure insulation as well as air flow; sometimes a greenhouse's main problem is that it gets too hot!

Our 12'x25' greenhouse was oriented north-south for the project, but is currently oriented east-west. There is a standard sized entry door on one end wall and a 2'x3' awning window on the opposite end. A solar fan facing the window is used for ventilation on sunny days. The compost bays are made up of un-cemented cinderblocks, three bays to a side. Each bay holds a little less than a cubic yard of compost.

Building Materials

- Should you get a greenhouse kit?
- Mastering the “found materials” greenhouse
- What kind of covering
- Materials for compost bays
- Landscaping fabric is your friend
- How will you hold it down?

We did not use a greenhouse kit because we were able to put together other elements to create a small, garden sized, greenhouse. Old frames can often be found on “the side of the road,” through other farming connections or on the internet. Most exterior doors and windows can be repurposed and do not need to be in perfect condition. Be on the lookout for cinderblocks and other materials you can use for building compost bays.

We used a plastic film to cover the greenhouse, but in hindsight flexible polycarbonate would have been a better choice even though it is more expensive as it is harder to break and could potentially last a lot longer. Underneath the greenhouse we used heavy duty landscaping fabric, or ground cloth to keep weeds from coming up.

We used ground screws to hold down the greenhouse when it was on dirt. Now that it is located on a paved area, we may be anchoring it with concrete anchors.

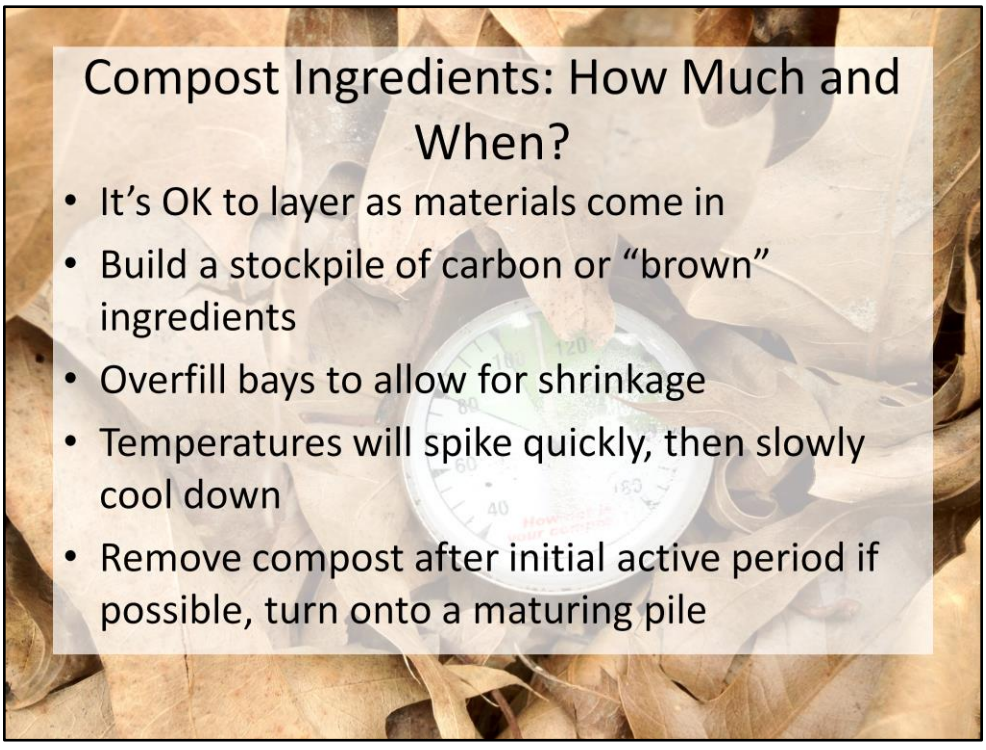
Compost Ingredients

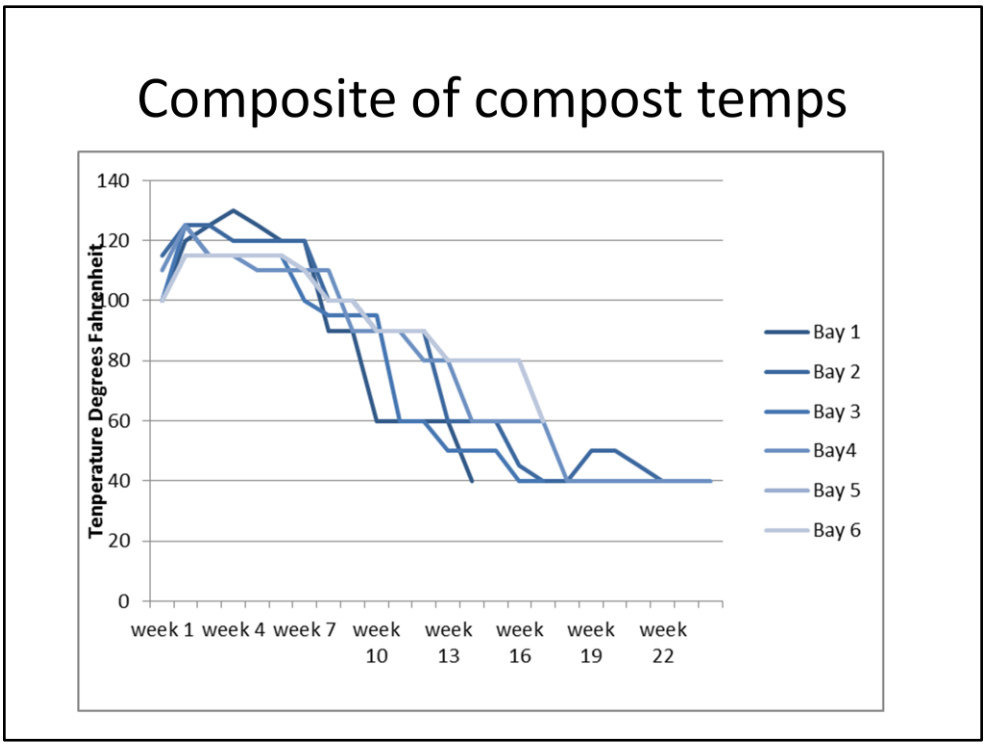
- Getting the right C:N ratio
- Finding free and readily available materials
- Keeping smells down
- Transportation and handling
- Priming the materials, aeration

I've found that getting the right C:N ratio is more a matter of trial and error than calculation, as estimates for the C:N ratio of each ingredient often has a wide range and the way it breaks down depends on many factors, including particle size and moisture content. A 2:1 ratio of used coffee grounds to dry "brown" material worked well for me, but each farmer should take good notes of how their pile is composting because their materials may be slightly different. Each ingredient was layered into the compost bay, in effect mixing them. Because we are using a relatively high C:N ratio, smells should be kept to a minimum, but if using animal manures or ingredients with a low C:N ratio, be sure to thoroughly mix them with a "brown" ingredient and keep the pile well aerated to encourage aerobic decomposition.

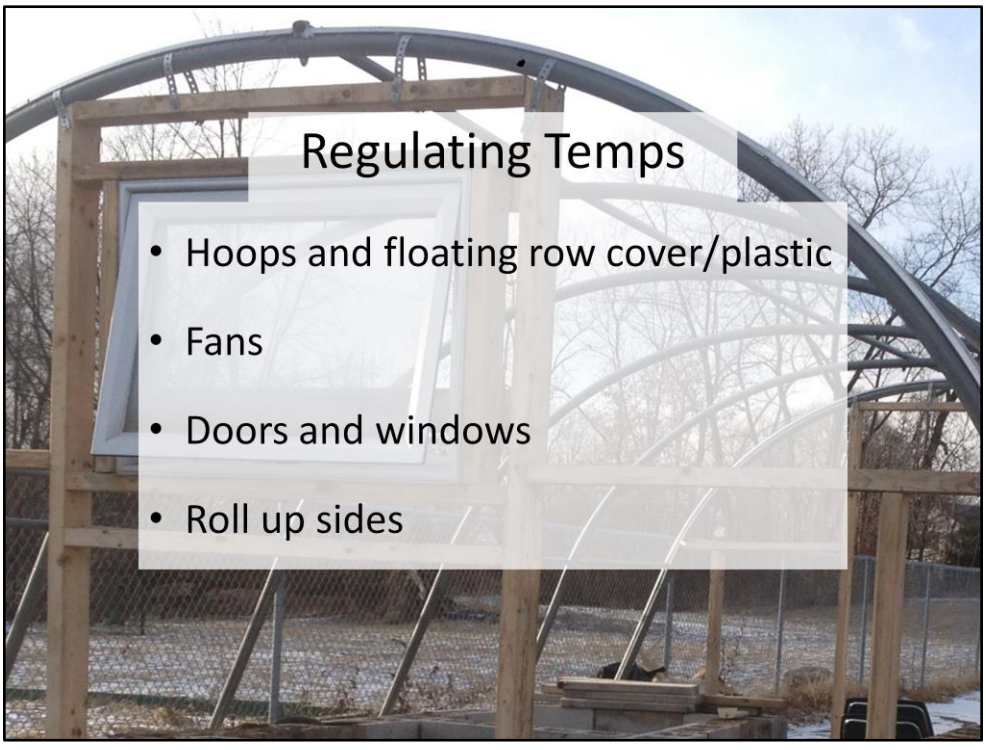
We transported our materials by both truck and bicycle. In an urban or peri-urban situation, it may be possible to have materials dropped off at the greenhouse by community members and/or nearby cafes.

Materials should be moistened and fluffed before piling into bays. Be sure to create and aeration system if the materials are dense, and be sure not to pack down materials as the pile is built.


Compost Ingredients: How Much and When?
• It's OK to layer as materials come in
• Build a stockpile of carbon or "brown" ingredients
• Overfill bays to allow for shrinkage
• Temperatures will spike quickly, then slowly cool down
• Remove compost after initial active period if possible, turn onto a maturing pile



Graph showing a composite of the temperature profiles for the 1:1 ratio of coffee grounds to chipped yard waste. The time span of this graph is 24 weeks. As you can see, the compost pile temperatures peak within a week or so and stay above 80 degrees for about 12 weeks.



It is important to regulate temperatures so that the greenhouse is neither too hot or too cool. Floating row cover or an extra layer of clear plastic over thin hoops can help retain heat overnight, but make sure to remove that plastic layer as the greenhouse warms up. Fans can help with airflow and to cool the greenhouse during the day. In areas without access to electricity, a solar powered fan is active when the sun shines, which is when the greenhouse needs venting. Doors and windows in a small greenhouse should be placed to maximize airflow. Roll up sides are useful when the greenhouse really warms up in the summer.

Growing winter produce

- Plan ahead
- Concentrated or staggered harvest?
- Choose appropriate varieties – needs to be frost tolerant
- Choosing the right growing medium
- Adding fertility
- Heat transfer from the compost

If you chose to grow winter produce in the greenhouse, plan ahead and chose crops with the best profit margin. A concentrated harvest is good for sales and a staggered harvest can be for personal use throughout the winter. Crops for this season in the Northeast still need to be frost tolerant, although much less so than for outdoors overwintering. Your growing medium should be lightweight as to not compact the compost underneath it and should also be able to hold a lot of nutrients, but without a high concentration of salts. A compost blend supplemented with organic fertilizers should work well. Picture shows pea shoots, a high-value crop.

Spinach growing in the greenhouse in December

Chard and lettuce in December

When to change over

- Plan last harvest to give enough time to build pile for seedlings
- OK to stagger piles for seedlings, but plan for max capacity in May
- Stockpile materials if you need to, will activate again when turned
- OK to have seedlings in the greenhouse by march if they are lightly frost tolerant

If you are growing both winter crops and spring seedlings in the greenhouse, you should start emptying some of the bays in early to mid-February, depending on when you want to start your first seedlings and how long it takes you to fill up a compost bay. Plan your last harvest of that bay accordingly. Also be sure that you'll have enough bays filled and warmed to coincide with your max-seedling production time. A good farm plan will help you decide when that is. You may need to stockpile materials in the winter for a big spring push – don't worry, ingredients will reactivate when turned and still heat up. Be sure that your first seedlings are of relatively frost hardy plants, such as kale, lettuce and onions. There is still a chance for freezing temps in the greenhouse in early March.

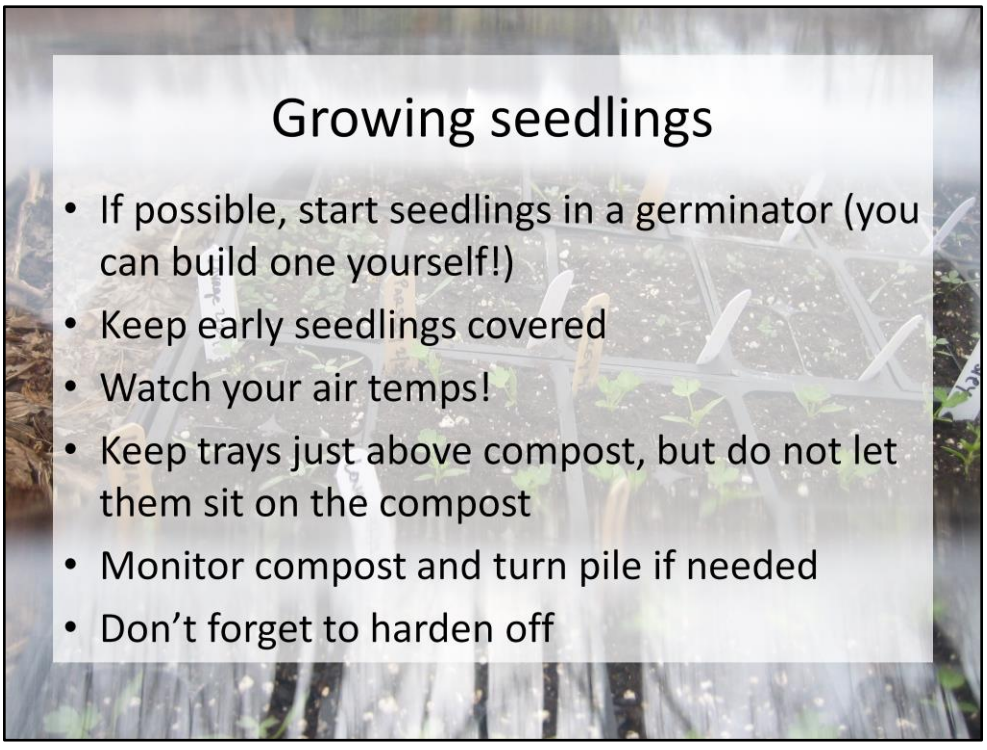

Growing seedlings
• If possible, start seedlings in a germinator (you can build one yourself!)
• Keep early seedlings covered
• Watch your air temps!
• Keep trays just above compost, but do not let them sit on the compost
• Monitor compost and turn pile if needed
• Don’t forget to harden off

Photo shows greenhouse in mid-late March. Note the seedlings on one side and the winter crops on the other. The hoops hold the row cover above the plants.

Participants in the Dig Kids program helped me build the greenhouse and create the compost bays.

On the left is baby arugula and the compost thermometer showing a 115 degree compost. This was in mid-October. The picture on the right is from late October and shows the first crops of spinach, mesclun and arugula. Note the box fan in front of the window and the hoops for floating row cover.

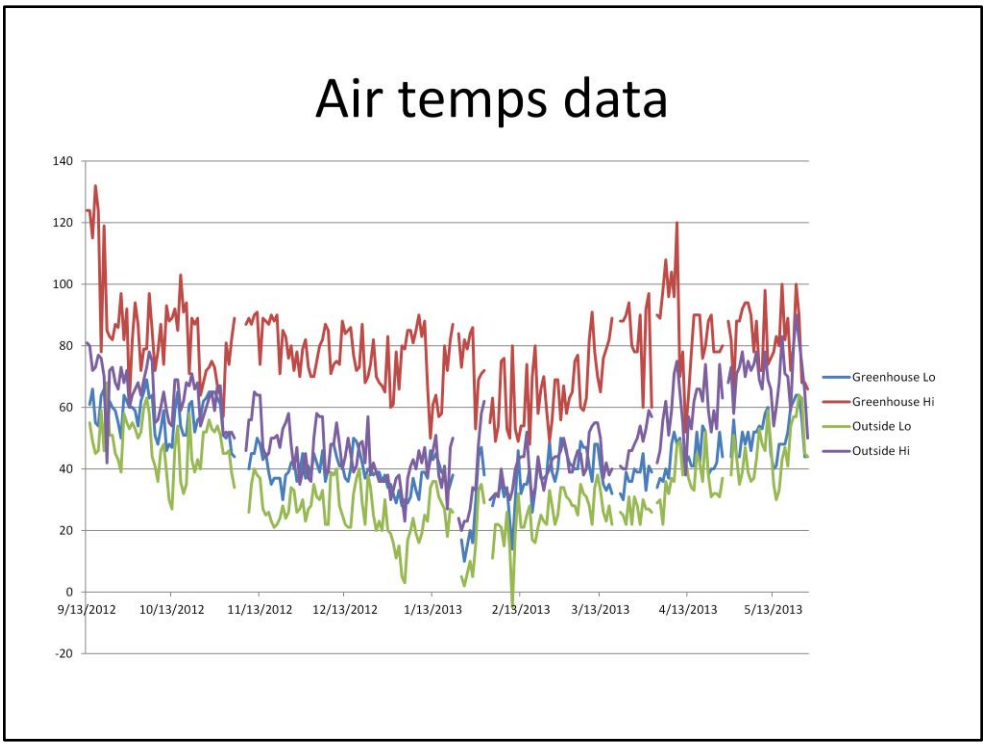
December photo

Winter growing (issues)

Mold on fresh compost

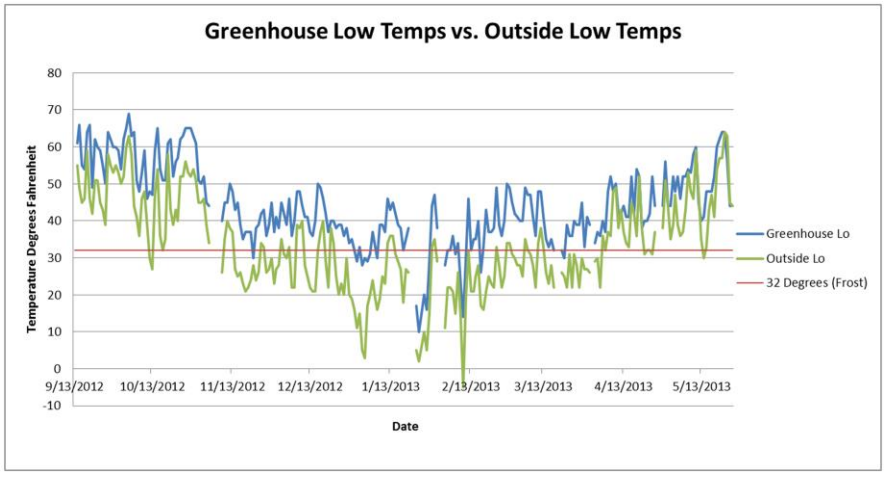
Problems with arugula

The mold on the compost pile was deemed innocuous and part of the decomposition process. We did have some issues with our arugula crop, you can see yellowing and some wilting in this photo. This may have been due to old seed, a nutrient deficiency in the soil or a high salt concentration in the soil.

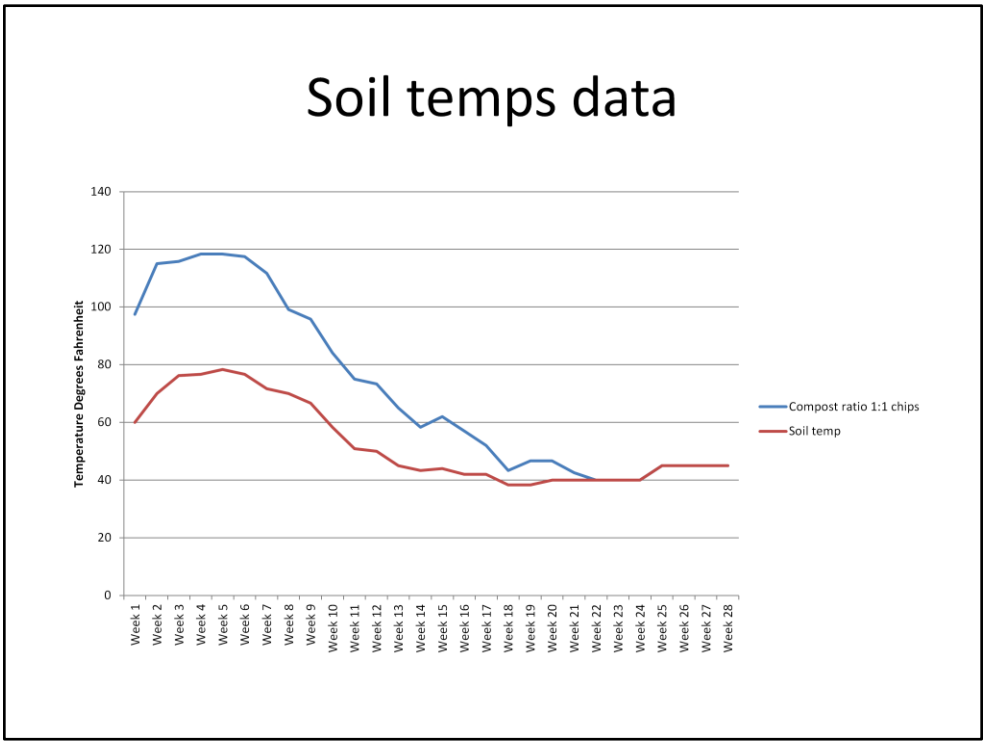


This graph show the daily air temperature data for the project. Any gaps are from a lack of data for that day. There are a few days at the beginning when the air temp was really high, this was due to a lack of ventilation after which I installed the fan in front of the window. The high temperature in the spring was before we got in the habit of ventilating again as the temperatures rose.

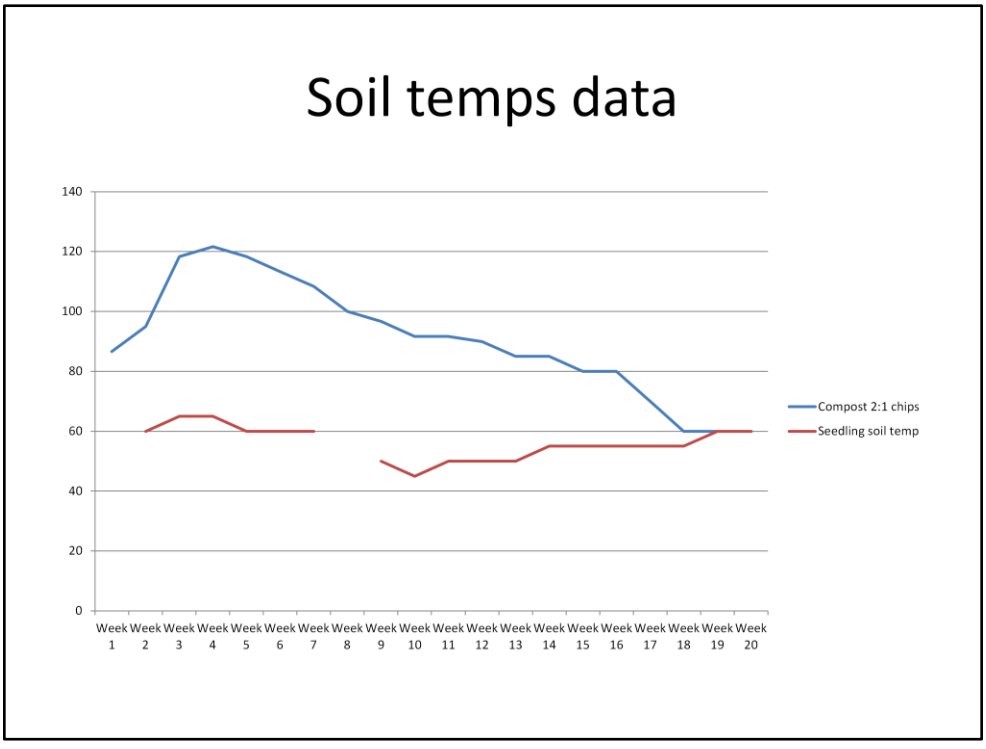
Air temps data



The same data, but only showing the low temperatures both inside and outside the greenhouse. Note that while air temps inside the greenhouse were on the whole warmer than the outside temps, there were days when the temperature inside the greenhouse dipped below freezing. Even so, the plants inside the greenhouse remained without frost damage.



This graph shows the average compost temperatures with the average temperatures of the soil in direct contact with that compost. Note that the soil temps were warm for about 9 weeks.



This graph shows the average compost temperatures with the average temperatures of the soil held above that compost in seedling trays. Note that the soil temps were not as warm as the soil in direct contact, but they were well above 40 degrees.

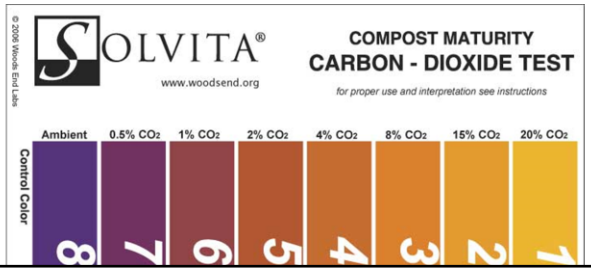
Photos show healthy seedlings in late March. Seedlings include onions, chard, lettuce, bok choi and broccoli. All seedlings were held above the compost so that roots were air pruned and wouldn't go into the compost.

Photo shows seedlings in late April, these include: tomatoes, peppers, chard and eggplant. Note that all the seedlings look healthy and without any cold damage..

A snapshot of the greenhouse in late April. At this point we were sharing the greenhouse with the community and youth gardeners. There is a final harvest of lettuce in Bay 4 and Bay 5 has been filled for more seedling space. Bay 6 is being filled. In the background you can see the sides rolled up for more ventilation.

Compost testing data

- Solvita tests
  - Compost consistently tested with negligible ammonia, good for smells, but C:N ration might still be too high
- Finished compost testing
  - Low salts
  - Medium nitrogen
  - Safe for soil amendment



The picture is the Solvita test color scale for carbon dioxide production. This measure, along with the volatile ammonia concentration indicate the compost's maturity level as well as the potential for phototoxicity from ammonia gas.

Issues

- Arugula did not do well for some reason
- Air temps in the greenhouse did go below freezing during the winter and very early spring
- Winter produce not as profitable at this scale
- Vandalism!
- Training coffee vendors

There is potential for improvement when it comes to profitability in winter crops. Balancing the labor of a compost-heated greenhouse with the scale and style of growing needed to create a profit will be key in solving this issue. Vandalism was a problem throughout the project. Our greenhouse covering was slashed on multiple occasions and our data logger was stolen. Moving the greenhouse to a more secure location behind a fence will hopefully solve this problem.

The nitty gritty

- 2485 gallons diverted from the waste stream
- 60 working hours to collect materials and maintain greenhouse compost
- $150 in gross sales of winter produce
- $1300 value of seedlings grown

Note that the 60 hours of labor was for maintaining the greenhouse both in the winter and the spring/early summer. If only used for spring seedling production, the number of hours would be cut in half.

Thank You!

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NORTHEAST SARE
Sustainable Agriculture Research & Education

Cornell University Cooperative Extension

Yes, thank you! Please use my email address to contact me, as the url for South Pine Street City Farm will be defunct after 2014. For more information about South Pine Street City Farm, please use the new website: http://revivalcityfarms.com/