Cold Storage Options for Small-Scale Diversified Farms in the Northeast

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December 12, 2012
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Table of Contents

I. **Introduction**

As winter farmers' markets and winter CSAs become increasingly viable as agricultural market outlets, many farmers may choose to invest in improved storage systems in order to maximize the amount, variety and quality of their stored crops. From 2010 to 2011, the number of winter farmers markets in the United States grew from 886 to 1,225, an increase of 38%. Although an expansion of winter markets is good for farmers, there has been a simultaneous increase in the number of vendors at each market. In Brattleboro, Vermont, the winter farmers' market grew from 18 vendors in 2006 to 32 vendors in 2011 (Koch).

To succeed in the winter marketplace many New England farmers are choosing to expand and improve their crop storage in order to store a greater variety of top-quality vegetables. Improved storage capacity adds value to the crops through investment in infrastructure although it may result in increased labor demands throughout the winter.

Alternatively, some farmers seek to streamline storage to minimize winter labor costs. In this case, the quality of stored crops may not be as high, they may not keep as long, or the grower may not store as many varieties, yet the farmer is able to save money on labor and is still able to turn a profit and collect income year-round.

As always, farmers are specializing in a diversity crops, and are using different storage techniques and marketing strategies. In March of 2012, I had the opportunity to visit six farms in Vermont, four in Massachusetts and two in eastern New York, each with innovative and varied storage infrastructure. In Vermont, I also visited Deep Root Cooperative's storage site and the Vermont Food Venture Center. These farms and sites store everything from beets and potatoes to kohlrabi and leeks to eggs and sauerkraut.

Some farmers chose to invest in completely new infrastructure; others chose to work with what they had, including retrofitting old cow barns to fit coolers or repurposing older coolers for winter warm-storage. All of these farmers have chosen to invest in infrastructure that caters directly to their farm systems and their target market. There are markedly different storage styles used by farms participating in wholesale markets, winter farmers markets, farms who sell through self-serve winter CSAs, and farms participating in a combination of the three. Storage types included coolers, root cellars, warm rooms, passive rooms and variations of each.

The diverse storage systems are generally designed to accommodate some combination of the four most common storage zones: cold and wet (i.e. root crop storage); cool and moist (i.e. potato storage), warm and dry (i.e. squash storage) and cold and dry (i.e. onion and garlic storage). Different types of vegetables require particular storage conditions, but many farmers have found that certain vegetables are more flexible than others, and can be kept in sub-optimal storage while maintaining their high quality. The types of vegetables that can compromise their storage conditions may also depend on the farmer's point of sale. For example, potatoes can tolerate cold and wet, although optimal storage is cool and moist. Potatoes become sweeter in cold and wet storage. If the point of sale is through CSA, and the farmer can be sure that customers don't mind that their potatoes have become sweeter, then it may make more sense to combine potato storage into cold and wet rather than build a separate storage space for potatoes. In this instance, it is within both the customer's and the farmer's financial interest to combine potatoes into cold and wet storage rather than build a new system.

II. Options in Cooler Construction for any Storage Zone

In constructing a cooler, there are a few options: some buy new pre-fabricated box coolers; others build their own coolers either by using all new materials, recycled cooler panels, and/or spray foam insulation. There are many details and considerations that need to be taken into account when building a cooler.

New cooler materials can be purchased as a box-set or as individual panels. The Intervale Community Farm in Burlington, Vermont chose to invest in all new materials and purchased a pre-fabricated box from Norbec[1], a cooler supply company based in Quebec. There are two flooring options when buying a pre-fabricated box. The first option is to create an insulated floor space beneath the cooler (e.g. an insulated cement slab). The second option is to purchase an insulated floor piece that is part of the box cooler. This allows for some versatility because the cooler can be easily moved to another location in the future. Unless a farm has an existing insulated slab on which to place the cooler, in most cases it makes more sense to purchase an insulated (and movable) floor piece for the pre-fabricated cooler.

Individual insulated panels can be purchased new and assembled into a box. Stressed-skin panels (also called structural support panels)[2] are pre-fabricated insulated panels that can be used for cooler siding. They are very versatile and can be used as a load-bearing wall or as roof insulation. Stressed-skin panels are used at Pete's Greens in Craftsbury, Vermont.

Another option is to use recycled cooler panels to create a cooler space. Two of the farms I visited sourced their used panels from American Wholesale Refrigeration[3] based in Cleveland, Ohio. It is also possible to create homemade panels using a combination of foam board insulation and vinyl siding or metal roofing. In homemade panels plywood is also used as siding. Plywood is an undesirable choice for cooler interiors (after vinyl or metal) because wood can hold crop diseases and could potentially re-infect crops each year. Also, plywood is not thoroughly washable and can present a food safety issue.

Polyurethane spray foam insulation is incredibly versatile and relatively inexpensive. Spray foam creates an insulated envelope with a tight seal that is highly effective at maintaining temperature and humidity. Spray foam should be applied to a frame created for the cooler. The cooler frame is similar to a frame built for a standard wall and can be built using wood or metal. If wooden framing is used, the wood must be completely sealed by the foam on the interior of the cooler to prevent it from rotting from high humidity. Wood should not be sealed on all sides, however, because moisture gets trapped within the wood, rotting the frame from within the foam. Sealing the wood on the inner walls also prevents potential issues of crop disease and food safety concerns. When using metal framing one must be aware of its potential to act as a thermal conductor. If exposed metal framing travels from within the cooler, through foam insulation and continues to be used as a support structure outside of the cooler, the metal will act as a thermal conductor drawing warm air into the cooler and cold air out of the cooler.

It is relatively easy to achieve an r-value of 50 or higher using spray foam insulation. High density spray foam has a better r-value per square inch so the coating can be thinner while maintaining insulation capacity. Spray foam is flammable which may be a concern for some. Some types of spray foam are more flammable than others. The flammability of certain spray foams can also be mitigated through the use of sealants and other products marketed as spray foam coatings. When using sealant or coating, it is important to ascertain whether the product in question will stand up to the cold, high-moisture conditions inside the cooler. Before investing the time, energy and expense to coat the entire cooler sealant it may be worth double-checking with the manufacturer and perhaps trialing the product in one section of the cooler. Lee and Ruth Blackwell of Blackwell Roots Farm in Cabot, Vermont have found that liquid rubber by Ames Research[4] works well for them as a spray foam coating.

Kilpatrick Family Farm in Middle Granville, New York uses insulated overseas shipping containers to achieve cold and wet (and cold and dry) conditions. These containers are well insulated, self-contained with no additional structure needed to cover it. A compressor and evaporator are retrofitted to fit the container. A grooved floor allows water to be dumped onto the floor without the produce coming into direct contact with the water. Similarly, some farms use a refrigerated trailer from a tractor-trailer to store produce in a cold and wet (or cold and dry) environment.

For more information on cooler construction see *Cooler Considerations* (page 12).

III. The Storage Zones

Each crop has specific requirements for storage. It is important to be aware of the ideal storage requirements of each crop and also how tolerant each crop is to a deviation to ideal storage conditions. The most comprehensive and detailed information about each crop's storage requirement and sensitivity can be found in the USDA's Agriculture Handbook 66[5] *The Commercial Storage of Fruits Vegetables, Florist and Nursery Stocks*. This handbook is considered to be one of the best sources of information available to farmers in the US as it covers almost every fruit, vegetable and nut that can be grown in the country. The handbook was originally released in 1986. A revised version of the handbook was released in 2004 and can be found online at http://www.ba.ars.usda.gov/hb66/contents.html.

There are four commonly identified storage zones for crops grown in the northeast. They include cold & wet (e.g. root storage) which ranges from 32-40˚ Fahrenheit and 90-95% relative humidity (RH), cool and moist (e.g. potato storage), 38-40˚F and 80-90% RH, warm and dry (e.g. squash storage) which requires 50-60˚F and 50-70% RH, and cool and dry (e.g. onion storage), 40-50˚F and 60-70% RH (Fact Sheet, Whole Farm Services).

A. Cold & Wet Storage (e.g. Root storage)

32-40˚ Fahrenheit and 90-95+% relative humidity

Creating cold and wet storage is usually achieved using a traditional cooler, with conventional compressors and evaporators. Many farmers find that the most effective way to add humidity is through the use of foggers, misters, or humidifiers. Intervale Community Farm uses the Aqua Fog Hidro[6], Blackwell Roots uses the Netafim Coolnet Fogger[7], and the Tangerini's Spring Street Farm uses an automatic humidifier and mister manufactured by Smart Fog Humidification Systems[8]. Others add humidity by simply pouring water onto the cooler floor. Generally, the desired humidity level is 95% or above.

In an effort to combine storage of vegetables needing different storage conditions some farms are coming up with innovative solutions to accommodate various crops in a single cooled space. In Montague, Massachusetts, Red Fire Farm stacks crops needing cold and wet conditions in plastic bins on pallets. They place wet burlap both underneath and on top of the bins before wrapping the entire pallet in plastic. They may also include water reservoirs within the containers depending on the humidity requirements of the crop. This allows the humidity level in the immediate vicinity of the produce to stay relatively high while the rest of the cooler can serve as cold and dry storage for a crop like potatoes. The plastic-wrapped pallet method also works particularly well if a farm needs to rent space in a commercial cooler that is not designed for produce. Such is the case of several farms in the Pioneer Valley who rent pallet space in cold storage at Pioneer Cold[9].

B. Cool & Moist Storage (e.g. Potato Storage)

50-60˚F and 50-70% relative humidity

Although it is possible to store potatoes in cold and wet storage, this type of compromise leads to sweeter tasting potatoes and potentially shorter storage ability. Optimal storage for potatoes hovers at 38-40 degrees and 80-90% humidity (Whole Farm Services). Cool and moist storage is generally achieved using the same types of cooler insulation previously mentioned.

Some farmers find that the enhanced storability of potatoes when kept at their optimum conditions is valuable enough to designate a separate space for potato storage. The storability and quality of stored potatoes also depends heavily on post-harvest handling and proper curing. Most farmers find that potatoes store best when they are not washed going into storage but are washed only as they come out of storage to be sold. Potatoes should be sorted and culled prior to storage and again as they are packaged for sale.

Potatoes should be cured at 50-60 degrees Fahrenheit with about 95% humidity for 10 to 14 days (Yanta). Curing can be accomplished through the use of a Cool-bot[10] and humidifier in an insulated space. Cool-bots can create optimum potato storage conditions post-curing. They are most effective at maintaining storage temperature when appropriately scaled. Cool-bots are not recommended for space much larger than 1100 cubic feet.

Potatoes can also be stored passively. Blackwell Roots Farm in Cabot, Vermont has two designated spaces for potatoes, one passive and one cooled with a Cool-bot. In the passive room the temperature is maintained by two stovepipes that exhaust warm air and bring in cool air. The intake pipe that brings in cold air comes down from the ceiling and ends just a few feet from the floor. The exhaust pipe is higher, ending closer to the ceiling to capture rising warm air. Blackwell uses this room only to cure potatoes in the fall but it is likely that with enough thermal mass to keep the room from freezing, one could store potatoes passively with minimal electricity. Another possibility for a passive room would be to install fans within the stove pipes and have the fans connected to thermostatic switches. The exhaust fan would turn on as the room became warm and the intake fan would turn on to bring in more cool air. As the stored potatoes are sold and the thermal mass diminishes over the course of the storage season, it may be necessary to consider including a small electric space heater on a thermostatic switch that would keep the room from freezing.

C. Warm & Dry Storage (e.g. Squash Storage)

50-60˚F and 50-70% relative humidity

Warm and dry storage can be accomplished relatively simply. Many farmers use older coolers no longer needed for cold storage. These coolers can create ideal storage conditions for squash with the addition of a small electric heater on a thermostatic switch. Air circulation is particularly important in squash storage.

Eric Rozendaal of Rockville Market Farm stores several thousand pounds of squash annually. He chose to construct a separate heated building for squash storage that consists of a large metal building with eight-inch thick spray foam insulation. Rozendaal chose to heat the building using radiant propane heat below the concrete floor. Rozendaal believes that radiant heat works better than forced air when storage is at full capacity. Ideally, Rozendaal would have a heat exchanger that he could run when the storage is at full capacity.

D. Cool & Dry (e.g. Onion Storage)

40-50˚F and 60-70% relative humidity

When planning a cold storage system, onions are not generally allotted a storage space that meets their ideal storage conditions (cool and dry). This is because onions are tolerant to being stored at less-than-ideal conditions. Many farmers are able to find appropriate storage for onions outside of designated cooler space. Onions can be given supplemental heat that prevents them from freezing by placing them near the exhaust of a Cool-bot or cooler compressor. Most farmers are able to find a good place for onions adjacent to the coolers because they store well at the ambient temperature of most barns that are in-use through winter. Certain alliums such as leeks, ramps and chives are best stored with root crops in cold and wet storage.

E. Very Cold & Dry (e.g. Sweet Potatoes)

32-38˚F and 60-70% relative humidity

Sweet potatoes are becoming an increasingly popular crop to grow in southern Vermont and adjacent eastern New York and western Massachusetts. This rise in sweet potato production has dictated an increased need for sweet potato storage. Sweet potatoes have unique storage requirements in that their optimal storage conditions are very cold and dry, around 32-38 degrees Fahrenheit and between 60-70% humidity (Whole Farm Services). Cold and wet storage for root crops is too humid for sweet potatoes. The cool and moist storage for potatoes is too warm and too humid, and the warm and dry storage for squash is too warm for sweet potatoes. However, sweet potatoes may be tolerant to any of these less than ideal storage conditions. Paul Arnold of Pleasant Valley Farm in Argyle, New York has found success in storing sweet potatoes with squash when stored in the washroom, closed in by standard (not super-insulated) garage doors. A vent-less propane heater adds heat and also humidity as a by-product. Additional moisture is added by the weekly washing of roots in the same room. As a high-value crop, many farmers may choose to build storage that suits sweet potatoes' unique conditions.

F. Very Cold & Moist (e.g. Cabbage & Other Brassicas)

32-38˚F and 80-90% relative humidity

Cabbage (and other brassicas) can store well in cold and wet conditions but humidity may become an issue. Brassicas prefer between 80 and 90% humidity and may show signs of rot or disease when stored at humidity above 90%. One way to offset this is to store them in bins with lots of air circulation. For smaller quantities, brassicas can be packed single layered in an open-top stackable plastic bin. For larger quantities, plastic (or wooden) bulk bins can be used with adequate air circulation. Dan Kaplan of Brookfield Farm has found an interesting solution that works for him. Dan operates a self-serve winter CSA and has found that his cabbage quality stays highest if he wraps each head individually in newspaper and packs it in a single layer into a small plastic bin. When storing cabbage it is inevitable that a certain number of outer layers will have to be removed due to rot or disease (or both). Good cabbage storage will minimize the number of wrapper leaves to be peeled off, decreasing crop loss. Some find that certain types of disease or rot can be tasted in the final product, even after the visibly affected leaves have been removed.

IV. Other Important considerations:

There are many details to consider that could easily be overlooked when constructing a storage system. Listed below are some tips and hints I gleaned from my research trip.

A. Washing & Packing

Wash Stations can be an important part of crop storage systems. Many farmers choose to wash almost all of their crops going into storage. Farmers who store produce through winter are likely to need certain parts of a wash station set up indoors during the winter to wash potatoes at the very least. Wash stations are increasingly moving indoors due to concerns about complying with GAP Certification (USDA Good Agricultural Practices, described below) which mandates that "packing facilities must be enclosed." An indoor wash station is inevitably more versatile because it can be used throughout the year.

Wastewater from wash stations must be properly drained. Larger operations use settling tanks, perhaps followed by a leach field or gravel filter. A local NRCS officer or the conservation district may want to have input in the way the wastewater is captured and treated, depending on the size and location of the operation. It is generally worth checking with NRCS before installing a wastewater capture system.

There are various approaches to **washing storage crops**. Some farmers choose to wash the produce as it enters storage. Advantages to washing immediately after harvest include the availability of summer labor and the immediate removal of soil which causes staining and could potentially contain pathogens. Others wash and grade produce as it is taken out of storage for sale. Advantages to washing immediately prior to sale include washing at a less busy time of year and potentially increased storage quality (arguable for either method depending on crop). Staining from soil can be an issue in carrots when they are stored unwashed. Paul Arnold and Michael Kilpatrick claim that washing carrots in a barrel washer using high water pressure can remove staining, although the effectiveness of this method may depend on the soil type in which the carrots were grown. In 2010, Jericho Settlers Farm completed a study that examined the correlation between carrot staining and washing and storing methods. The study showed that carrots harvested and washed same day, put into cold storage immediately after washing had the least amount of staining after six-months of storage while maintaining marketable quality based on crunchiness and sweetness (Alexander).

GAP Certification[11] **(**Good Agricultural Practices as defined by the USDA) is of growing concern to many farmers who are looking to expand into institutional and wholesale markets. GAP's protocols have established certain specific standards for packaging and storage which can be viewed online (http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=stelprdc5097151).

B. Cooler Considerations

Air-circulation is essential in all storage but is especially important in cold and wet storage. Adequate air circulation can help minimize diseases like fusarium rot that become a problem at extremely high humidity. Methods that increase air circulation in cold and wet storage include leaving space in the produce bins to allow for air movement between stacked bins and leaving space between the bins and the walls. In dry storage (e.g. squash storage), fans are a good option to keep the air moving. This helps maintain the desired temperature throughout the stored product and may also help reduce rot.

Low-velocity fans are helpful in lessening energy costs and reducing moisture loss from the produce. Evaporator fans should be low velocity and/or should only run when the compressor is on. Compressor sizing is also an important consideration that needs to be taken into account. A compressor needs to be powerful enough to quickly remove all field heat from produce, but also small enough to maintain cool temperatures without excessive energy consumption. Here there are two clear options: the first is to find a compressor that is self-adjusting to run on fewer horsepower once field heat is removed. The second option is to buy two equally-sized smaller compressors that run simultaneously while field heat is being removed. Once produce is cooled, only one compressor will run. The advantage of the second option is that there is a back-up compressor if the first compressor were to fail. Some farms may choose to use a single smaller compressor and remove field heat by other means (e.g. by using an ice bath). Removing field heat becomes a nonissue with fall-harvested roots and brassicas when harvested at cold temperatures.

Another energy-saving invention is the Free-Aire System[12], a "cold-air economizer" which can help lower energy costs by pulling in cold air during the winter time to maintain the coolers at temperature. Free-Aire systems for produce introduce dry outside air during the cold winter months so it is essential to include an effective humidification system, either with humidifiers, misters or foggers, by packaging produce to minimize humidity loss, or both. The Free-Aire system adds start-up infrastructure costs but will save on energy costs over time. A cost comparison can be calculated to find out whether the Free-Aire system will be cost effective to install. For Vermont residents: Efficiency

Vermont[13] may have rebates available to offset some of the costs associated with the installation of Free-Aire.

Cooler doors are an important consideration; the wrong door in the wrong place can prevent logical flow of produce in and out of the cooler resulting in dramatically reduced efficiency. Sliding doors are generally superior to doors that open out because they do not create a vacuum effect that pulls cold air out and replaces it with air at ambient temperature and humidity. Sliding doors are best suited for small- to medium-sized coolers. Frank Doors[14] were recommended by Lee Blackwell. For bigger coolers that will be loaded and unloaded with a forklift or tractor a well-insulated garage door will likely be needed. For large coolers with lots of traffic, cloth doors, such as the Rytec[15] brand door, might be worth considering. Because these stand up well to being bumped by machinery, they may have fewer technical issues than a traditional garage door. In all coolers, **plastic curtains** immediately inside the cooler door help maintain internal temperature. Again, for Vermont residents: Efficiency Vermont[13] may have rebates available to offset some of the cost of cooler doors.

Lighting is often overlooked in the construction of a cooler or root cellar. In selecting the type of lighting, it is important to find bulbs than can turn on quickly at cold temperatures. Many compact fluorescent bulbs are slower to brighten at cold temperatures and may never be as bright as they would be at a warmer temperature. For this reason, Tony Lehouillier of Foote Brook Farm in Johnson, Vermont uses and recommends T8 fluorescent bulbs. Shatterproof or shatter resistant bulbs or a protective guard around a light bulb are also important considerations. Shatterproof or protected lighting is required for GAP certification.

Cellulose insulation (derived from recycled paper material) is becoming increasingly popular for use in coolers, wash stations and pack houses. Cellulose insulation is relatively inexpensive and can provide a high r-value. Installing effective moisture barriers is essential when using cellulose insulation. Ideally cellulose insulation is used only in exterior walls where the inner wall has a moisture barrier and the exterior side is able to shed moisture. Cellulose insulation is used in the exterior walls of the packing house and cooler space at Pete's Greens in Craftsbury, Vermont, and in the walls of the wash house at Red Fire Farm in Montague, Massachusetts.

Cool-bots[10] are popular as a cost-effective replacement for an evaporator and compressor in small coolers (less than about 1100 cubic feet). Cool-bots are a device that allows the user to override the temperature controls on a standard air conditioner (Cool-bot recommends LG brand). Cool-bots are effective at maintaining temperatures but are slow to remove field heat from a large mass of produce. They also have a tendency of icing-up when cooling a large thermal mass of vegetables. Their best application may be cooling small amounts of produce as they move in an out of the cooler during the summer months, or maintaining the temperature of produce that has already been cooled. The Cool-bot website (http://storeitcold.com) has extensive information, including tips for success when using Cool-bots.

C. Rodent & Pest Control

Rodents and pests can become a costly issue in any type of crop storage system. Prevention and careful management is crucial in avoiding large losses. Some systems have more trouble eradicating pests than others. For example, storage systems built into existing structures generally have more rodent problems than those that are built as new freestanding structures. All of the farms I visited had a pest management program in place that involved some combination of bait and traps. Paul Arnold of Pleasant Valley Farm in Argyle, New York has found success using Agrid3[16] which is an OMRI-approved (Organic Materials Research Institute[17]) rodenticide made from vitamin D3. Lee Blackwell of Blackwell Roots credits the air-tight envelope formed by the spray foam insulation with his success in pest control. As he explained, if a rodent can't smell the produce stored on the inside of the cooler they will be less motivated to dig through the insulation looking for food. At Pete's Greens, their newly created storage and packing house sits on a cement slab with a three foot curb. The cement curb has prevented the infiltration of rodents and other pests, and as of March 2012, they had not had any issue with rodents. In any storage system, the manager must always be vigilant for signs of rodents, constantly checking and replacing bait stations and traps so that extensive crop loss from rodent damage does not become a problem. Producers can look to OMRI for an up-to-date list of organic-approved pesticides and rodenticides by following this link: http://www.omri.org/simple-opl-search/results/Processing%20Pest%20Controls.

D. Crop Varieties

Of course, the varieties a farmer chooses to grow play a significant role in both the quality and the longevity of stored produce. **Growing varieties that have been bred and proven to store well is essential to successful storage.** In production planning it is imperative to consider which varieties of crops to grow for fresh sale and which varieties to grow for storage.

V. Conclusion

The caliber and diversity of the storage sites I visited for this study demonstrates the creativity and innovation of the farmers who built them. The farmers' thoughtfulness and careful consideration in their design and decision-making is exemplary.

Chris Callahan, University of Vermont-Extension's Agricultural Engineer, has recently completed a survey of farmers in Vermont. The results of the survey told not only of the types of storage in use in the state but also of farmers' understanding and their need for more information. The survey confirmed the degree of diversity among Vermont's farming community. Winter market outlets were dominated by wholesale (74% sell to this market), but sales to the retail sector and through farmers markets and winter CSA were equally divided with 38-41% reporting sales to each. Many storage systems were represented in the survey including walk-ins, heated winter storage, root cellars, and cool-bots. The survey's major finding was the unexpectedly high degree of interest in learning about storage systems. Callahan is now working on the creation of a UVM-Extension course designed to help farmers understand and evaluate their cold storage options.

Much remains to be learned in the optimal storage of vegetables for small- to mid-scale diversified farms. As I've come to understand through this study, in order to make an informed decision about improving crop storage through infrastructure improvement, there are a great many things to consider. Consideration of economics and end-markets ultimately weigh heavily in a farmer's decisions regarding infrastructure investments for crop storage and are not fully-examined in this study. Each farmer must examine these factors individually; taking into consideration the goals he or she holds for the farm.

There are many subtle nuances that must be considered in the creation of a storage system. It was my intention in writing this narrative to bring as many of those subtleties to light as possible so farmers do not have to learn of them "the hard way."

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VII. Tools and Resources Cited:

1. Nor-Bec (based in Quebec)
Source of pre-fabricated cooler boxes and other materials
Used at Intervale Community Farm
http://www.norbec.com/

2. Stressed Skin Panels/Structural Insulated Panels (SIPs)
Foam Laminates of Vermont is a SIP manufacturer (based in Vermont)
Recommended by Isaac Jacobs at Pete's Greens
http://www.foamlaminates.com/structural_insulated_panels.html

3. American Wholesale Refrigeration
Source of used cooler panels and other materials
Used at Kilpatrick Family Farm and Red Fire Farm
http://www.awrco.com/

4. Ames Research- Liquid Rubber
Used as spray foam sealant
Used at Blackwell Roots
http://www.amesresearch.com/

5. USDA Agriculture Handbook Number 66: The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks
A comprehensive publication on storage requirements of most crops grown in the U.S.
http://www.ba.ars.usda.gov/hb66/contents.html

6. Aqua Fog Hidro
Humidifier for cold and wet storage
Used at Intervale Community Farm
http://www.cloudtops.com/misting_fans_fog_fans/aquafog700.php

7. Netafim Coolnet Fogger
Greenhouse fogger, can be used for humidity in cold and wet storage
Used at Blackwell Roots Farm
http://www.netafimusa.com/greenhouse/products/foggers

8. Smart Fog Humidification Systems
Humidifiers and misters that can be used in cold and wet storage
Used at Tangerini's Spring Street Farm
http://www.smartfog.com/

9. Pioneer Cold
Cold storage space for rent, used by some Pioneer Valley Farmers
Chicopee, MA
http://www.pioneercold.com/

10. Cool-bot (based in Vermont)
A/C unit to cooler compressor converter
Used by Blackwell Roots, Jericho Settlers', and others
http://storeitcold.com/

11. USDA-Good Agricultural Practices
User's Guide
Part 3: House Packing Facility (p 17-20)
Part 4: Storage and Transportation (p. 20-21)
http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=stelprdc5097151
Checklist:
Part 3: House Packing Facility (p 14-17)
Part 4: Storage and Transportation (p. 17-21)
http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5091326

12. Free-Aire Refrigeration (based in Vermont)
Cold air economizer
Used at Intervale Community Farm, previously used at Pete's Greens
http://freeaire.com/

13. Efficiency Vermont
Energy efficiency consulting, energy efficiency rebates for Vermont businesses
http://www.efficiencyvermont.com/for_my_business/ways-to-save-and-rebates/Refrigeration/rebates.aspx

14. Frank Doors
Cooler doors
Used by Lee Blackwell and others
http://www.frankdoor.com/index.php

15. Rytec Doors
Cloth overhead doors
Used by Pete's Greens
http://www.rytecdoors.com/industry/?id=11

16. Agrid3
Organic pest control
Used by Paul Arnold
http://www.motomco.com/p_agrid.htm

17. Organic Materials Review Institute
Review of pest control systems
http://www.omri.org/simple-opl-search/results/Processing%20Pest%20Controls

VIII. Other Tools and Resources:

Alpine Refrigeration (based in Vermont)
Refrigeration specialists, consulting and materials, dealer for Free-Aire systems
Used by Blackwell Roots
1532 Hill Street Ext, Montpelier, VT 05602
802-229-0074

American Warehousing
Source of used cooler panels and other materials
Used by Tangerini's Spring Street Farm
http://www.americanwarehousing.net/index.htm

Davis Weather Station
Wireless temperature and humidity alert system
Used by Pleasant Valley Farm
http://www.davisnet.com/weather/index.asp

NOFA-Vermont
On-farm research studies of carrot and squash storage
http://nofavt.org/programs/technical-assistance-education-vegetables/winter-growing-research-results

Stone Brothers Inc (based in Vermont)
Installation of cooling systems
Used by Deep Root Cooperative
47 East Hill Ext, North Troy, VT
802-988-2373

RC Soule of Dick Soule Inc (based in Vermont)
Installation of cooling systems
Used by Intervale Community Farm and Jericho Settlers' Farm
3598 VT Route 105, Enosburg Falls, VT 05450
802-933-6167

Winter Panel Company (based in Vermont)
Source of cooler panels, structural insulated panels, and other materials
Used at Kilpatrick Family Farm
http://www.winterpanel.com/

Whole Farm Services (based in Vermont)
Crop Storage Systems Consulting Service
http://wholefarmservices.com/crop_services.shtml

IX. Farms Visited:

Blackwell Roots Farm
Lee and Ruth Blackwell
Cabot, Vermont

Brookfield Farm
Dan Kaplan and Karen Romanowski
Amherst, Massachusetts

Foote Brook Farm
Tony and Joie Lehoullier
Johnson, Vermont

Jekanowski Potato Farm
Paul Jekanowski
Hadley, Massachusetts

Jericho Settlers' Farm
Christa Alexander and Mark Fasching
Jericho, Vermont

Kilpatrick Family Farm
Michael Kilpatrick
Middle Granville, New York

Pete's Greens
Pete Johnson
Craftsbury, Vermont

Pleasant Valley Farm
Paul and Sally Arnold
Argyle, New York

Red Fire Farm
Ryan and Sarah Voiland
Montague and Granby, Massachusetts

Rockville Market Farm
Eric Rozendaal
Starksboro, Vermont

Tangerini Farm
Charlie and Laura Tangerini
Millis, Massachusetts

Other Sites Visited:

Deep Root Cooperative Storage Facility
Anthony Mirisciotta, Manager
Johnson, Vermont

Vermont Food Venture Center
Monty Fischer, Executive Director
Hardwick, Vermont