WINTER STORAGE RESOURCE- FEB 2010

EXISTING STRUCTURE RETROFIT CASE STUDY

Based on Intervale Community Farm

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For
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INTRODUCTION

Intervale Community Farm is a CSA farm serving 520 summer CSA members with about 20 acres in organic production in Burlington, VT. ICF has been in business for about 20 years, and in 2005, we started a winter CSA share in order to hold the interest of existing summer CSA members throughout the winter months and to provide year-round employment for more employees. ICF now produces 175 winter CSA shares.

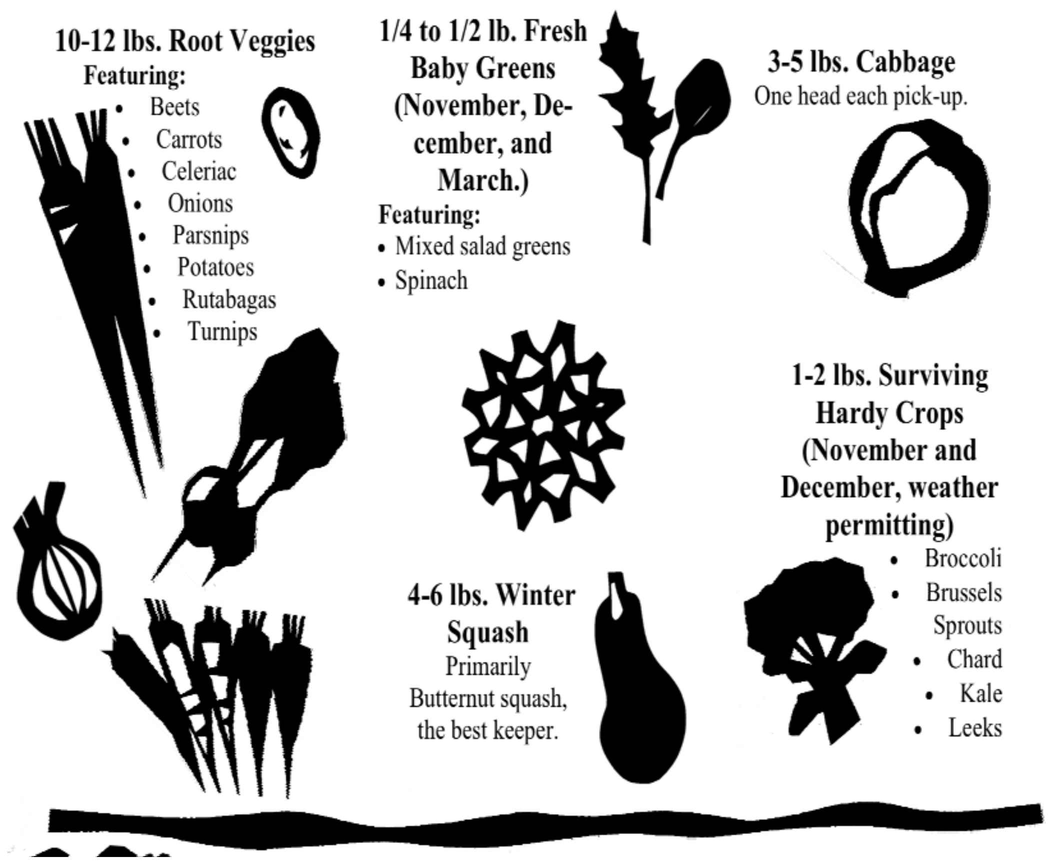
Unlike your typical farm, ICF is owned not by the growers, but instead by a consumer cooperative of interested CSA members. For a $200 one-time, refundable co-op membership fee, those CSA members that opt in have the right to vote for the co-op board (which has ultimate control of the farm), receive favorable membership priority, and receive a share (if any) of farm annual profits. In addition to providing a pool of long-term, untaxed capital for the business, the co-op model also places operational priority squarely on serving the interests of the CSA members.

After our inaugural winter CSA season in 2005-2006 with rudimentary facilities (dirt floor & propane salamander heaters for distribution), it became clear that we needed a storage and distribution plan in order to make our winter share thrive. If we designed intelligently, it would also improve our operations the rest of the year.

We're in the unusual situation of distributing all of our produce at the farm, which saves a lot of effort in trucking and packing. It also means our distribution space needs to function in both the winter and the summer. Our winter share runs mid-November through mid-March, with CSA members receiving produce every other week with a two week break over Christmas and New Year's.

CROP CONSIDERATIONS

As far north as we are, the easy and secure winter CSA share was clearly going to be based on storage crops. Fresh components are always important, particularly as a member morale boost, but the bulk, calories, and eating focus has to be on stored crops. I figured if every vegetable grower in Vermont was banking on the root crops they grew for fall harvest, that was good enough proof for me that it was a reasonable foundation for the business. We aim to provide as much diversity in the winter CSA as possible while still maintaining an affordable share price. Our typical winter CSA share pencils out at about a 10% discount off of comparable retail.



The winter share includes nearly every root crop: beets, carrots, celeriac, daikon, garlic, leeks, onions, parsnips, parsley root, potatoes, rutabaga, salsify, scorzonera, and turnips. With the exception of daikon, garlic, and leeks, the remaining roots are usually available for the entire November-March winter CSA. We don't aim to have every variation of each root available. Except for potatoes, for which we offer red, white, blue, and yellow options, we mostly stick to the standards: orange carrots, red beets, yellow onions, etc. This is practical for us on the production side, allowing us to minimize the number of cultivars we're treating differently in the field, and practical on the distribution side, as we lack display space for multiple colors and sizes of each of the roots. The roots are distributed through a choice based system based on weight: usually 12lbs of roots, to be selected as the CSA member chooses. Winter CSA member root preference has typically run about 30% carrots, 30% potatoes, 15% onions, 10% beets, 5% parsnips, and a few % each of everything else. This has us storing a bit more than 20,000 lbs of root vegetables (6000lbs carrots, 6000 lbs potatoes, etc.) in total to meet our expected demand (12 lbs/pick-up x 175 shares x 9 pick-ups/share) while maintaining enough surplus to allow for member preference to fluctuate.

In addition to the roots, we provide a head or two of cabbage each CSA pick-up: green, red, or Napa (while it keeps, usually late January-early February). Butternut squash rounds out our storage crops. We've not had much luck with storing other squash, so we've opted not to attempt it unless we have an unusual surfeit of other squash we're carrying over from our summer share.

In November and December we still pull what weather permits out of the field, typically kales, Brussels sprouts, leeks, and salad greens. Just before killing frost for those crops – typically early December – we harvest the remainder from the field and shoehorn it into the walk-in in the last couple of pallet locations. Once we lose our outdoor option we rely on our unheated greenhouse and high tunnels of spinach. We've gradually eliminated all our other winter greens crops in favor of spinach, with an occasional bit of arugula thrown into the early winter plan. Spinach grows well, allows us to harvest it at many different stages of growth, regenerates well enough for a decent second-cut, and is versatile for members to use either fresh or for cooking.

STORAGE FACILITY LAYOUT

We were advised by other farmers to pay attention to material handling and flow. Since much of what a vegetable farm does involves moving relatively heavy and bulky objects from one part of a farm to another, it pays to consider how to reduce the frequency of handling and the increase the ease of handling.

For us, this meant upgrading our thinking to involve inexpensive tools that would permit us to move weight and volume easily. Pallet jacks, hand trucks, and platform carts are inexpensive, efficient, and easy to use. For a pallet jack, 48” wide doors are required; standard width pallets are 40”x48”, and a 48” door allows some overhang on the sides. Concrete floors with minimal slope are also important; pallet jacks are poor performers on uneven surfaces. We have a concrete sidewalk from our cooler to our summer CSA distribution shelter with a slope of 1-2%; this seems to be very workable with the pallet jack. Door height is worth considering as well; we like to stack our bulk bins, and a stack of 3 bulk bins requires a door over 7’ to fit them through stacked. With pneumatic (air) tires, platform carts and hand trucks are more suitable to rough terrain, but both have to be manually loaded and unloaded. With planning, the bulk bins and pallets of boxes and totes can come straight from the field or wash area with only one hand stacking operation.

STORAGE ARRANGEMENT

We began with an existing 23’x45’ enclosed pole barn, divided into three 15’ x 23’ bays. With the planned addition of an open-air pole shed off of the east end of the barn, that provided four bays for us to work with. The barn has 48” doors between sections to permit the passage of produce from wash area to summer CSA distribution shed without unnecessary handling. In the winter, the ‘hallway’ portion of the cooler is blocked by additional pallets of produce, as we only access the cooler from inside the squash room.

Had we conceived of our pole barn as a storage area from the beginning, the overall design would probably be similar, though the dimensions would likely be standardized. Instead of a strange 15’ x 23’ bay, which worked for our site and site constraints, something closer to a 16’ or 17’ bay would have been useful, permitting a cooler and warm storage area with a full 16’ interior width allowing four pallets to fit across the room in either orientation; right now we can orient them in only one direction. That said, the extra foot or two of span width would need to be able to be built without additional interior posts.

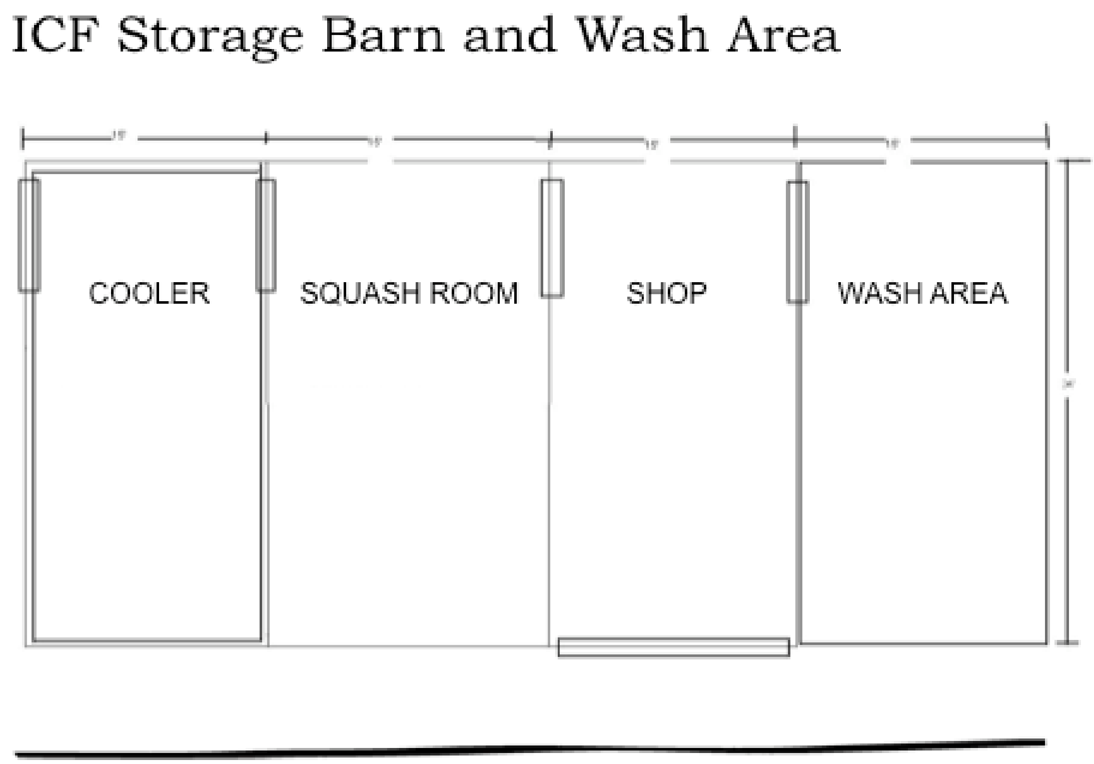


Figure 1: Note - small rectangles are 48" wide doors.

With roots, cabbages, and squash clear as our primary storage crops, we began to design our facility. We aimed to achieve two basic temperature / humidity regimes: cold (32°- 34° F) and damp (90%+ rh) and warm (50°-55° F) and dry (50-60% rh). In hindsight, a third zone at cool (40°- 42° F) and damp (90%+rh) is probably warranted for potatoes. Potatoes do not keep well for long periods in the low 30°s F, and by late winter tend to become overly sweet and rather watery in texture. We've been fortunate most years to have other local options (though it does require some local trucking on our part) for storage of potatoes where the temperatures run 40°- 44° F. In some walk-ins, you'll find enough thermal variation in the room to put the potatoes at the warm end and the other roots in the cool end; however, while 8°-10° F is an optimal difference for the potatoes vs. others, you probably don't want a cooler with quite that much variation.

A fourth zone, cold (32°- 34° F) and dry (50-60% rh) for onions and garlic is only warranted, in my opinion, if you have the ability to segregate easily or grow large volumes of those crops. For our storage needs and with our CSA market, the cold and wet zone has been a fine choice. We see a little white surface bloom on the outer scales of onions beginning in February some years, but it doesn't look too bad, and doesn't appear to affect the interior quality of the bulb. Similar with garlic, but with a greenish bloom instead. To be fair, this arrangement works for us in part because we can explain it to our CSA members, and we aren't presenting these adjacent to sparkling perfect competitors. If so inclined, the onion and garlic blooms both wipe and peel off relatively easily, but we tend not to bother with the extra step.

The cold/cool sections require refrigeration most of the year, even in the winter, due to the heat of respiration generated by the stored produce. The warm section is heated only in winter while we store our butternut; for 7 months of the year it runs at ambient temperatures. During the summer we use the squash room to hold tomatoes, onions, potatoes, and other crops that don't require refrigeration for short-term storage.

STORAGE CONTAINERS

Containers are an important consideration in our storage plans, from the perspectives of cost, ease of use, materials handling, and crop quality. Ideally a container is cheap, easy and efficient to move, durable, excellent at preserving crop quality and can be recycled when we are finished with it. We use many different types of containers, but basically they break into three groups: bulk containers, reusable bushel-size containers, and various large bags.

Larger vegetables we move in large quantities are harvested and stored in wooden bulk bins: winter squash, cabbage, and rutabaga. Potatoes are usually stored in bulk bins as well, as we generally do not wash them prior to distribution. We are also able to pull the potatoes out of the bins easily without breakage, unlike something brittle such as a carrot. For the crops that require humidity, we'll cover the produce with burlap or plastic. We use a fairly large 20-bushel bin since it is available locally in small numbers at a time. Our bins have larger 3"x3" skids to allow easy access with a pallet jack beneath.

We use a wide variety of smaller containers, both wooden and plastic, with most holding about 1 bushel. For quality in storage, the covered plastic clamshell totes are excellent as they preserve humidity in the crop for long-term storage. The commercial brands Buckhorn and Otto have both been durable; discount store and other commercial brands have been subject to quick breakage. While expensive at $18+ a bin, we can use them for many years. They typically hold about 50 lbs. of roots when filled to capacity. They are relatively easy to stack to ceiling height. Wooden bushel boxes are easier to use in the field for harvest, as they don't have encumbering lids, and provide a lovely aesthetic for display. Unlike the plastic bins they can also be repaired a little, and are useful for kindling when they've reached the end of their service lives. They don't, however, prevent the crop from drying out very well unless covered, so we tend to mostly use them for harvest, display and short-term storage of a week or less.

When we run out of boxes and bins we pack into 25 lbs. slightly perforated poly bags. These are disposable items, but they are an inexpensive way for us to extend our storage capacity. They do a good job of preserving crop quality, and also are easy to move around. They have the additional advantage of being the local standard for wholesale delivery of root vegetables. We generally will pack at least some of each root (save potatoes and onions) into the bags, and save them until the later CSA pickups; which allows us to sell these without repacking them in the event that we have some that aren't needed for the winter CSA. Aside from their disposable nature, the big disadvantage of the poly bags is that they don't stack particularly well. In order to stack them more than 4'-5' high, we have to build some containment structure within the cooler or place the bags inside bulk bins.

Figure 2: We use a variety of containers -- lidded totes, poly bags, wooden bulk bins -- to store produce. The key for preserving quality for us has been to keep the produce protected from direct airflow.

COLD STORAGE

The farm is in a floodplain and when we started business we had no infrastructure at all. Given flood potential and water table concerns, we are limited to above-ground structures. Flat terrain and flood restrictions also prevent mound root cellars built up above grade. Given those restrictions, a walk-in cooler at grade quickly became our best option.

The cooler was sized to take up one interior bay of our pole barn, approximately 15'x20'. We learned that adding height was inexpensive relative to adding floor area, so we pushed the ceiling up from a typical 6 ½'-7' ceiling to a 9' ceiling, which is about what we could fit below the trusses of the barn roof. This has allowed us to use more vertical space in the cooler during the winter, while still permitting reasonable air circulation above the produce.

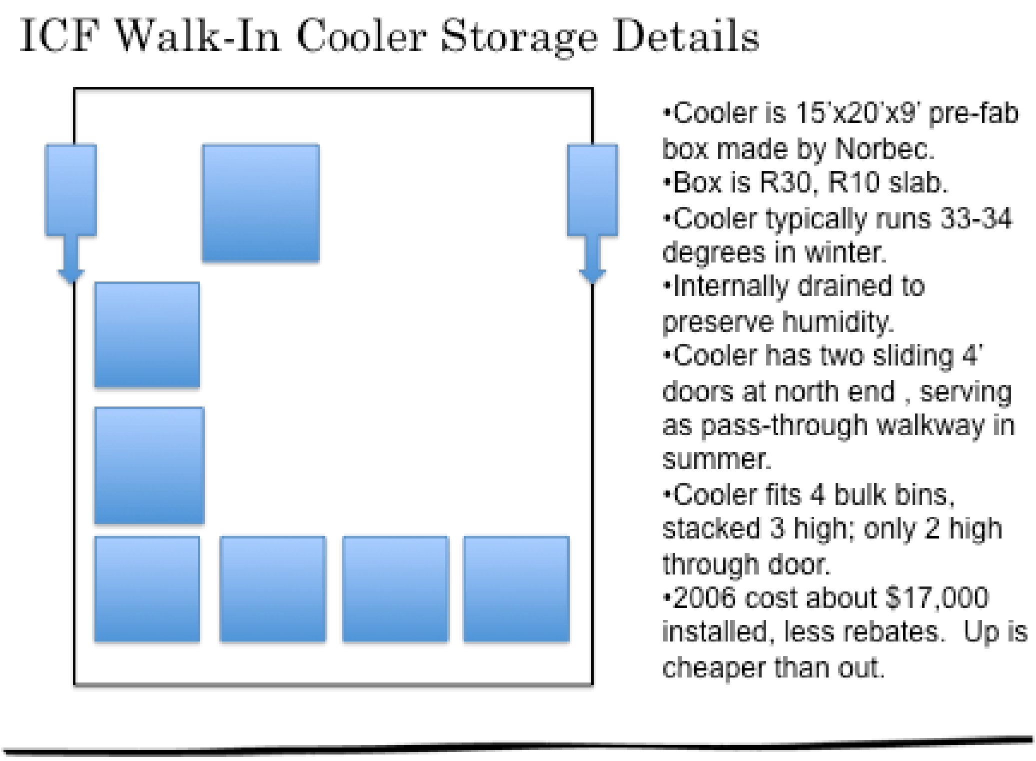


Figure 3: Sliding doors move in direction of arrows. The 'hallway' between doors is filled with produce during winter months, and used as a passage to summer distribution during the summer months.

We opted for a pre-fabricated walk-in box, as it was quick to install and simple to move if needed. It also provided us with an R-30 envelope. At 15'x20'x9' our cooler isn't huge, but it is large enough to accommodate 40 or so bulk bins, some 30,000-40,000 pounds of produce. Ours was made by Norbec, a Quebec company, and installed by our refrigeration contractor. We have been very happy with the design of the doors and box, which came with bright white walls that really reflect light. Having worked in dark coolers, we installed four 4 foot fluorescent fixtures. Combined with the white walls, it allows us not only to store things but to actually work in the cooler as well. Installing the box inside of the barn walls proper provides us with a shell within a shell, which I think has reduced our energy use in summer and protected us from frozen corners in winter.

Figure 4: The cooler as it is being loaded in the fall. The top level of bins are hand loaded; only a two-bin stack will fit through the cooler doors.

Due to the geometry of our barn and our summer CSA distribution area, we installed two 4 foot wide sliding doors on opposite walls at one end of the cooler. Having two doors likely reduces our overall energy efficiency a little bit in the summer, though with both doors being prefab R30 sliding units with very good closing and weatherstripping characteristics, it is probably a minimal amount. If we had only one door, it would be open more of the time than each of the two doors. In the summer, when our cooler turns over inventory weekly, the two doors form the top of a 'T' shape to our aisles. One door comes in from the washing area, and the other leads to our open air summer distribution area. The main stem of the 'T' is then the aisle that allows access to the pallets along the walls. In the winter, we fill all available space with roots, allowing access only from the door on the interior side of the barn.

COOLING SYSTEM & HUMIDITY CONSIDERATIONS

The refrigeration system proper is a 5 hp high-efficiency condenser, and two low-velocity evaporators with four fans each. This has been sufficient evaporator capacity to maintain low temperatures and high humidity on hot days without icing. Sizing evaporator area for humidity and produce is key: an older convenience-store evaporator and cooler we used previously in an older box frequently iced up until we replaced it with more capacity. We also had the contractor add a cutoff switch to change the evaporator fan controls from circulating 24/7 to only running when the condenser is running. This has cut our winter electric bills in half relative to running the fans full time. I suspect we're also conserving humidity in the produce as well by cutting down on the fan running time. Produce quality seems to be holding well. All evaporator drainage is internal, with no floor drains, which also helps to keep humidity up in the cooler. Ideally we'd be up in the mid 90% relative humidity range, but we typically run in the 70%-80% range in the air, and depend on the produce containers to provide the final line of defense from desiccation.

FREE COOLING

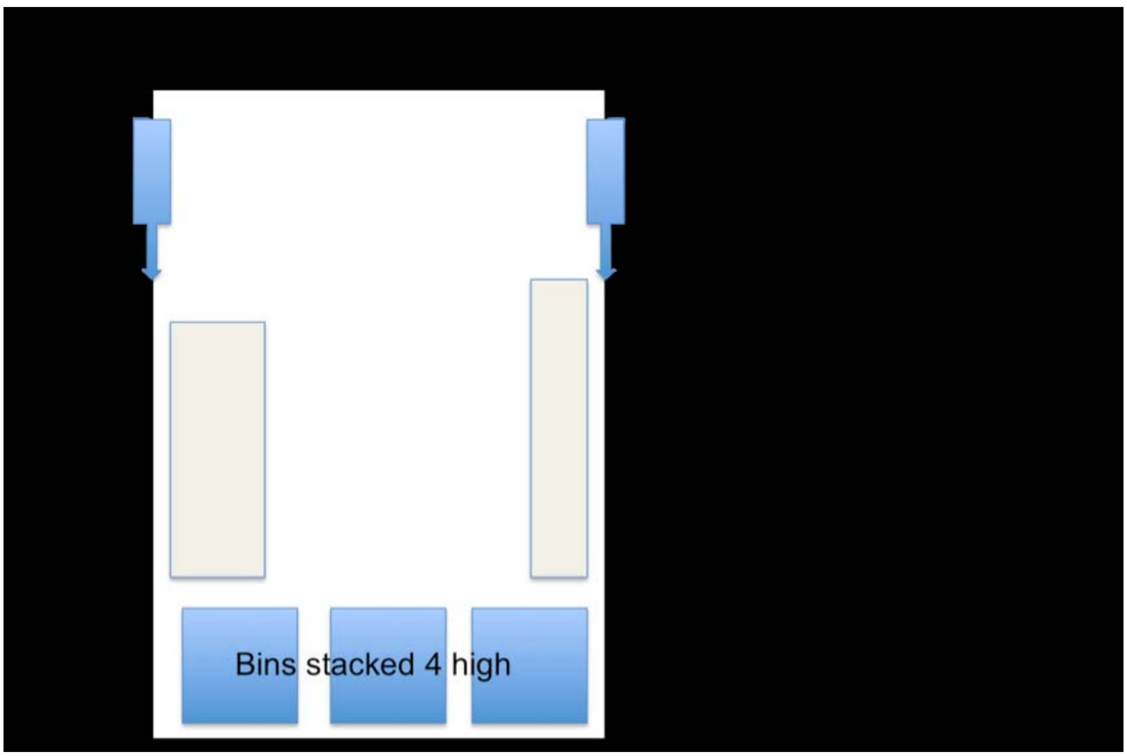
We investigated bringing in outside air for cooling during the winter months, a concept that makes intuitive and efficiency sense. We ruled out the standard free-air economizer (as those units are known to the refrigeration folks), though, as the winter outside air is so dry that we were concerned it would reduce the humidity of the interior air enough to compromise produce quality. Looking at it now, a free-air economizer coupled with an automated humidifier to increase the moisture content of the external air might well save significant energy and maintain product quality.

COOL STORAGE FINANCIALS

Overall cost: $17,500 for cooler and refrigeration equipment, after $1300 in energy efficiency rebates. Also had investments in 4" insulated concrete floor (R10), and electrical service, about $7000 apportioned to the cooler space. If we look at the cooler over a 20-year lifespan, which is probably short for the box and long for the mechanical systems, annual capital cost is around $1250. With operating costs around $150 monthly and with $300,000 in produce moving through annually, the cooler adds around 1% to the overall cost of the produce.

WARM STORAGE

Winter squash, a major component of our winter CSA shares, requires relatively warm and dry conditions for long-term storage. Variety selection helps as well. The Cucumis moschata squash (butternut) store significantly better than the C. pepo (Acorn, Delicata) and the C. maxima (buttercup, kuri, et al). While the pepos can be stored until December, we never seem to have enough of them, and *we've* never had much luck keeping the maximas, despite their theoretical storability.



Harvest and post-harvest treatment are nearly as important for good storage of winter squash as the storage facility environmental conditions. Butternut will store well until March or April if undamaged during harvest or storage; even a small nick on the skin of the squash will develop into consuming soft rot, so careful handling is critical. We harvest all of our winter squash into bulk 16-20 bushel bulk bins we can move through the field on trailers and pallet forks. We've found that quickly wiping or brushing the surface soil off of the squash (damp rags or cotton gloves with gripper dots work well) seems to prolong storage life. We also remove the stem of the squash at harvest, as cuts from other squashes' stems are the primary source of skin damage in the bulk bins. Paradoxically, a large open wound from stem removal does not typically lead to fruit rot, while a small poke in the skin anywhere along the side or bottom of the squash will. We aim to snap off the stem by hand at harvest (gloves are nice for this); reluctant stems are typically knocked off on the edge of the bulk bin prior to placing the fruit gently inside. When we have several days of sunny weather forecast (not all that common in later September in our location) we will cure the self-inflicted stem wounds in the field prior to pickup, but we're typically harvesting and packing in one pass through the field. The difference appears to be cosmetic, with the stem wounds curing more neatly in the sun-cured batch; even the bin-cured squash store well.

Figure 5: While our high ceiling allows for four stacked bins, the top bins must be unloaded by hand.

Following harvest, the squash are stacked three bins high using a tractor forklift. Once stacked, we pull the three bins into the storage room using a pallet jack. At 3000 lbs, it's nice to have two people to move it. Once the bin stacks are placed against the back wall of the room, we lift an empty bin up on top of each stack, and hand fill it by tossing up individual squash. It doesn't take more than 15 minutes a bin, and we aren't filling more than three bins this way, so it works for us. With our three stacks of four bins each, we can store 10,000-11,000 pounds of squash neatly out of the way along the back wall and still have room for our winter share distribution in the remainder of the space.

The storage room, or 'the squash room', as we refer to it, we built alongside the cooler inside the pole barn shell. While the cooler was a prefab box, we built the squash room directly into the walls of the barn. We tried to construct it on the cheap, with an eye toward expanding into the other third of the barn, in the event that we are able to re-locate our shop space from there into another building.

The squash room shares the R10 insulated 4" concrete slab with the cooler. One of the cooler walls makes up one wall of the room as well, providing an R30 on that side. The other three walls are lightly built partition 2"x6" walls with simple fiberglass insulation, working out to R19 efficiency. Given that we may relocate some of the walls, I opted for the minimum 2"x6" R19 wall with fiberglass instead of a warmer 2"x8" wall or a wall that incorporated highly-insulating spray foam. The ceiling is open to the roof cavity above, and has about an R60 quantity of blown cellulose insulation. We built a custom 4'x8'x4" door, weather-stripped it and filled it with foam for a tight envelope. Without windows and with minimal traffic during much of the winter, the room does well at keeping temperature at a modest cost.

The squash room is heated by the smallest, direct-vent Rinnai propane heater we could find; this was an economical choice and seems to do the trick. Propane has run us anywhere from $150-$300 for a winter of heat, depending on the season and the price of propane. We installed the heater just above floor level, and with the small, internal fan, haven't found additional air circulation devices necessary in the 14' x 22' room. Radiant floor heat would be a great option in a larger facility or where one had another use for the boiler; our room was too small for even the smallest unit. We do see a bit more rot in the bottom layer of bins, and radiant floor would likely solve that problem.

WARM STORAGE FINANCIALS

With all materials, components, electricians and so forth, the heated space cost us approximately $12,000. We a 20-year life on the installation and $400 annual operating costs, the squash room adds almost $.10/lb to the cost of the squash we generally store. That said, the same amount of space could store another 20,000 lbs of squash annually; we've just found we don't need that much squash. Instead, we're using the space in the room to organize and host our winter share distribution; this seems like a bargain to have a warm heated space for $700 annually, and then we can apportion $0.03/lb to the squash for storage purposes.

All in all, we've been pleased with the performance of the squash room. We typically have <5% storage loss by late March when we're finishing our winter share, though 2009 is going to be higher than that. The room can get fairly ripe smelling even from one or two rotten squash in a bin; since we're distributing our winter share in the same space, we've found it worthwhile to spend ½ day in late January sorting through the bins and removing the few offending squash.

CONCLUSIONS

While our facility could hardly be classified as inexpensive, it has been a worthwhile investment. We depend on and use our storage facilities as much or more than we depend on our tractors. Downtime on tractors is manageable by shifting work from one machine to another or leasing from a neighbor; non-functional storage systems are worse than useless. Designing an efficient system that minimizes labor, reduces body strain, improves crop quality, and expands the marketing season has been a great investment on all counts.