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Organic Vegetable Farms in New England: Three Case Studies

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Cover: New Leaf Farm apprentices and farmers harvesting salad greens. They are harvesting a row that has had its white row cover removed. The row cover is used to keep out flea beetles and other insect pests and to extend the growing season.

GENERAL ACKNOWLEDGEMENTS

First, I must acknowledge the extraordinary cooperation of the farmers profiled in this study. All three spent an enormous amount of time working with us, answered all of our questions – even sensitive questions about the economics of their farms – and are deeply committed to sharing their knowledge with others for the benefit of organic farming. Second, the dedication of the technicians who collected data from the farmers and in the field was also extraordinary: Erin Sturgis-Pascale, of the Connecticut Agricultural Experiment Station; and Chris Cousins and Sigurd Spearing, of the New England Small Farm Institute. Dr. Sue Ellen Johnson (formerly of the New England Small Farm Institute, now of North Carolina State University), had responsibility for overseeing the field work for the case studies in New England. Funding for the research presented here came from the U.S. Department of Agriculture Initiative for Future Agriculture and Food Systems, "Northeast Consortium for Organic Agriculture."

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All photographs were taken by Chris Cousins or Sigurd Spearing.

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Introduction

The case studies presented here grow out of a tradition in organic agriculture of scientists working closely with experienced organic farmers to learn how an organic farm works as an integrated system. Organic farming grew up independent of the scientific establishment, with farmers learning mainly from each other. The Northeast Organic Farming Association (NOFA), the Maine Organic Farming and Gardening Association (MOFGA), and similar organizations across the U.S. and the world, have promoted farmer-to-farmer learning since the 1970s through conferences where farmers have a major role as organizers and educators.

These organizations started working with researchers and extension educators to document the practices of organic farmers in the 1990s. A landmark document was *The Real Dirt* (Smith 1994), which supplemented extensive material from farmer interviews with commentary from researchers and extension educators. Around the same time, NOFA collaborated with the University of Massachusetts Cooperative Extension System in holding a series of farmer-to-farmer conferences, with research and extension personnel also participating, and published reports of the results (NOFA 1994). This was followed by a series of farmer-scientist conferences dealing with particular topics, such as managing vegetable insects (Stoner 1999). The Organic Farming Research Foundation pushed the idea of farmer-scientist conferences on a broader scale, with three national conferences in 2001 (see the website http://ofrf.org/scoar/archives.html).

The Northeast Organic Network (NEON), which did the research for these case studies, explored several more structured ways of having farmers and scientists work together to describe organic farming systems.

The goal of the case studies was to engage scientists in a wide range of disciplines in learning from organic farmers, getting a deeper understanding of how their systems work, and presenting that understanding in ways that would be useful to other farmers, researchers, educators, and students. These case studies are unusual in that they combine several different approaches: interviews with the farmers, collection and analysis of their records for certain selected crops, and field data on the same crops collected by scientists and technicians. Eleven organic vegetable and cash grain farms in the Northeast were studied. For various reasons, the full reports have never been completed for many of the other eight farms, but these three farms in New England had complete case reports, similar in structure and level of detail, and so we decided to go ahead and publish them as a group.

The data for the case studies came from the growing seasons of 2002 and 2003, a critical moment in the development of organic farming in the U.S. The U.S. Department of Agriculture published a final rule to implement the National Organic Standards in December of 2000. The rule went into effect in April of 2002, and was fully implemented in October of 2002. So the farmers were all in transition from locally run organic certification programs, based on rules set by non-profit organic farming organizations, to the national organic certification program, with rules set by the Federal government. This is sometimes reflected in changes in practices from 2002 to 2003, such as the loss of cottonseed meal as a fertilizer at the Carusos' Upper Forty Farm, but is also reflected in the interviews with farmers.

These case studies are probably more valuable as illustrations of diversity than as a population from which to make generalizations. Each of these farms is a unique combination of the interests, skills, and resources of the farmers with the capacities and limitations of a particular piece of land. In the text we have identified a few key choices that determine many of the other characteristics of each farming system: the Colsons' decision to "ride the wave" of mixed salad greens in the 1990s (a wave which they feared was running out in 2003); Tom Harlow's decision (with his brothers) to build storage facilities at Kestrel Farm and focus on winter storage crops; and the Carusos' decision to focus on diversity, novelty, and most of all, flavor that would command a premium price in direct marketing.

There are challenges that organic vegetable farms have in common. Soil building and weed management are two major challenges, but while the principles are the same, the specifics for these farms differ. At New Leaf Farm, the foundation of both soil building and weed management is the long rotation into cover crops, so that only 1/3 of the crop acreage is in intensive vegetable production in any growing season, with the other 2/3 in a cover crop program. This program lowers the overall weed level, but has to be supplemented with considerable mechanical cultivation and other methods such as mulching and flaming stale seed beds. At Kestrel Farm, composted dairy manure is the basis of the soil building program. Weeds are managed through rotating fields through different kinds of vegetables with different growth patterns and weed vulnerabilities, and with timely management through cultivation and flaming, made much easier by the excellent, well-drained soil. At Upper Forty Farm, with its difficulties with soil drainage, soil building and weed management are both much more difficult. The Carusos continue to work with composting for soil building, and cultivation equipment and mulches for weed management, to find a system that will work consistently for them.

All three of these New England farms make very little use of organically acceptable pesticides. This was not true of some of the NEON case study farms in other parts of the Northeast – some of those organic farms made quite frequent applications of copper hydroxide for control of plant disease and botanical insecticides. The very minimal pesticide use by these three farms probably reflects a lower pest pressure in New England than in the mid-Atlantic states, but also reflects the philosophies of these three farmers. They are prepared to accept some loss to pests and disease in order to limit the use of even the pesticides available to them as certified organic farmers. Our field studies did not indicate high pest levels on these farms, except for foliar diseases in tomatoes at Upper Forty Farm.

These three studies illustrate three different routes to successful management of an organic vegetable farm. By having scientists collect information from the farms, they illustrate how the organic methods of these farmers look from a scientific point of view: an estimated nutrient budget for their crop rotations and soil amendments; estimates of pest, disease and weed densities; yield estimates; and a rough accounting of income and expenses for the focal crops. This scientific data was of value to the farmers – for example, none of them had ever had a nutrient budget for their farms, and it was enlightening for them to be able to relate their nutrient budgets to their soil tests, and to get some quantitative evaluation of their soil fertility practices.

Each farm clearly does some things extraordinarily well, and most things fairly well – otherwise the farms could not survive as businesses in the difficult world of small, diversified farms. There are always constraints on farms and farmers – mostly lack of time, energy, and information, and sometimes also limits imposed by weather and soil, that keep things from running perfectly. But the object of this exercise was not to evaluate each practice, or farmer, or farm, but to provide a detailed description of how the farming system works that would be useful to other farmers, scientists, educators, and students who want to gain insight into a few shining examples of organic vegetable farms.

Literature Cited:

NOFA. 1994. *Proceedings of the Northeast Farmer to Farmer Information Exchange.* Sweet Corn, Apple, Greenhouse, Strawberries, Livestock. Northeast Organic Farming Association and the Universtiy of Massachusetts Cooperative Extension System.

Smith, M. (ed.) 1994. *The Real Dirt: Farmers Tell About Organic and Low-Input Practices in the Northeast.* Northeast Regional Sustainable Agriculture Research and Education Program, Burlington, VT.

Stoner, K.A. (ed.) 1999. *Alternatives to Insecticides for Managing Vegetable Insects: Proceedings of a Farmer/Scientist Conference.* Natural Resource, Agriculture, and Engineering Service. NRAES – 138. Ithaca, NY.

Kestrel Farm
Tom and Merrilee Harlow, Westminster, VT

Crops:	Vegetables: mainly lettuce, sweet corn and winter storage vegetables
Markets:	90-95% wholesale, 5-10% farmstand
Total Farm Acreage (cultivated acres):	89.5 (50)
Certifier (1st year certified):	Vermont Organic Farmers (1988)
Soils:	Highly productive, well-drained, flat, river bottom soils
Hardiness Zone:	5a
Frost Free Days:	100-120 days per year
Watershed:	Connecticut River
Rainfall Average:	36-40 inches per year
Irrigation Sources:	Connecticut River, Cob Brook, pond

The Connecticut River Valley has the finest agricultural soils in New England, thanks to its geological history of thousands of years as the bottom of a giant glacial lake at the end of the last Ice Age. This glacial lake, called Lake Hitchcock, formed behind a natural dam in the area of Rocky Hill, Connecticut, and as the glacier retreated north and the ice melted, the water backed up 250 miles over the next 4,000 years. When the lake finally drained 12,000 years ago, it left behind major silt deposits that have formed the highly fertile land just above the Connecticut River.

The Harlow family settled on this fertile land in Westminster, Vermont in 1918. The original family farm was bought by Tom's grandfather and is still farmed by his brother Paul. Tom started out working for his father right after graduating from high school, then later worked for Paul. Paul Harlow was one of the first farmers in the area to convert to organic, becoming certified in 1985. Tom learned organic methods working with Paul, and then started out on his own, organic from the beginning, in 1987 on rented land.

Figure 1. Tom Harlow.

Tom spent five years shopping for a farm to buy before Kestrel Farm became available in 1994. It was a stretch to buy nearly 90 acres of this prime Connecticut River Valley farmland . It has been a great purchase. Not only does it have level fields of prime alluvial soil with no large stones, it also has an ample supply of water from the Connecticut River and a creek. The location, close to his brother Paul and the family farmstand, run by Tom's other brother Dan, allows the three brothers to work together closely in production, processing, and marketing.

Tom's main goal for the farm is to keep it in as good condition as he can. Soil improvement was a major reason he began farming organically, along with a dislike of handling hazardous chemicals. Tom does not know who will be farming at Kestrel Farm in the long run, but he is confident that it will continue as a working farm into the future, because of the conservation easement on the farm and local zoning that requires keeping 60% of large parcels in agriculture. He intends to maintain and improve the soil and the buildings for future farmers, whoever they may be.

As pioneers in the organic movement, the Harlows have championed larger scale organic farming and marketing techniques since the mid-1980's. They maintain a commitment to supporting local community enterprise, family farming and healthy food production, and have been innovators in working out appropriate wholesale marketing approaches for farms located a distance from population centers.

Key Features Critical to the Farm's Success

Tom identified his crop mix, and particularly the emphasis on winter storage crops, as critical to Kestrel Farm's success. His crop mix allows him to spread labor, marketing, and cash flow over the year, and to reach out to wholesale markets over a large area. Tom says that he could grow and sell more storage crops, but his limitation is storage capacity. It would cost him $50,000 to build more storage space. Another key feature has been his ability to recruit and keep skilled labor over several years in a difficult labor market. The labor supply is a concern for the long-term future, as is true for many farmers.

His network of family, neighboring farmers, markets, and truckers is another critical factor, and the nearly ideal combination of deep, level, fertile, well-drained soils and abundant water for irrigation supports the production capacity of the farm.

Community Interactions

Paul Harlow was a charter member of the Deep Root Organic Co-op, and Tom joined in 1988. The Co-op was based for many years at Paul's farm. Deep Root played an important role in developing markets for organic vegetables in the Northeast, and as the markets grew, vegetable farmers around Vermont took notice and began producing organically for those markets. The Harlows stayed in the Co-op as long as they could for the community aspect, but finally decided that economics of the Co-op were no longer benefiting them. From their position relatively close to markets in southern Vermont, they could do better themselves without the burden of subsidizing more remote growers stretching all the way into Quebec. So the brothers formed their own company, Westminster Organics, and took over their own marketing and distribution.

Figure 2. Moving pumpkins into storage at Kestrel Farm.

The local networks Tom has built up over the years have been key to his success. He recognizes that it would be hard for a new farmer to get started without his connections to family, neighboring farmers, distributors, and local markets.

Farm Assets

The floodplain soils at Kestrel Farm are highly productive but some fields are subject to periodic flooding of the feeder streams, especially after a winter with heavy snow. The Hadley silt loam and Ondawa fine sandy loam along the river runs deep with 40 inches or more entirely free of stones. While this nearly flat farmland is well suited to cultivated crops, it is very well drained and requires irrigation from the river or nearby streams and ponds in the summer.

Tom's capacity to store crops for months under suitable conditions allows him a wide range of options in crop mix, marketing, and labor management, as mentioned above. Kestrel Farm has 450 bushels of cold storage capacity and 1500 bushels of warm storage capacity (Fig. 2). In addition, Tom can keep 1000 bushels of crops in cold storage at his brother Paul's farm. Parsnips and beets are the major crops Tom keeps in cold storage, while potatoes, winter squash, and pumpkins are kept in warm storage.

Another key asset to Kestrel Farm is its skilled and dedicated workforce. One full-time, year-round employee has lived and worked on the farm for the past six years. She is both the foreman of the crew of 8-10 local high school and college students each summer and a skilled equipment operator, doing much of the transplanting, cultivating, and bed preparation for Tom and Paul's farms. Another long-term employee has worked for Tom for five field seasons, spending the winters off the farm, and a number of the summer workers stay for two or three seasons before moving on.

The long-term workers get annual raises and a guarantee of 40 hours a week of work, with great flexibility to let them work as many hours as they want when they need the money, or to take vacations as needed.

Tom's focus on growing storage crops helps him to keep his skilled workers, because washing, sorting, and packing these crops spreads the work for the long-term employees throughout the year. As shown by the crop availability chart (Fig.3), the marketing season for Kestrel Farm stretches 10 months of the year from May to February.

General Crop Marketing and Business Strategies

Westminster Organics, the Harlow brothers' marketing and distribution arm, sells mainly to large wholesale markets. The storage crops, especially parsnips and beets, are trucked to distributors in Florida, Pennsylvania, and the Hudson Valley of New York, as well as to the primary market in Boston and other cities in New England. Tom would add more wholesale accounts if he could, but he sees the markets consolidating as larger distributors like United Natural Foods buy up smaller distributors, and large chain groceries like Whole Foods displace local chains. Trucking to these larger and more distant markets can be difficult, but the Harlows take advantage of their connections with local trucking to get the produce out.

Their sales to local stores, like the Brattleboro and Putney Co-ops, and to regional distributors are increasing, and the costs of trucking and packaging are reduced, but keeping a diverse product line of crops for these local markets tends to increase labor costs.

In addition their wholesale marketing, the Harlows also run a retail business. The Harlow Farmstand was built in 1991 at an excellent roadside location, was modernized in 1999, and now houses a café and deli as well as coolers full of fresh organic produce.

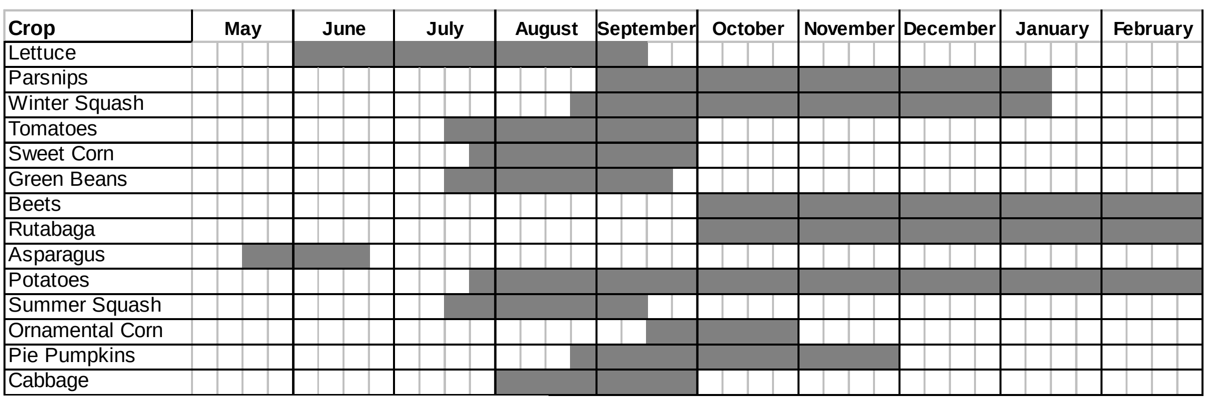

Figure 3. Crop availability at Kestrel Farm.

Crop Management

The typical rotation at Kestrel Farm follows the basic sequence lettuce – parsnips – corn or winter squash – lettuce. Ideally, Tom would like to be able to put his fields into red clover between the parsnips and the corn or squash, but his current 3-year sequence does move through a leaf crop, a root crop, and a fruiting crop in 3 different families.

In our assessment of field cover in April, 2003, Tom had 13% of his field area in clover, 73% was under "rye/vetch" cover, 8% was in rye alone, and only 6% was bare. Although Tom mixes 10-15% hairy vetch with his winter rye seed (which he combines himself on the farm), very little vetch was present in spring of 2003. Tom tries to get a cover planted on all of his fields except those designated for parsnips in the following year, because cover crop residue interferes with making the fine seedbed needed for parsnip germination. He seeds covers on some fields in early September, but because he grows so many fall crops, many of the fields do not get seeded until October. This is too late to get good germination of hairy vetch.

Dollar-wise, looseleaf lettuce is Kestrel Farm's primary wholesale crop, grown on about 10 acres over the course of the season. The farm crew sows successive crops of 10,000 plants in flats every week that are grown out in cold frames and mechanically transplanted into field beds six weeks later.

Parsnips are Kestrel's other major wholesale crop, grown on 6 to 7 acres annually. This makes Tom Harlow one of the largest producers of organic parsnips in the Northeast, and Westminster Organics sells parsnips through the winter to a wide range of wholesale distributors of storage crops.

The farm's largest crop in acreage is 16 acres of sweet corn, grown in successive plantings for regional wholesale and retail sales at the farmstand. Around 10 acres of winter squash (mostly butternut) is grown for the same markets. A variety of other vegetable crops (see Fig. 3) are each grown on 1 or 2 acres.

Soil Management and Crop Fertility

Compost made from dairy manure with sawdust bedding (0.3% N, 0.08% P, 0.3% K measured in a single sample) is the basis of Tom's fertility program. For side-dressing and to fill in when he doesn't have enough dairy compost, he uses a fertilizer based on pelleted composted chicken manure: either Kreher's (NPK of 5-5-3) or Purdue (4-4-3). Soil amendments are tailored to the needs of particular crops: Early plantings of lettuce (when the soil is too cold for good microbial release of N) are side-dressed with Chilean nitrate, and later plantings are side-dressed with pelleted fertilizer. Parsnips (which, unlike the other crops, do not get an initial application of compost) are side-dressed with one of the pelleted fertilizers and later with Sul-Po-Mag. Sweet corn is side-dressed with the pelleted fertilizer and also with Chilean nitrate if the pre-side-dress nitrate test indicates a need for readily available nitrogen. According to the rules of the National Organic Program, the use of Chilean nitrate is restricted to 20% of total N requirements.

Soil tests taken from 1995 to 2002 (see Table 1) indicate that most soil measurements have changed very little over 7 years. The major exception is potassium, which has moved from a level rated "low" by the University of Vermont up to the "medium" range for most fields. Many soil measurements were already in a favorable range in 1995 and have remained there. Magnesium levels are always rated as "optimum," and the pH ranges from low in some fields (5.6 – 6.1) to optimum (6.6 – 6.9) in others. Phosphorus measurements on different fields are rated by UVM from "high" to "excessive," and have increased over time, which would be a concern if the increase continues into the future.

Table 1. Soil test results for Kestrel Farm, 1995-2002, analyzed by the University of Vermont. Mean (standard error) of 10 fields.

	1995	1998	2002
Phosphorus (lb/acre)	32 (3.1)	37 (4.4)	37 (4.6)
Potassium (lb/acre)	110 (11)	140(12)	140 (18)
Magnesium (lb/acre)	160 (14)	180 (15)	170 (16)
Calcium (lb/acre)	1460 (89)	1660 (78)	1500 (57)
pH	6.4 (0.1)	6.4 (0.1)	6.3 (0.1)
Cation Exchange Capacity (meq/100g)	4.5 (0.3)	5.1 (0.3)	4.7 (0.2)
Percent Organic Matter	2.2 (0.1)	2.3 (0.1)	2.1 (0.1)

The increase in potassium and slight increase in phosphorus in the soil tests correlate generally with the nutrient budget for a 6-year sample rotation below, although the nutrient budget shows larger projected increases for both P and K than found in soil tests over a 7 year period.

Kestrel Nutrient Budget

In order to make rough estimates of the tendency of Kestrel farm's rotation and fertility practices to either accumulate or deplete soil nutrients, the Northeast Organic Network (NEON) made a nutrient budget for nitrogen, phosphorus, and potassium on a hypothetical field using a typical rotation, yield, and fertilizer inputs. We used a six year rotation: 1) parsnips, 2) sweet corn, 3) lettuce, 4) parsnips, 5) winter squash, and 6) lettuce.

Following typical fertilization practices at Kestrel Farm, we assumed a base of 20 yards/acre (18,500 lb dry weight/acre) of dairy manure compost for fertilizing the sweet corn, lettuce, and winter squash. Kreher's 5-5-3 and Chilean nitrate were used in side-dressing the sweet corn and lettuce according to Tom's practices. The dairy manure compost is not applied to fields for parsnips, so we assumed an average rate of 550 lb/acre of Kreher's 5-5-3 and 400 lb/acre of Sul-Po-Mg for this crop. A contribution from hairy vetch to the nitrogen budget was assumed only for the winter between year 2 (sweet corn) and 3 (lettuce), when it would fit into the timing for the crops.

The model nutrient budget (Fig. 4) showed accumulations of all three major plant nutrients over the six year period. There was a moderate projected rise in P levels of 32 lb/acre. Given the high P levels in soil tests, a large accumulation over the long term would be something to avoid, especially in Kestrel Farm's river location. Potassium levels are also rising (+94 lb/acre), although, as we have seen above in soil test results, some excess of K may actually be beneficial in order to increase the low levels of K found in past soil tests. Note that the projected increases in both P and K based on this model budget are larger than the measured increases in soil tests. Part of this can be explained because much of the excess P may be converted into unavailable forms.

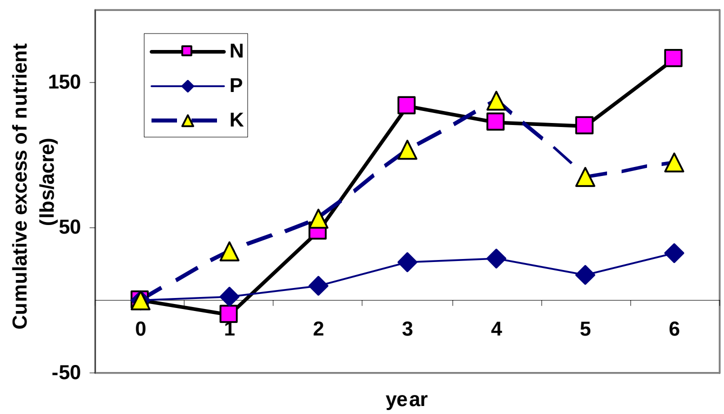

Figure 4. Kestrel Farm nutrient budget. Cumulative nutrient balance (excess of amounts applied over amounts exported as crops) for nitrogen (N), phosphorus (P) and potassium (K) on a modeled field at Kestrel farm over six years, with the following rotation: parsnips, sweet corn, lettuce, parsnips, winter squash, and lettuce.

Nitrogen also seems to be over-applied in the course of the rotation (+165 lb/acre, or roughly 27 lb/acre/year), although nitrogen is not as precisely estimated in the model as are P or K. Leaching, gaseous loss, and the tendency of a legume like the vetch cover crop to auto-regulate the amount of N fixed based on soil N concentrations are all factors that could lower this very rough estimate of N accumulation. Nevertheless, the Kestrel rotation appears to be maintaining N at levels that are sufficient or above what is needed for good crop yields. It is possible that levels of sidedressed N could be reduced without affecting yield.

Pest and Disease Management

Tom does little spraying or other intervention directed at pest management. Because he has been growing the same crops for a long time, he has a good sense of which pest problems are likely to affect the final harvest, and which aren't. His experience has also been that, in many cases, the available organic sprays aren't likely to make much difference in pest or disease control.

He applied only two sprays to any of the focal crops in two years. He applied a spray of OxiDate ® (a hydrogen dioxide product) to 2 of his 4 parsnip plantings in 2002. He was concerned about the potential for spread of the *Itersonilia* root canker (Fig. 5). His observation was that the rate of spread slowed, but it might well have been an effect of changes in the weather, rather than the spray. *Itersonilia* is a continuing concern because he grows such a large area of parsnips and the pathogen is present every year, but the disease seldom reaches a level that results in a significant loss of marketable roots. He also applied Aza-Direct (a neem product) in 2002 to some of his lettuce plantings (not the ones we tracked) to manage aphids.

Another way to manage pests and diseases is to have market channels that reduce the importance of mild cosmetic damage to the product. Tom does this by selling some of his butternut squash already peeled and sliced. Squash with surface imperfections due to black rot or growth cracks can be sent to the peeling operation and sold as a value-added product.

The main spray material Tom generally uses is *Bacillus thuringiensis* (Bt). In addition to applying Bt to sweet corn to manage European corn borer and corn earworm, he also uses Bt against imported cabbageworm and tomato hornworm. In the past, he used a different strain of Bt (*Bacillus thuringiensis* var. *tenebrionis*) against Colorado potato beetle, although there is currently no formulation of this material approved by the Organic Materials Review Institute.

Figure 5. *Itersonilla* root canker in parsnip.

Tillage and Weed Management

Tom's crop rotation pattern puts into each field in successive years a series of crops with different timing and that can handle different cultivation tools. Because his soil drains so quickly, Tom can nearly always get in to prepare and cultivate fields when needed. The list of equipment at Kestrel Farm (Table 2) shows the range of tools he has available for the different crops in his rotation. (Some of the equipment is shared with Paul.) He relies heavily on mechanical cultivation, supplemented with hand labor. The weed seed banks at Kestrel Farm are considerably higher than on some of the other NEON focal farms, so even though our focal crops were cultivated frequently and in a timely way, the weeds still produced considerable biomass and seeds in some of the fields we studied. A summary is given in Table 3.

Table 2. Equipment list for Kestrel Farm

Tractors	**Planters**
1978 Massy Ferguson 285 83 HP	4 row Planet Jr.
1988 John Deere 900 High Clearance 24 HP	2 row John Deere MaxEmerge
1990 Landini 4wd Mudders 60 HP	1 row Cole Pumpkin Planter
Attachments	**Transplanters**
5 bottom CASE moldboard plow	2 row Powell
John Deere 115 Disk Harrow	4 row celled planter (not sure of make)
Glencoe Field Cultivator	**Flame Weeder**
Manure Spreader, 300 bushel (currently broken)	Custom made German propane, 4 feet
Spinner/Spreader, 3 point	**Spray Equipment**
Cole/Powell Sidedresser	Solo Mist Blower, 3 point hitch
Lely tine weeder	Boom sprayer (fungicide)
Antique steel wheeled cultivator	**Harvester**
Buddingh basket weeder	2 AMC carrot harvesters
various sweeps and shovels for John Deere and Landini	**Irrigation**
Lilliston two row rolling cultivator	4000 feet of aluminum piping
Bed forming tools	overhead sprinklers
Ridger	PTO driven pump
Bed renovator	**Washer**
Press pan	Knolts brush washer (squash, rutabaga, potato)
Bed lifter	Barrel washer (beets and turnips)
Combine	**Peeler**
Allis Chalmers Gleaner (old)	modified wood lathe (winter squash)

Table 3. Kestrel Farm weed density, above ground dry weight, main weed species, and seed production. Mean (standard error)

Crop	Year	Weed density, all species (plants/acre)	Weed above ground dry weight (lb/acre)	Main weed species	Important weed seed producers
Lettuce	**2002**	**51,000** (19,000)	**47** (26)	Barnyardgrass Purslane Carpetweed	Nightshade Pigweed Lambsquarters
	2003	**33,000** (1,700)	**11** (5)	Pigweed Lambsquarters Witchgrass	No seed production
Winter squash	**2002**	**123,000** (29,000)	**187** (43)	Pigweed Lambsquarters Crabgrass	Pigweed
	2003	**14,000** (8,000)	**980** (410)	Pigweed Crabgrass Galinsoga	Pigweed Crabgrass Galinsoga
Parsnip	**2002**	**19,000** (6,000)	**1,100** (760)	Lambsquarters Pigweed Barnyardgrass	Lambsquarters Pigweed Barnyardgrass
	2003	**18,000** (3,000)	**470** (260)	Crabgrass Pigweed Lambsquarters	Crabgrass Pigweed Lambsquarters

Focal Crop - Lettuce

Cultivars: 2002: 'Two Star,' and 'Red Sails' (looseleaf), 'Green Forest' (romaine)
2003: 'Two Star' and 'Red Fox' (looseleaf), 'Green Forest' (romaine)

Fertilization: composted dairy manure on east half (20 cu. yd/acre), Krehers 5-5-3 on west half (400 lb/acre). Plantings 1-3: Side-dress with Chilean nitrate (180 lb/acre). Plantings 4-7: Side-dress with Kreher's 5-5-3 (300- 450 lb/acre)

Planting: Transplanted weekly April 21 – June 1.

Spacing: Raised beds 33 inches wide, with 9-inch furrows between. Two rows per bed, 15 inches apart, 12 inches between plants in a row (Fig. 6)

Harvest: Daily by hand, May 28 -- June 30.

Crop Establishment and Management: The specific field information for lettuce given here will be just for 2002 because in 2003, Tom's lettuce operation was so thoroughly entwined with his brother Paul's that Tom felt he could not give us accurate records for that year. Unfortunately, 2002 was an unusual year, because Tom lost a large wholesale account for lettuce in the beginning of the summer. He would normally have kept planting and harvesting lettuce through the summer, but in 2002, he stopped harvesting lettuce June 30, disked and harrowed the field, planted beets and rutabagas in half the field, and left the other half fallow except for a small, late season planting of lettuce harvested in August.

Figure 6. Lettuce field at Kestrel farm.

Field preparation for lettuce in 2002 began with plowing down the cover crop of winter rye and hairy vetch, followed by application of compost. After disking the field twice and using a Glencoe field cultivator, Tom formed beds using a ridger and press pan, and then began transplanting 6-week old seedlings into the beds, 2 rows per bed, 14 inches apart.

The farm crew sows successive crops of 10,000 plants in flats every week that are grown out in cold frames, and then transplanted to the field weekly to allow continuous daily harvest. Lettuce needs close cultivation without throwing soil, so Tom uses the Buddingh basket weeder with just a 2.5 inch space on either side of the center of the lettuce row. Each planting is normally cultivated twice with the basket weeder. The 60 day period for a typical lettuce planting doesn't allow much time for weeds to go to seed – as long as the crop gets turned under soon after harvest. Late season romaine lettuce in 2002 was an exception, with large weeds going to seed.

All plantings were side-dressed, either with Chilean nitrate or with Kreher's pelleted chicken manure. Tom cultivated each planting twice in the first two weeks with a Buddingh basket weeder. Then, each planting was weeded one more time by hand with a hoe (84 hours for the field, an average of 17 hours per acre). The lettuce is irrigated as needed with overhead sprinklers to make sure that it gets 1 inch of water per week, which meant 2-3 irrigations up through the end of June in 2002. The lettuce is hand harvested early in the morning several times a week and packed in the fields. The boxes are transported to the hydrocooler, where the lettuce is cleaned and cooled in one operation and palleted for shipment.

Pest and Disease Management and Sampling: The fields of lettuce we followed were not sprayed in either year. Our field sampling for lettuce pests showed that there were no pests in our fields that warranted spraying. Although 36% of the lettuce plants sampled at 90% growth on 6/25/2002 had aphids present, the infestations were always rated "light" and there was a substantial lady beetle population at work cleaning up the infestation. The yield data (Table 4) for lettuce shows only 1% culls of lettuce in 2002 to pests and disease, all due to leaf wilt, and no measurable loss to pests or disease in 2003.

Weed Sampling: Although in 2002 the weeds were numerous in late June, when the main season lettuce was being harvested, they were still all vegetative and less than 6" tall. They probably did not reduce yield, but the grassy weeds, in particular, may have slowed down the harvest. Lambsquarters, nightshade and pigweed in the late planting, although still limited to about 7" in height, were going to seed at the end of August. It is unusual to see such long-season weeds going to seed in a lettuce field, since lettuce is usually a short-season crop. Again, yield loss was probably negligible, but the weeds may have interfered with harvest. The reduced weed management in 2002 may have reflected the reduced lettuce market in that year. Since there was more lettuce planted than was marketable, maintaining weed control in lettuce may have been a lower priority than in other crops. In 2003, the weeds were less dense and smaller, so probably did not affect yield or harvest, and did not go to seed.

Yield: The differences in yield by weight between the two years shown in Table 4 result from differences in the average head size, which are in turn related to differences in the timing of sampling. In 2002, we did our harvest sampling for lettuce on 6/11, 7/9, and in a late romaine planting on 8/27. In 2003, all NEON lettuce yield sampling was done 8/26 and 8/29.

Tom harvests differently over the season. Heads from 0.75 to 1 lb. per head are generally considered the standard, and Tom harvests his heads this size, or a little larger, early in the summer. But late in the summer, as temperatures rise, the lettuce will bolt before it reaches this size, so Tom harvests the heads at a smaller size. He has worked this out with his accounts, so they accept the smaller heads late in the season. Because the heads were harvested at a smaller stage in 2003 (average weight of 0.3 lb per head vs. 1.1 lb per head in 2002), the yield in pounds per acre was much less, even though the number of marketable heads per acre was slightly higher.

In interviews, Tom estimated that in a typical year, he loses 20% of the lettuce heads in the field, mostly due to timing of harvest – the heads are either immature, overmature, or bolting at the time that section of field is being harvested.

Economics: Because Tom's lettuce operation is so closely tied to his brother Paul's, we were not able to do an enterprise budget or revenue projections for lettuce.

Table 4. Yields of focal crops studied at Kestrel Farm, 2002 and 2003. (na = not available)

Crop	Year	Stand count (plants/ acre)	Marketed yield from farm records (lbs/acre)	Neon sampled yield (lbs/ acre)	Market-able number/ acre	% market-able yield by wt	% physiolo gical culls by wt	% pest culls	Mean wt per fruit/ plant	Yield per plant (lbs)
Parsnips	2002	67,700 (8,800)	13,830	14,100 (2,200)	67,700 (8,800)	100	0	0	0.22	0.22
	2003	217,500 (50,600) 109,000 (28,000)	6,900	14,500 (2,100)	167,500 (53,800)	87	4	9	0.11	0.11
Lettuce	2002	24,900	na	17,200 (5.900)	15,200 (3,500)	61*	38	1	1.1	1.1
	2003	21,300 (800)	na	6,200 (1,300)	17,900 (1,800)	85*	16	0	0.3	0.3
Butternut Squash	2002	5700 (400)	22,400	27,900 (4,500)	9,400 (1,300)	98	0	2	3.0	5.0
	2003	7000 (240)	19,000	32,100 (3,300)	11,000 (1,000)	99	0	1	2.9	4.6

***** Percent marketable and culls based upon head numbers, not weights.

Focal Crop - Parsnips

Cultivar: 'Javelin'

Fertilization: 2002: Side-dress with Kreher's 5-5-3 (300-800 lb/acre), later with Sul-Po-Mg (400 lb/acre)
2003: Side-dress with Kreher's 5-5-3 (300-800 lb/acre), later with Sul-Po-Mg (325-388 lb/acre)

Planting: 2002: Seeded on April 30, May 19, May 29, June 15. Total of 2.2 acres in study field
2003: Seeded on April 15, May 7, May 25, June 7. Total of 3.4 acres.

Spacing: Raised beds 33 inches wide, with 9-inch furrows between. Two rows per bed, 15 inches apart, ideal spacing within row is 2 inches apart, but this varies (Fig. 7)

Harvest: 2002: August 25 (bed lifter and by hand), September 25 (carrot harvester), October 15 (custom harvest)
2003: August 25, September 10, September 25, October 7, some left for spring harvest. All with bed lifter and hand harvest

Crop Establishment and Management: One challenge of growing parsnips is to create a fine seedbed that will encourage the notoriously difficult parsnip seedlings to germinate and grow. The need for meticulous seedbed preparation is why Tom does not grow cover crops or apply compost to the fields designated for parsnips. Field preparation for the parsnips started with plowing, disking, cultivating with the Glencoe, and then forming 2-row beds with the ridger and press pan. The parsnips were direct seeded, and the first three plantings were flamed (using a custom-made, 4-foot wide, tractor-mounted flamer) just before plant emergence. For the second and later plantings, each bed had to be renovated and re-formed with the press pan just before seeding. There were four plantings in the field we followed in 2002, and a fifth planting in another field. There were 4 plantings in a 3.4 acre field in 2003.

Parsnip's slow germination and long season also make weed management a challenge. Weeds can also make it difficult and expensive to harvest the crop. Tom uses a combination of weed control methods for the parsnips, including flaming, cultivating each planting 3-4 times with the Buddingh basket weeder (allowing him to get within 2.5 inches of either side of the row without throwing soil up onto the delicate plants), and hundreds of hours of hand hoeing (155 hours per acre in 2002 and 66 hours per acre in 2003).

At the first cultivation, Tom side-dressed with Kreher's pelleted composted chicken manure (5-2-3) at rates varying from a maximum of 800 lb/acre down to 300 lb/acre. (He generally intends to put on 300-400 lb/acre, but there are frequently glitches with the equipment that result in higher rates.) At the second or third cultivation, he side-dressed with Sul-Po-Mg at a rate of about 400 lb/acre. After the last cultivation, he laid T-tape for drip irrigation. Once the tape was laid, the planting was irrigated every 4-5 days at a rate of ¼ to ½ inch. After the plants were 8 inches tall, he irrigated once a week at a rate of 1 inch. Tom uses drip rather than overhead irrigation on parsnips because he has found that overhead irrigation spreads fungal disease through the field.

Figure 7. Parsnip field at Kestrel Farm after cultivation between the beds.

In 2002, the first two plantings were lifted with a bed lifter, and then the parsnips were harvested by hand. The third planting was harvested with a carrot harvester, and the fourth and fifth plantings were custom harvested. The first three plantings were washed and sold directly. The last two plantings were put into cold storage, to be washed and sorted when they were ready for sale. In 2003, all of the plantings were harvested with a bed lifter.

Cull parsnips (culled mostly due to small size, but some due to canker or physical damage in harvesting) are put back onto the parsnip field. (Fig. 8) Since the parsnip field will not go back into parsnips for three years, Tom feels that there is less likelihood of *Itersonilia* spread by putting the culls into the field instead of into the compost. The rye-vetch cover crop was planted following the first two parsnip plantings, but not after the later plantings.

Figure 8. At left, a sample of parsnips suitable for storage. At right, parsnips culled due to shape, small size, or disease. These parsnips will be plowed back into the field, which will go into sweet corn or squash the following year, and will not be used to grow parsnips again for a minimum of 3 years.

Pest and Disease Management and Sampling: In 2002, the third and fourth plantings were sprayed twice, on September 14 and 16, with OxiDate®, a hydrogen dioxide fungicide, at a rate of ½ gallon per acre for management of *Itersonilla* canker, visible on the leaves of the plants. Nothing was sprayed in 2003. Essentially no insect pests were found (12% of plants with light aphid infestations at mid-season in 2002.) Symptoms of *Itersonilia* infection of the leaves, petioles, and shoulders of the roots were widespread at pre-harvest in both years, but in 2002, none of the roots in harvest samples had disease symptoms severe enough to make them unmarketable. In 2003, 9% of the harvest by weight was lost to disease (Table 4), with half of that loss due to *Itersonilia* canker and the other half due to root dieback. Tom confirms that even though disease threatens the parsnips every year, he rarely has much loss to disease, and most of his culls are due to undersized roots.

***Weed Sampling*:** As shown in Table 3, the biomass of weeds was high in 2002, probably resulting in yield loss, and certainly interfering with harvest (discussed below). Weed management was better in the parsnips in 2003, and interfered much less with harvest, but there were still probably enough large weeds to affect yield and produce seed.

In 2002, pigweed was the major weed in the early (6/11) sample, with 15,000 individuals per acre, brought down to 7,000 per acre in the late (9/3) sample. Lambsquarters was the major weed in the late sample (10,000 per acre), with barnyard grass also present (2,000 per acre). After considerable efforts at weed control (flaming the seed bed, 3 cultivations per planting, and 349 hours of hand-weeding in the 2.2 acre field), the weed density and biomass were still high enough that they probably caused yield loss. At the end of the season, the weeds of all three species were 3 to 6 feet tall and producing seed, adding to the weed seed bank for future years.

In 2003, crabgrass and pigweed were the major weed species. Although the mean density of weeds overall was about the same as in 2002, the biomass was less than half of that in 2002, and the weeds were limited to edges of each planting missed in cultivation. It was easy to work around these patches of weeds, so they did not interfere with harvest. These weeds also went to seed.

Yield: In 2002, our estimate of yield was 14,100 lb of roots per acre (Table 4). The plant density, and thus the size of the roots, which averaged about 0.2 lb each, varied with different plantings across the field because germination was low due to hot, dry weather in the last planting. The roots were noticeably larger in the late, low density plantings. Yield, measured in total weight of the roots, did not vary in any predictable way with plant density. Since small size is the main reason for culling roots, having a similar weight in fewer, larger roots might be a benefit. None of the roots harvested in our samples were classified as culls. Some loss of roots probably takes place in cold storage, but we did not measure that.

Yield in 2003 was similar to that in 2002, but there were much higher plant densities (Table 4). Tom was trying out pelleted seed, and it did not work well with his equipment, and the result was much higher plant populations than intended. The average root size (0.1 lb) in our measured sample (taken from the most densely seeded planting) was about one half the weight observed in 2002, because of this high population. Despite this high population and smaller root size, 87% of the yield (by weight) was marketable, according to the NEON sample. Although 19% of the roots (by count) in 2003 were unmarketable due to small size, this represented only 4% of the yield by weight. The remaining 9% loss was due to *Itersonilia* canker or root dieback.

The marketed yield per acre from Tom's records for 2003 differs considerably from the measured yield in the field. Some of this difference may come from variability among plantings in the field. Due to timing limitations, we could only sample from the second of the four plantings. This planting was the most densely seeded (which explains why the number of parsnips per acre was so much higher than the average stand count, taken over all four plantings).

Two other factors clearly contributed to the lower marketed yield. About 10% of the field was not harvested in 2003. The 5 late-planted beds were allowed to overwinter with the plan to harvest them early the following spring. However, because there was almost no winter snow cover, the parsnips did not overwinter well into 2004, and there was nothing to be harvested. The other factor, which Tom believes was the most important, was heavy loss in storage in 2003.

Economics: There was a big difference in the cost of production of parsnips between 2002 and 2003. Most of that difference was due to reduced labor in 2003 (Fig. 9), particularly for harvesting and packing, but also for weeding. The high weed biomass in the field made harvesting difficult in 2002. The first three plantings were lifted with a bed lifter and then harvested by hand by the Kestrel farm crew, requiring a lot of time and labor and costing $1,731 per acre. The last two plantings in 2002 were custom harvested, and cost only $133 per acre. By contrast, all of the plantings were lifted with the bed lifter and then hand harvested in 2003, but this cost $159 per acre – one-tenth the cost of harvesting by the same method the previous year. There was also a substantial difference in labor and cost in hand-weeding between the two years: $1099 per acre in 2002 compared to $846 per acre in 2003. The most important difference in input costs in the two years was the cost of seed, which was $411 per acre in 2002, compared to $175 per acre (for the pelleted seed) in 2003.

The break-even graph in Fig. 11 shows that at the 2002 marketed yield of 13,830 lb/acre, Kestrel Farm would have broken even on parsnips at a price of $0.41 in 2002 and $0.24 in 2003, or, at the 2002 price of $0.85 per pound, he would have broken even at 6,600 lb/acre in 2002, and 4,000 lb/acre in 2003. Projected revenues are presented in Table 5. The 2002 figures indicate a profit of $6,139 per acre.

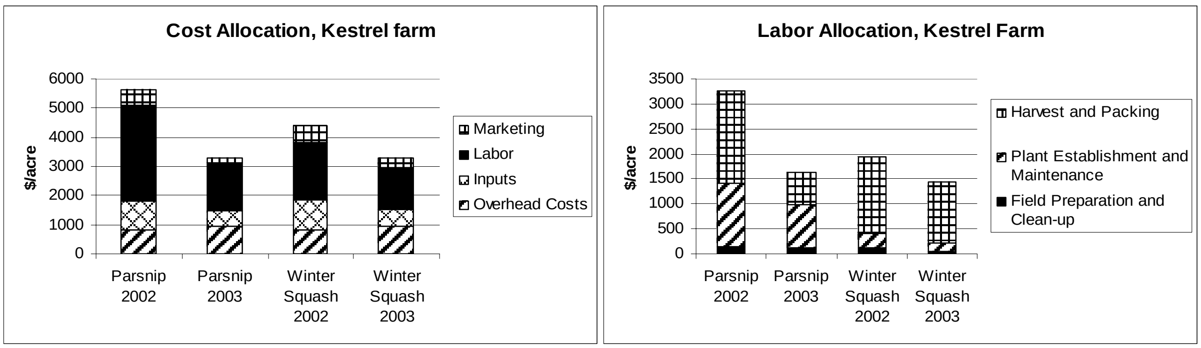

Figure 9. Overall costs of production and labor for parsnips and winter squash at Kestrel Farm, 2002-2003.

Focal Crop - Butternut Squash

Cultivar: 'Nicklows Delight'

Fertilization: 2002: Dairy manure compost on east side (20 cu.yd/acre), chicken manure compost on west side (18 cu.yd/acre)
2003: Dairy manure on east side (30 cu.yd/acre), on west side Purdue 4-4-3 chicken manure-based fertilizer (360 lb/acre)

Planting: 2002: Seeded May 25. 4.8 acres.
2003: Seeded May 29. 1.73 acres (in the field we tracked).

Spacing: Rows 6 ft. apart, plants 1 ft. apart in row

Harvest: 2002: August 21 – September 21
2003: September 24

Crop Establishment and Management: Field preparation consisted of plowing the cover crop, disking, and cultivation with the Glencoe. Tom's usual practice would have been to cover the field with composted dairy manure at 20-30 cu.yd/acre, but in 2002 he had a large quantity of chicken manure compost to try out, and in 2003, he didn't have enough dairy manure for the field, so he filled in with the Purdue fertilizer. In both years, the field was seeded in late May and the first cultivation was 1-2 weeks later. Both years the field was cultivated three times, a week apart, with

Tom's "antique steel wheel cultivator" fit to straddle the rows with a series of shovels on either side until the vines begin to run (Fig. 10).

It was also weeded once each year by hand (36 hours per acre in 2002, 12 hours per acre in 2003). This field was not side-dressed, sprayed, or irrigated in either year. In 2002, the squash were harvested by hand several times over the month from August 21 to September 21 by the Kestrel Farm crew, taking 74 hours per acre. In 2003, a Jamaican crew was brought over from Paul's farm to harvest the squash in one day (9/24), using only 19 hours of labor per acre. In both years, the squash were washed with the brush washer, unblemished fruit packed into boxes for sale, and blemished fruits (bruised, cracked, punctured, or spotted, including with lesions due to black rot) peeled on a modified wood lathe. The field was harrowed and planted with a rye-vetch cover crop the first week of October in both years.

Pest and disease management and sampling: As mentioned above, nothing was sprayed on winter squash in either year. In 2002, there were no serious insect pests or diseases found in the butternut squash at Kestrel. It is particularly remarkable that we found no cucumber beetles at the seedling stage (when they would have the greatest effect on the plants). The cucumber beetles (1.8 per flower) observed at the flowering stage would not have had any effect on squash yield. We did not find powdery mildew or any other disease at the flowering stage, but we can not assess the effects of powdery mildew in 2002 because we were not able to sample at harvest.

Figure 10. View from the edge of winter squash field at Kestrel Farm. Winter squash has more weeds than other crops because it can only be cultivated by machine until the vines begin to run.

We did not sample at the seedling stage in 2003, but the numbers of cucumber beetles sampled at later stages were low, suggesting that there was no problem in 2003 either. Squash bug numbers were low at flowering, and they were not found at harvest, so they were not a problem. Powdery mildew was present at flowering in 2003, and widespread at harvest. The disease generally does not affect yield, but might affect the quality (level of sugars) in the fruit.

Weed sampling: In 2002, the weeds were effectively suppressed with cultivation until the vines began to run, and then were mostly shaded out by the squash plants. The result was that, although the weed density was very high at the end of the season, the weeds were all very small and did not produce enough biomass to affect yield (Table 3). Weed management was less successful in squash in 2003, when the weeds were less dense but much larger at the end of the season (5 times more biomass) and produced a massive crop of weed seeds. Even though this level of weed biomass was high enough to affect production, this field still had high yield.

Yields: In 2002, our yield estimate was 27,900 lb/acre (Table 4). The cull rate we recorded in the field due to rotten or visibly moldy fruit was low (2%). Fruit are not culled for surface imperfections, since those fruit can be peeled and sold. Yields measured in the field were slightly higher in 2003 (Table 4), while Tom's figures for marketed yield were slightly lower in 2003 than in 2002.

Part of the reason why the marketed yield was substantially lower than the measured yield is that our estimate of 1% loss in 2003 was an underestimate of culls. Tom's records for the squash sold in 2003 indicate that 10% (by volume) of the fruit harvested and put into storage were composted rather than sold. The fruit were rejected for physiological defects (too small, or misshapen with too large a cavity and no neck). Loss in storage also contributed to the lower marketed yield. Another possibility may be that our estimate of yield in the field was high because we did not do sufficient sampling on one side of the field where the fertilization rate, and thus perhaps yield, was much lower.

At other farms studied by the NEON project, significant yield was lost to black rot, particularly in the wet year of 2003, but that was not true at Kestrel, both because disease levels were low and because fruit with only surface lesions of black rot can still be marketed. Tom estimates that 21% of the butternut squash cases in 2003 were sold in pre-processed, peeled form (Fig.12).

Economics: As with the parsnips, the lower cost of production in 2003 compared to 2002 (Fig. 9) was primarily due to lower labor costs, and those lower labor costs were mainly in the areas of harvesting/packing and hand-weeding (the two largest categories of labor). Using the Jamaican crew in 2003 resulted in a lower cost of harvest that was partially offset by higher labor costs in peeling and packing (including grading) the squash. But still the combined harvest, peeling, and packing costs in 2003 ($1228) were lower than in 2002 ($1539). The reduction in hours of hand-weeding in 2003 also reduced the cost of production by $172 per acre. According to the break-even analysis (Fig. 11), at the 2002 marketed yield of 22,400 lb/acre, Tom would have broken even at a price of $0.20 per lb. at the 2002 cost of production, and at $0.15 per lb. at the 2003 cost of production. Assuming the price of $0.33 per lb., Tom would need a yield of 13,300 lb/acre at the 2002 cost of production, and 10,000 lb/acre at the 2003 production cost. Our analysis of revenue (Table 5) shows a profit of $4,599 per acre on butternut squash for 2002, and $3021 for 2003.

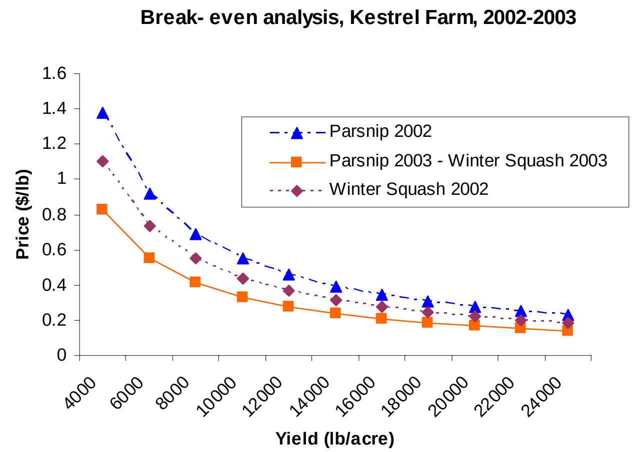

Figure 11. Break-even analysis for parsnip and winter squash, Kestrel Farm.

Conclusions

Kestrel Farm is remarkable in having no significant insect pests on any of the three crops we studied, and only minimal losses to plant disease, with very little use of any sprays. This is particularly remarkable for the butternut squash, where no sprays were applied, and densities of cucumber beetles were still quite low. Other NEON farms in New England also went without any sprays on their winter squash, but they are growing it on a much smaller scale. In contrast, the NEON farms in New Jersey and Pennsylvania sprayed their squash from 3-8 times per season with various materials, and still had higher numbers of striped cucumber beetles and losses to black rot.

Unlike some other NEON organic farms, Kestrel Farm does not follow a strategy of reducing the weed seed bank by trying to keep all weeds from going to seed or by using summer fallows or long-term cover crops. Tom's strategy is to strike a balance between the costs of weeding and either crop loss or additional harvesting costs due to weeds given the current weed pressure.

Table 5. Revenues for parsnip and winter squash at Kestrel Farm 2002-2003.

Crop	Year	Amount Sold (lbs. per acre)	Average price per lb.	Revenue	Total Cost of Production per acre	Profit per acre
Parsnip	2002	13,830	$0.85	$11,776	$5,637	$6,139
	2003	6,882	$1.00	$6,882	$3,295	$3587
Butternut squash	2002	22,400	$0.40	$8,990	$4,391	$4,599
	2003	19,000	$0.33	$6,318	$3,297	$3,021

Our assessment of weed densities and biomass suggested probable yield loss and certainly additional costs of harvesting due to weeds in parsnips in 2002, and also likely yield loss due to weeds in parsnips and winter squash in 2003. Yet all of these crops were highly profitable, and the yield of winter squash was higher than all but one of the NEON farms, which was growing squash very intensively on a much smaller scale. Although parsnips are one of the most challenging crops for organic weed management, due to their fine seedbed, slow germination, lack of rapid competitive growth, and difficult harvest in weedy fields, Tom's strategy is also successful with this demanding crop. So, weed management continues to require considerable effort, using flaming, mechanical cultivation, and many hours of hand-weeding, but it is not clear that putting more effort into weed control would pay off.

Figure 12. Bins of butternut squash in storage at Kestrel Farm. Tom Harlow estimated that 21% of the butternut squash he sold was peeled, sliced, and packed into plastic bags on the farm. This creates a value-added product, and creates a use for squash with cosmetic or surface imperfections.

Tom had not done a full enterprise budget on any of his crops before the NEON project, but had always kept good labor records. The economic analysis here confirms the importance of his decisions about labor management in keeping down the cost of production of his crops and maximizing his return.

When we asked Tom what research questions had emerged for him during the NEON project, he was most interested in the results of the nutrient budget. From our analysis, his rotation over a 6-year cycle and soil amendment practices result in an excess of potassium that may be gradually improving his soil test levels; a moderate excess of phosphorus, which should be monitored; and a level of nitrogen which should be sufficient for his crops.

Upper Forty Farm
Kathy, Ben, and Andy Caruso, Cromwell, Connecticut

Crops:	Diversified vegetables, especially heirloom varieties, also herbs, cut flowers and eggs
Markets:	Primarily farmers' markets in Darien and West Hartford, also 42-household CSA
Total Farm Acreage (cultivated acres):	22 acres, 7 owned, 15 rented (3.5 cultivated)
Year started farming:	1987
Certifier (1st year certified):	Baystate Organic Certifiers (1992)
Soil Types:	deep, fine silty loam with highly variable drainage
Hardiness Zone:	6a
Frost Free Days:	174 days
Watershed:	Connecticut River to Long Island Sound
Rainfall Average:	46-48 inches
Irrigation Sources:	overhead and drip irrigation from town water

Kathy Caruso's huge selection of tasty traditional and heirloom vegetable varieties has earned Upper Forty Farm a wide following at the upscale Farmers Market she currently attends in West Hartford and, during this study, another upscale market in Darien, Connecticut. Tomatoes are a major specialty of the farm. Kathy produces 99 varieties annually, displaying them with name cards describing their history and attributes at her market stand. Upper Forty Farm's diversity extends to other crops, producing 35 varieties of hot peppers, 18 varieties of potatoes, and a wide selection of beans, featuring successive crops of specialty snap bean varieties, early season fava beans and, later in the year, edamame (edible soybeans). Other featured crops include eggplants, kale, watermelons, winter squash and pumpkins, and cut flowers (Fig. 15). The Carusos also maintain a flock of 100 chickens to provide fresh eggs for their regular customers at the markets and for a regular supply of manure for composting.

Figure 13. Kathy Caruso, working at a farmers' market

Kathy Caruso and her husband, Ben, started farming relatively late in life. They purchased their 7 acres of farmland in 1986, when Kathy was 41 and Ben was 49. They had never farmed before, although Ben had grown up in an agricultural family – his father was a market gardener all his life, while holding down a night job in a factory – and Kathy had been a passionate gardener for years. They both had off-farm jobs, Ben full-time as a heavy equipment operator, and Kathy working 25 hours a week in a pediatrician's office.

Figure 14. Ben Caruso, harvesting beans

They planted a garden on the property in 1987, and bought their first piece of equipment, a Super H International Harvester Tractor, charged to a credit card. In 1988 Kathy started selling produce at farmers' markets. Her first year at market was a major learning experience. Kathy looked around at the mix of large farms and backyard gardeners and realized that she would not be able to compete by offering the same basic vegetables as the others. She also realized from talking to the other farmers, all conventional growers, that she did not want to use all the chemicals they were using and made the decision to go organic. The farm shifted to organic methods the next year, and was certified in 1992.

Kathy was able to leave her other job and work full time on the farm in 1998, while Ben continues to work 35 hours a week off the farm and 40 hours a week on the farm. Their son Andy, who works full time for a local farm equipment dealer, also plays a major role on the farm, working 20- 30 hours a week. Andy has put together an impressive array of planting and cultivation equipment for such a small farm, including seven tractors ranging from a 1963 Ford 2000 and a 1970 International 544 to a 1948 John Deere B and a 1950 John Deere 720 (Table 6). They began renting the 15-acre farm adjacent to the land they own in 2000.

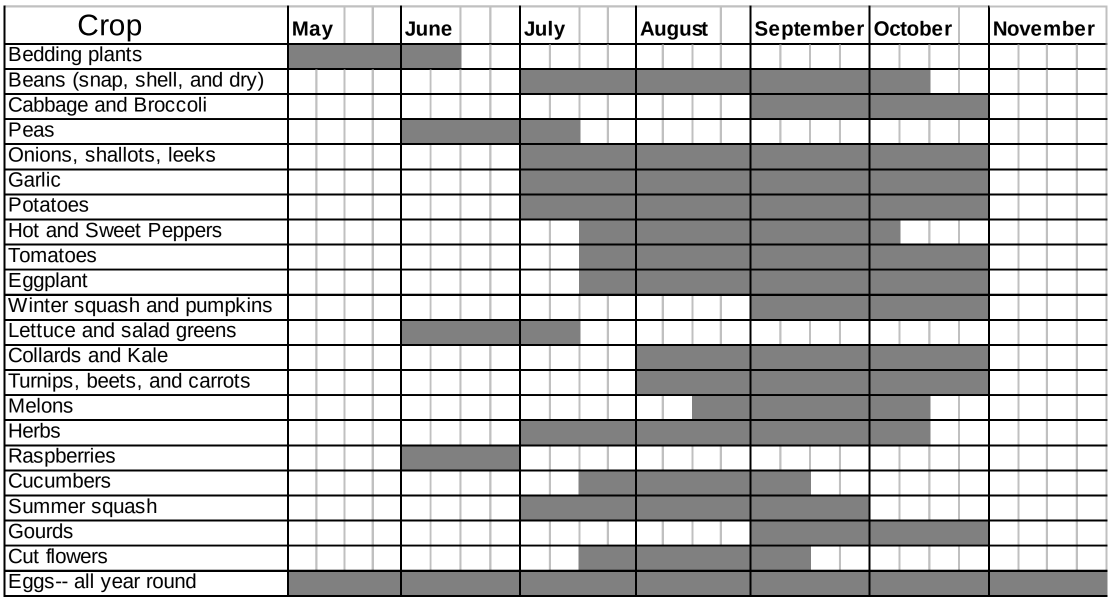

Figure 15. Crop availability at Upper Forty Farm

Mission Statement

Upper Forty Farm strives to be the grower and purveyor of the finest tasting vegetables available anywhere – worldwide.

Kathy takes this mission and her search for flavor and for diversity very seriously. During the winter, she does research, tracking down sources of seed for the vegetables she wants. In her 2002 application for organic certification, she listed 28 different companies as sources for her seed and plant stock. She continues to fine-tune her production system and is always seeking new varieties, reducing the amount she grows of standard varieties and replacing them with more heirlooms and other unusual forms, colors, and flavors.

The long-term future of the farm is unknown at this point. Andy, who is in his early 30's, has been deeply involved in the farm for many years, but he isn't clear if he wants to farm on his own in the long run. At the time of the final interview, he had just become engaged to be married, so he has a new factor to consider in determining his future (see note below for update).

Key Features Critical to Success of the Farm

Kathy's skills in working with her clientele, listening to what they want, educating them about unusual and traditional heirloom vegetables, and getting them to pay premium prices for novelty and flavor, have been critical to the success of the farm. Kathy defines success for Upper Forty Farm as being the place to find the best, most flavorful vegetables, rather than in terms of quantity of production or even financial success.

A factor working in combination with Kathy's skills has been the location of the farm, within reach of a clientele able to appreciate and pay well for the variety and quality of vegetables Upper Forty Farm produces. It has taken Kathy a long period of trying out markets in various parts of Connecticut in order to get into a really high-end farmers market, but the farm is benefiting from that groundwork now.

Another critical factor has been the tenacity and resourcefulness of the Carusos in pursuing their dream of farming. Unlike many of the other farmers studied in the Northeast Organic Network (NEON) project, the Carusos plunged into farming without much background in organic agriculture and without financial resources, and they have had to build up the farm gradually while working other jobs, as Ben and Andy continue to do even now. (Update: As this bulletin goes, to press, Andy continues to help with the farm while also working full-time and juggling his responsibilities as a new father, while Ben has had to scale down his off-farm job and his farming to deal with serious health issues.)

Figure 16. Kathy Caruso at a farmer's market with her produce display. Note the cards in front of each vegetable giving the customers information about the variety and its characteristics

Community Interactions

Kathy has worked since the beginning to develop farmers' markets in Connecticut. She was the president of Connecticut Farm Fresh, the organization of growers that works with the Connecticut Department of Agriculture in setting up farmers' markets. She helped to start new markets in Meriden, Deep River, and Essex, and at the time of this project, she was the market master (organizer) of the market in Darien. Her favorite form of outreach is educating her clients. She has cards she sets out at the market for everything she sells, giving the name of the variety, where it comes from, if it is open-pollinated or hybrid, and some history (Fig. 16). She takes the opportunity to talk to her customers and write in her CSA newsletter about the heritage of open-pollinated and heirloom varieties, and the importance of seeking out and supporting local farmers.

Farm Assets

Upper Forty Farm covers 22 acres, with 15 of them leased from adjoining neighbors. They are now in the process of getting the rented land into production – cultivating, building soil fertility and even clearing land in some cases. It is located on gently rolling terrain in the Connecticut River Valley, about 1 km from the river. The farm is bordered by "Dead Man's Swamp" – a preserved and protected wildlife habitat -- on the east and wooded home sites on the other three sides. This land has a long history of farming, and for the preceding 60 years was a pig farm growing hay, silage, and pasture along with some vegetables.

Table 6. Equipment list for Upper Forty Farm.

Tractors
1963 Ford 2000
1970 International 544
1948 Farmall Cub
1942 Farmall H
1958 John Deere 720
1956 John Deere 50
1948 John Deere B
Farm Vehicles
Ford Bronco II
Ford Ranger
John Deer Gator
Kawasaki ATV
Tillage
John Deere 975 Two-way moldboard plow
John Deere 444 Moldboard plow
International #8 Moldboard plow
Athens 62 Disc Harrow
Athens 47 Disc Harrow
Clark Cut-Away Disc Harrow
Planting
Rain-Flo 1600 Waterwheel Planter
John Deere 2 row corn planter
Garden Way push-type seeder
Planet Jr. Push-type seeder
Eureka Potato Planter
Massey-Harris Grain Drill
Scott's 20" Walk-behind drop sower
Rain-Flo 3 point hitch plastic mulch layer
Cultivation
BHC 2-row 3 point hitch spider gang cultivator w/sweeps
Ford 3 point hitch shank cultivator 2 row
John Deere tractor mounted shank type 2 row cultivators (2 sets)
Mantis Rototiller
Miscellaneous
Bobcat skid-steer loader
John Deere Manure Spreader
John Deere 5' Rotary Mower
International One-row Potato Digger
3 point hitch carrying platform
New Holland Lime sower
John Deere 24 ton Hay Baler
John Deere #10 Sickle Bar Mower
International 4' sickle bar mower
Honda push mower
Homelite chainsaw
Assorted trailers and carts
Walk behind measuring wheel
3 point hitch spin spreader
3 point hitch pallet forks
Irrigation
5000' drip tape
2 overhead sprinklers
1000' Rain-Flo collapsable tubing

The whole farm is under organic management and certified by Baystate Organic Certification, established by NOFA Massachusetts. Kathy produces all of the seedlings used on the farm and additional plants sold at the markets in three small (10 ft. X 34 ft. each) greenhouses. These greenhouses are used only for starting seedlings, and are closed down except in spring and early summer.

Cromwell, Connecticut is a little too far south to have the prime agricultural soil types of the upper Connecticut River Valley. The soils at Upper Forty Farm are predominately a Sudbury sandy loam on 0 to 5 percent slopes. This soil type is moderately well drained and its main limitation is that it remains wet for days after a heavy rain. It can also be slow to dry out (and warm up) in the spring. In excessively wet seasons some fields remain unworkable due to standing water. There is a central pond that stays full except in times of protracted drought and helps drain the surrounding fields during wet periods. The farm is set up for both overhead and drip systems on a need basis, using town water.

Labor on the farm is nearly all from the Caruso family. As mentioned above, Kathy works full time on the farm. In spring and early summer, she grows all the seedlings in the greenhouse and then helps with planting them. During the farmers' market season (May through October), she spent 4 days a week at farmers' markets, part of a day setting up for her Community Supported Agriculture (CSA) shareholders to pick up their shares at the farm, and the rest of her time harvesting produce for these markets. Ben and Andy do all of the plowing, cultivating, and other work involving heavy equipment. The Carusos occasionally get help from friends and neighbors as casual labor or through barter.

General Crop Marketing and Business Strategies

Kathy's primary markets have always been farmers' markets. She started out in the Middletown Farmers' Market, and has also been a part of markets in Hartford and Essex. In more recent years, she has been able to move up to better markets with a larger and more affluent clientele. She had to wait for 2 years to get into the West Hartford Farmers' Market, where she has been selling 3 days a week since 1995. During this project (2002-2003), she also sold one day a week at the Darien Farmers' Market, where she was market master. Although this was a very lucrative market, she has since decided that it involved too much time and hassle in fighting traffic, and so she is now focusing on the West Hartford Farmers' Market and selling the rest of her produce through other channels. Part of her marketing philosophy is to get premium prices for her premium produce. She never reduces her prices when a particular crop is particularly abundant, and never puts anything on sale.

The farm recently started a Community Supported Agriculture (CSA) group, expanding to 42 member households in the 2003 season. This started as a result of demand from her regular customers, and she has never made any serious effort to advertise – she gets as many shareholders as she wants through word of mouth and a listing on the Robyn Van En CSA website.

Crop Management

Soils and Fertility Management

Although the predominant soil is a Sudbury sandy loam, as mentioned above, the soil types in the small area of Upper Forty Farm are a mosaic of different soil types varying widely in drainage from excessively drained Penwood soils, through moderately well drained Sudbury soils with a seasonal high water table, to poorly drained Walpole soils. The variation in drainage interferes with crop rotation because, regardless of any plan to rotate early and late season crops, when part of the farm is still wet at planting time, the early crops generally have to go onto the better drained fields.

During the main growing season, the farm makes use of buckwheat, Dutch white clover and annual ryegrass to suppress weeds and sequester soil nutrients. Rock powders -- principally lime, granite meal and greensand are used to provide additional nutrients and balance soil fertility. Soil tests are taken for analysis every few years or when needed for a new project. Otherwise, particular attention is paid to crop growth and plant color characteristics to determine when supplements are needed.

Fall-sown winter rye is the primary cover crop used on the farm (Fig. 17). Legumes such as clover are occasionally used to fix nitrogen and the Carusos have also experimented with a smooth brome/cowpea combination for the same purpose. However, blood meal, cottonseed meal and the poultry manure compost generated on the farm have been the primary nitrogen sources. (Note: Upper Forty Farm had to stop using cottonseed meal after the 2003 season. Her certifier said that the National Organic Rule requires "uncomposted plant material" not to be genetically engineered, and thus cottonseed meal was not allowed because it would have come in part from genetically engineered cotton plants.) The compost also makes use of the refuse of a local organic landscaper – leaves, grass clippings and spring thatch are collected in large piles and mixed with the chicken manure.

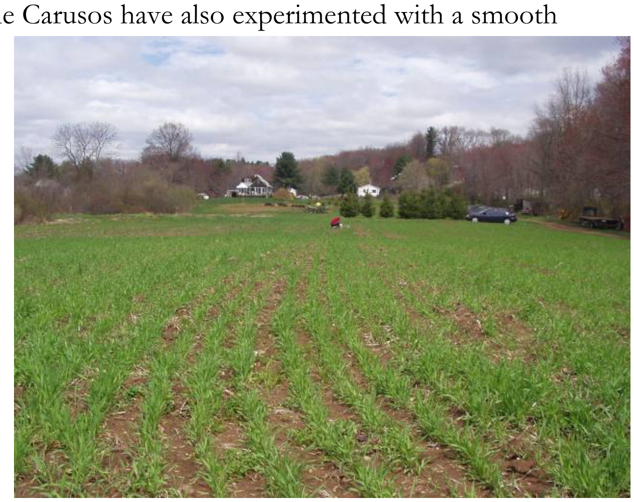

Figure 17. Winter rye, the primary cover crop at Upper Forty Farm

Upper Forty Farm nutrient budget

By tracking inputs and exports from a hypothetical field in Upper Forty's rotation for six years, we were able to make some rough calculations about the tendency of this farm's rotation and fertility practices to either accumulate or deplete soil nutrients. The rotation incorporated two cycles through crops that are common on the farm: tomatoes - snap beans – winter squash – tomatoes – snap beans – winter squash. Yields and fertility inputs followed those we recorded over the study. Fertility inputs over six years totaled 6350 lb/ac. of granite meal, 3600 lb/ac. greensand, 8 tons/acre of leaf/grass compost, and 5300 lb/acre of cottonseed meal. We also estimated that about 35 lb/acre of nitrogen was fixed by white clover in tomato pathways.

As seen in Figure 18, the Upper Forty rotation shows positive balances for nitrogen (+204 lb/ac.) and potassium (+190 lb/ac.), with a tendency to deplete phosphorus over time (-30 lb/ac.) Nitrogen accumulation was mainly due to cottonseed meal inputs of N that exceeded the harvested crop exports in years two, three, and four. It is possible that reduced rates of this fertility amendment, which is quite rich in N, could be used with little reduction in yield. Interestingly, the compost had a low nutrient content and contributed mainly carbon – important for soil nutrient cycling by microbes - rather than N, P, or K to soil stocks.

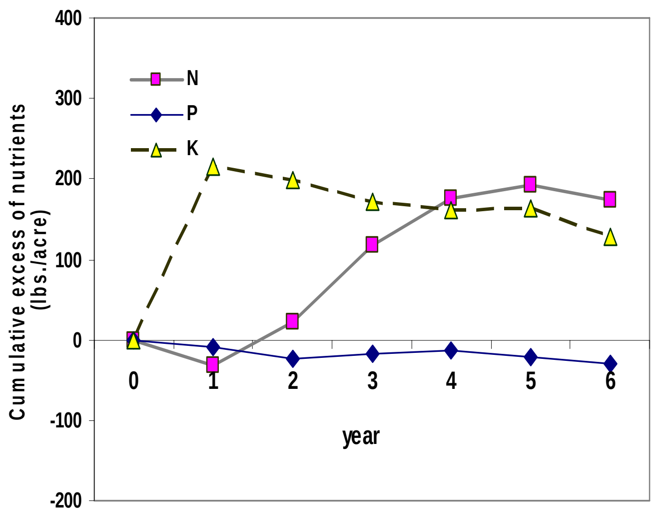

Figure 18. Upper Forty Farm nutrient budget. Cumulative nutrient balance (excess of amounts applied over amounts exported as crops) for nitrogen (N), phosphorus (P) and potassium (K) on a modeled field at Upper Forty Farm over six years, with the following rotation: 1) tomatoes, 2) snap beans, 3) winter squash, 4) tomatoes, 5) snap beans, and 6) winter squash.

Potassium showed a dramatic accumulation in year one, due to a heavier than normal application of greensand/granite meal and a lower than average tomato yield. These amendments have a low proportion of soluble K, however, which helps to limit loss from the system. K showed a slow decline in years 2-6, as exports from harvests were mostly balanced by inputs from these rock powders and cottonseed meal. Potassium status on this farm is likely adequate without being excessive for crop needs.

The small depletion in P over six years would be of concern if it were to continue, as crop health might suffer. As shown in soil test results from 2003 (Table 7), P in the 14 fields tested ranged from "very low" to "medium." Small amounts of amendments like poultry manure, bone meal, or rock phosphate would help to keep P levels adequate for maintaining good yields of healthy crops. The fact that this farm is not accumulating P in its soil is probably good for local watershed health.

Table 7. Soil test results for Upper Forty Farm, 2003. 14 fields tested by the University of Connecticut.

Nutrient	Mean (Std. error)	Range	Range of ratings
Phosphorus (lbs/acre)	8.6 (0.9)	2 - 14	Very Low - Medium
Potassium (lbs/acre)	177 (11)	127 - 263	Low – Medium High
Calcium (lbs/acre)	1600 (215)	499 - 2599	Very Low - High
Magnesium (lbs/acre)	230 (23)	66 - 370	Low - High
Organic Matter Content (%)	3.3 (0.2)	2.2 – 5.0	
pH	6.5	5.6 – 7.1	

Tillage and Weed Management

Weeds are controlled mechanically with shank and spider gang cultivators, as well as by hand. Andy has outfitted several tractors with an array of cultivation and tillage equipment that enables him to respond quickly to weed outbreaks in the crops. Prolonged wet soil conditions are a major limitation on the farm, however, hampering cultivation efforts and giving weeds a head start.

Black plastic is used on tomatoes, eggplant, watermelon and flowers in combination with drip irrigation. The pathways between are sown to a mix of white clover and annual ryegrass that help to keep down weeds in areas that are difficult to cultivate. Annual ryegrass seed is also broadcast into pumpkins and squash after the last cultivation, before the vines start to run. Hand weeding is relied upon to control weeds in the row.

Pest management

In the two years of our study, no sprays of any kind were used on the farm. The Carusos have done some spraying in the past with a few selected organic pesticides (mainly *Bacillus thuringiensis* or Bt), but prefer not to spray, and are often willing to accept some loss in yield rather than using an organic pesticide. Kathy is particularly opposed to the use of copper for disease management, even though foliar diseases are an annual problem, especially on tomatoes.

The Carusos have participated in trials with agricultural researchers over the years. Colorado potato beetle and Mexican bean beetle were the major insect pests in the past and are now largely under control with assistance from Kim Stoner at The Connecticut Agricultural Experiment Station in New Haven. Beneficial wasps (*Pediobius foveolatus*) are released in the field for Mexican bean beetle control and a combination of Bt sprays and hand picking have effectively controlled the Colorado Potato beetle over the years. (Note that there is not currently an organically acceptable formulation of *Bacillus thuringiensis* var. *tenebrionis*, the form of Bt used for Colorado potato beetle control.)

A number of years ago the Carusos cooperated in trials with Ruth Hazzard of the University of Massachusetts to develop the Zealator Bt application system to manage corn earworm in sweet corn. They were also cooperators in a SARE grant with Kim Stoner in a successful project to rear and release beneficial lady beetles in the greenhouse to control aphids on brassicas and other susceptible seedlings.

Raccoons and woodchucks are sporadically a problem on the farm and are controlled with dogs, loud music and close monitoring. Deer can also be a problem. The farm is not fenced and the Carusos have had some success using soap as a deterrent.

Economics and Marketing

The crop mix on the farm is determined by market acceptance of the specialty vegetable varieties. Kathy sources her seeds from dozens of catalogs and over the years has developed a number of favorites that have become excellent sellers at the farmers' markets. The enhanced flavors of the heirloom varieties are a value-added factor in marketing and their uniqueness fetches a premium price. Kathy's enthusiasm and belief in her products have further gained her a devoted following at the markets. Overall, the heirloom tomatoes and peppers along with flowers and bedding plants are the top sellers. The Carusos are also working with alternative markets. The farm continues to expand its CSA membership annually and is looking into establishing a roadside stand.

Focal Crop - Snap Bean

Cultivars:	2002: 'Maxibel' French Filet
	2003: Early season 'Maxibel' planting failed due to flooding of the field. 'Morgane' French Filet planting followed late in the season.
Area of focal planting:	2002: 0.046 (3 rows in planting 1 and 4 rows in planting 2).
	2003: Late planting of 'Morgane' 0.017 acre
	2003: Early planting side-dressed with alfalfa meal. Late planting unknown.

Fertilization: 2002: Hi-Cal lime (2 tons/acre), cottonseed meal (1800 lb/acre), leaf compost (2000 lb/acre).
Planting: 2002: Planting 1 seeded 5/12 with a corn planter. Planting 2 seeded 6/1. Both seedings filled in by hand on 6/15.
2003: Early season 'Maxibel' seeded 5/25, abandoned in early July. Late season 'Morgane' seeded 8/10.
Spacing: 2002: Rows 2.5 ft. apart, beans 2"apart in row.
2003: 4 inches apart in 2003.
Harvest: 2002: harvested 2 'Maxibel' plantings from 7/10 to 8/9
2003: harvested late 'Morgane' planting from 10/10 to 10/24.

Crop Establishment and Management: There were big differences between the two years because 2002 was a year with reasonably good weather and 2003 was a difficult year, especially because of Upper Forty Farm's problems with poor soil drainage. Field preparation began in 2002 with moldboard plowing on May 4, followed by harrowing and application of the hi-calcium lime, cottonseed meal, and leaf compost (see text box for rates). The plantings we studied of 'Maxibel' French filet beans were seeded on May 12 and June 1 with a corn planter, the first planting was reseeded to fill in spaces by hand on June 15, and the second planting was reseeded July 1. The plantings we focused on for this study were cultivated nine times, using a rolling cultivator equipped with spider gangs, from May 15 to June 29. Each planting was also hoed by hand to remove the remaining weeds at least once. The plantings were irrigated twice in early July (Fig. 19).

All the beans at Upper Forty Farm are picked by hand, a labor-intensive process, but it improves the quality and price of the product. The first planting was picked between July 10 and July 22, and the second planting between July 26 and August 9. In 2003, the normal May 25 planting of 'Maxibel' beans failed and was abandoned in early July. The ground was just too cold and wet, resulting in poor germination, poor growth, and poor weed management, since the ground was too wet for tractor cultivation.

Figure 19. Snap bean field at Upper Forty Farm

A late planting of 'Morgane' French Filet beans was seeded on August 10. Kathy planted about 300 row feet of the beans, with seeds set 4 inches apart in the row. This provided a population of 47,400 plants/acre, which was significantly lower than the populations used in 2002. The planting was cultivated twice by machine and once by hand, and then harvested by hand from October 10 to 29.

Pest and Disease Management and Sampling: There were no significant problems with pests or diseases in beans in either year. Before she began a biological control program for Mexican bean beetle in 1999, Kathy had lost all of her late season bean plants to these beetles for several years. In recent years, however, the releases of *Pediobius* wasps have been so effective in controlling the local Mexican bean beetle population that we never saw any in our samples. During our study, Kathy continued using the parasitic wasp *Pediobius foveolatus* to control Mexican bean beetle, buying two shipments of 1000 wasps each from the Maryland Department of Agriculture as soon as she saw hatching eggs in the field (July 16 and July 23). We saw a few leafhoppers in June 2002, but no evidence of hopperburn. We also saw very light infestations of aphids. In 2003, when we sampled late in the season due to the loss of the early planting, again we saw only low numbers of leafhoppers with no hopperburn, and a little damage from deer.

Weed Sampling: The weed density in the beans at the end of 2002 was very high at 750,000 plants per acre (Table 8), but the weeds were all small, as indicated by the moderate biomass. This reflects the heavy germination of weeds from the last cultivation (June 29) to the weed sampling, which was near the end of harvest (July 22). These small weeds would have had a negligible effect on yield. Several species of weeds did go to seed.

In the late planting of 'Morgane' snap beans (data also reported in Table 8), the weed density and biomass were both much lower than in 2002, and pigweed was the only species going to seed. In the abandoned early 'Maxibel' planting, however, weeds were allowed to continue to grow for several months after the field was abandoned, and there was a heavy production of biomass and weed seeds, which will add to the care required for weed management in that field in future years.

Table 8. Upper Forty Farm weed density, dry weight and seed production. Mean (standard error)

Crop	Year	Weed density, all species plants/acre Mean (std. error)	Weed aboveground dry weight lb/acre Mean (std. error)	Main weed species	Important weed seed producers
Snap beans	2002	750,000 (370,000)	280 (180)	Purslane Bluegrass Galinsoga	Bluegrass Pigweed Lambsquarters
	2003	78,000 (53,000)	18 (13)	Galinsoga Crabgrass Lambsquarters	Pigweed
Tomato	2002	5,000 (4,500)	0.9 (0.9)	Galinsoga Lambsquarters Bluegrass	No seed production
	2003	17,000 (1,300)	440 (80)	Crabgrass Galinsoga Purslane	No data available
Butternut squash	2002	73,000 (12,000)	130 (40)	Bluegrass Mugwort Purslane	No seed production
	2003	490,000 (62,000)	3,900 (150)	Ragweed Pigweed Crabgrass	Ragweed Pigweed Crabgrass

Yield: Because of the difficulty of accurately measuring yield in a crop that is harvested on a daily basis and grown on a small scale, NEON did not make its own estimate of yield in the field for snap bean, so Kathy's sales data are presented in Table 9. The late planted beans in 2003 produced the same yield per plant as the early summer planted beans in 2002, but the plant density, and also yield per unit area, were cut in half in 2003.

Economics: Upper Forty Farm has high costs but also high revenues, and is thus able to make a profit in most of the crops we studied, even in a bad year like 2003. The overhead costs alone (See cost allocation graph in Fig. 22) for the whole farm were $5896 per acre, with major items being taxes, depreciation on equipment, office and market fees, vehicle depreciation, fuel, and maintenance of equipment and vehicles. Marketing costs were $3621 per acre, reflecting the hours of labor involved in marketing at farmers' markets – hours of loading and unloading produce, hours spent at the market – and, in addition the costs of transporting produce to the market 4 times per week.

Labor was also a major cost at $4130 per acre in 2002, with most of the labor spent in hand-picking the beans and hand-hoeing the weeds (see also labor allocation graph in Fig. 22). In 2003, the labor cost for the abandoned 'Maxibel' planting was $497 per acre (this field was abandoned before hand-weeding or harvest). The labor cost for the successful 'Morgane' planting was $2566, with most of the labor again going to hand-harvesting and hand-weeding.

The cost of inputs was $1572 in 2002, with the highest cost being the *Pediobius* wasps for biological control of Mexican bean beetles at $519 per acre and the second highest cost for irrigation. Input costs in 2003 were $497 for the failed 'Maxibel' planting and $328 per acre for the 'Morgane' planting. These were mainly for seed and fertilizer.

Since the overall cost, including overhead and marketing, was $15,200 per acre in 2002 and $14,500 in 2003, this crop needs to bring in considerable revenue to break even. The break-even analysis for all three focal crops is given in Fig. 24. At an average cost of $14,850 per acre, Kathy needed to get a price of $1.93 per lb. for her snap beans at the 2002 yield of 7,700 lb/acre, and a price of $4.24 per lb.at her 2003 yield of 3,500 lb/acre. And, because she is very good at marketing her high quality product, she got those prices and more, as shown in the table of revenues and profits (Table 10). With a price of $5 per lb. in 2002 and $6 per lb. in 2003, Upper Forty Farm made over $23,000 per acre in 2002 and, even in the difficult year of 2003, still made $6,500 per acre. Remember that these figures are scaled up from plantings on a much smaller area – even if we are looking at all the snap beans, not just the plantings and varieties we focused on for this study, the area was just 0.12 acre in 2002, and 0.041 acre in 2003.

Table 9. Yield of focal crops (SE -std. error) from Upper Forty Farm, 2002 -2003.

Crop	Year	Cultivar	Stand count plants/ acre Mean (SE)	Yield from farm records lbs/acre Mean (SE)	Neon sampled yield lbs/acre Mean (SE)	% marketable yield	Yield lbs per plant Mean (SE)
Snap Beans	2002	Maxibel French Filet	115,200 (9000)	7,700	na	100	0.07[1]
	2003	Morgane	47,400 (4000)	3,500	na	na	0.07[1]
Butternut Squash	2002	Waltham	1800	14,200 (all winter squash)	11,800 (1,300)	100	7.8[1] (based on all winter squash)
	2003	Waltham	1600	9,900	na	na	6.3[1]
Tomato	2002	Jet Star	4300	47,600	na[2]	94 (4)	10.9[1]
	2003	Jet Star	4300	19,600	na	91 (3)	4.6[1]

[1]Per plant yield based upon grower yield records
[2]NEON sampled yields on two dates in 2002. This data is presented in the text. (na = not available)

Focal Crop Tomatoes

Cultivars: 'Jet Star'
Acreage of focal planting: 2002: 0.063 acre, total tomato planting 0.56 acre
2003: 0.068 acre, total tomato planting 0.71 acre
Fertilization: 2002: Compost (2.5 tons/acre), Hi-Cal lime (2 tons/acre), cottonseed meal (1500 lb/acre), greensand (2000 lb/acre)
2003: Compost (2.5 tons/acre), granite meal (400 lb total = 6350 lb/acre), greensand (100 lb total = 1590 lb/acre)
Planting: 2002: transplanted 5/27

	2003: transplanted 6/9
Spacing:	Plants 24" apart in rows. Rows 5' apart, with 2.5 ft. covered by black plastic, and 2.5 ft. aisles planted in white clover, crimson clover, and annual ryegrass.
Harvest:	Daily. 2002: 7/25 to 9/19. 2003: 8/15 to 9/9

Crop Establishment and Management: The NEON project followed just the plantings of 'Jet Star,' a standard hybrid tomato variety, but, as discussed above, Upper Forty Farm specializes in open-pollinated heirloom varieties and promotes the diversity and flavor of these varieties (Fig. 20). In most respects, the management was similar for 'Jet Star' and the heirloom varieties, but there may have been differences in yield and other field measurements.

Field preparation began in both years with plowing the preceding cover crop of rye, adding compost, greensand and other fertilizers, harrowing, forming the beds, and covering them with plastic mulch. The aisles between plastic-covered beds were seeded with a mixture of white clover, crimson clover and annual ryegrass, to reduce weed pressure and add organic matter (Fig. 21). Tomato plants were transplanted into the beds with 2 ft between plants, and were staked and trellised in both years. Sideshoots that developed below the first flower cluster were removed about two weeks after transplanting.

Figure 20. Heirloom tomato from Upper Forty Farm. These tomatoes are typically grown for direct sale because their irregular sizes and shapes make them difficult to pack and ship.

Pest and Disease Management and Sampling: NEON staff assessed insect pest and disease in tomatoes on May 30, June 10, and June 24 of 2002 (with an additional rough estimate of disease at harvest), and July 7 and September 8, 2003. Damage from insect pests was minimal in both years – limited to slight flea beetle damage to lower leaves in 2002 and to feeding holes in a small percentage of the fruit in 2003.

In both years, however, foliar disease (predominantly early blight, *Alternaria solani*) was widespread. Unfortunately samples were not frequent and well-timed enough to give quantitative assessment of disease over time, and without a control it is impossible to determine how much yield was lost, but we have some observations. At harvest on August 19, 2002 (when 40% of the total yield from this plot had already been harvested), NEON staff observed that 90% of the plants were infected with early blight. Due to the wet weather in 2003, disease was probably even more severe. On September 8 (when 98% of the total yield had been harvested), every plant sampled had symptoms of early blight on the leaves, and NEON staff recorded that 75-100% of the leaves on every plant were dead. In addition, all of the plants also had symptoms of early blight on at least some of the fruit, too, with 28% of the plants rated as having "severe" fruit disease, 64% rated as "moderate," and the remaining 8% rated as "light."

Figure 21. Tomatoes at Upper Forty grown on black plastic with annual rye, crimson clover and Dutch white clover in the aisles

Weed Sampling: The system the Carusos set up for managing weeds in tomatoes, combining plastic mulch with a living mulch between the beds, was effective in controlling weeds both years (Table 8). In 2002, both weed density and weed biomass were low, the weeds could not have had any effect on yield, and none of the weeds were allowed to go to seed. In 2003, both weed density and biomass were higher in the measured samples, but because harvest was already finished by the time the samples were taken, any effect of weeds on yield would have been slight.

Yield: The total yields presented in Table 9 are based on Kathy's records. In 2002, she harvested about 3000 lb of tomatoes from her 'Jet Star' planting. This was equivalent to about 47,600 lb/acre. In 2003, the1330 lb of tomatoes harvested from the 'Jet Star' planting were equivalent to about 19,600 lb/acre. Yields in 2003 were much lower due to cold, wet weather, which delayed the beginning of harvest by 21 days compared to 2002, and probably also due to disease, which caused the harvest to end 10 days earlier (even though disease was also present in 2002).

Economics: The economics of the Upper Forty Farm tomato crop is once again a case of high costs being compensated for by high revenues. The overhead and marketing costs given above for snap beans were calculated on a per acre basis for the entire farm, so those base costs (which combine to equal $9517 per acre) are the same (Fig. 22). But tomatoes have higher input costs than the snap beans and higher average labor costs.

The overall inputs for tomatoes were similar in both years, $4200 in 2002 and $4329 in 2003. Over 2/3 of the input cost is due to the cost of oak stakes, at $2 each, although Upper Forty Farm uses each stake for 3 years. Each plant is staked, giving a cost per acre of $2910 in 2002 or $2824 in 2003. Much of the rest of the cost is in soil amendments (granite meal, greensand, cottonseed meal, fish emulsion) and plastic mulch.

The largest labor cost was in harvest and packing for both years. The harvest and packing labor cost in 2002 was $2929 per acre compared to $1303 in 2003. This corresponds to the greater quantity of tomatoes to be harvested, since the yield in 2002 was close to 2.5 times the yield in 2003. Plant establishment and maintenance cost $1510 per acre in 2002 and $1020 in 2003 with the major labor costs going to transplanting, staking, and trellising the tomato plants, and also mowing the paths. Field preparation and clean-up cost $514 - $597 in the two years, with most of the labor costs in removing the plastic mulch and the stakes.

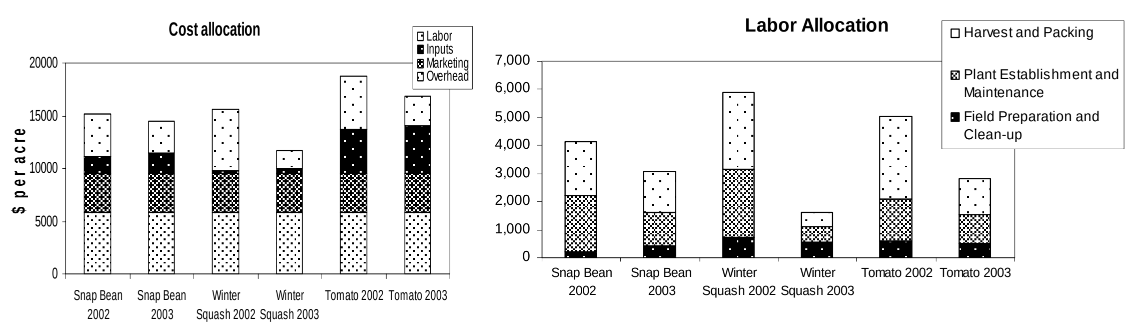

Figure 22. Overall costs of production and labor for snap beans, winter squash, and tomatoes at Upper Forty Farm, 2002-2003 in $ per acre.

The relationship of break-even prices and yields is given in Figure 24. For tomatoes, with an average overall cost for the two years of $17,800 per acre, the price needed to break even at the low 2003 yield of 19, 600 lb/acre would be $0.91, and at the higher 2002 yield, the break even price would be $0.37. At the prices Kathy Caruso actually charged ($2.50 per lb. in 2002 and $3 per lb. in 2003), the break-even yields would be 7,100 lb/acre and 5,900 lb/acre, respectively.

As shown in Table 10, Upper Forty Farm did much better than breaking even on its tomatoes, even in 2003 when the yield was low. In 2003, the profit per acre was $41,800, and in the much better year of 2002, the profit per acre was just over $100,000.

Once again, remember that these numbers are calculated up to a per acre scale from much smaller plantings. The plantings we studied were 0.063 and 0.068 acres, although the total tomato acreage at Upper Forty Farm, with all of its diverse plantings of heirloom varieties, ranged from 0.56 to 0.71 acres in the two years.

Focal Crop - Winter Squash

Cultivars:	2002: Mixed cultivars 2003: 'Waltham' Butternut
Area of focal planting:	2002: All winter squash = 0.14 acre. Just butternut = 0.033 acre 2003: 0.033 acre
Fertilization:	2002: compost (2.5 tons/acre), Hi-Cal Lime (2 tons/acre), cottonseed meal (275 lb for field of 0.14 acres = 2000 lb/acre) 2003: No fertilization – couldn't get tractor into field
Planting:	2002: transplanted 6/23 2003: transplanted 7/1
Spacing:	Plants 2' apart in rows, rows 12' apart on black plastic (4' wide plastic, 8' aisles)
Harvest:	2002: 9/5 to 10/5. 2003: 9/1 to 10/5

Crop Establishment and Management: As with the other focal crops, Upper Forty Farm grows a wide variety of winter squash, but the NEON project focused only on butternut squash, in order to simplify our sampling and to have similar data to compare with other NEON farms growing butternut squash.

In 2002, field preparation began with the application of compost, lime, and cottonseed meal. The field was plowed June 9, but was too wet and was plowed again later (June 22). The plastic mulch and drip irrigation line was laid just after the second plowing, and squash plants (seeded in the greenhouse on June 3) were transplanted the next day. Row cover was immediately set up over the plants to protect them from striped cucumber beetle. The aisles were harrowed 3 times (June 30, July 10, and July 20), and then the row cover was removed July 23, when the vines began to run. The planting was irrigated 4 times (July 20, July 27, August 3, and August 10), for 5 hours each time. The Carusos hung bars of soap ('Irish Spring') as a deer repellent on August 30, but a few plants (estimated at 1%) were still lost to deer and raccoons. Fruit were cut from the vines August 15 to September 15 and allowed to cure in the field, and were collected and sorted from September 5 to October 10.

Things were different in 2003, because the Carusos could not get machinery into the squash field, which was very wet. The squash went back into the same field where it was in 2002 (not the usual practice, but the Carusos were not able to carry out their rotation plan because they had to plant early crops on the drier fields). There were no compost or soil amendments added, again because the field was too wet for the applications. The field was plowed June 29, the plastic and drip lines were laid the next day, the squash was transplanted on July 1, and row cover was applied July 2. The row cover blew partly off, and was removed July 9. There was only one cultivation, on July 29. The fruit were cut from the vines on August 25, and collected and sorted on September 1, September 28, and October 5.

Pest and Disease Management and Sampling: The limited NEON sampling did not show insects to be a problem in butternut squash in either of the two years. Both striped cucumber beetles and squash bugs were present, but not at damaging levels. Upper Forty Farm had a population of squash beetles in the past, but these beetles are closely related to Mexican bean beetles, and are also attacked by *Pediobius foveolatus*, the bean beetle parasite. The numbers of squash beetles had declined in the years before this study began, along with the Mexican bean beetles. NEON did not evaluate powdery mildew or other diseases at harvest in 2002, but Kathy Caruso's end of season interview that year indicated that only a few plants died prematurely due all causes, including powdery mildew, deer feeding, and raccoon damage.

In 2003, the season was cut short by extensive powdery mildew damage. The NEON sample on September 8 indicated that 100% of the plants were infected, 76% were rated as severely damaged, and 28% of the plants were already dead. No pesticides were sprayed on the winter squash in either year.

Weed Sampling: The severity of weeds in the butternut squash varied substantially between years, as shown in Table 8. In 2002, a drier year when cultivation could be carried out as needed, the weed control was good for winter squash (which tends to have weeds emerging late in the season because the crop can no longer be cultivated once the vines run). The weeds probably did not affect yield in 2002, and did not go to seed, since the field was promptly mowed at the end of harvest. In 2003, the Carusos could only get into the field for one cultivation in this very wet year, and the weeds took advantage of the situation, with remarkable densities and biomass of ragweed, pigweed, and crabgrass. The black plastic provided a protected area for the squash to grow, but the weed density was at a level that would be expected to affect yield (Fig. 23).

Figure 23. Butternut squash at Upper Forty Farm grown on black plastic. Weeds in the aisles were a problem because of the difficulty of cultivating early in the season.

Yield: Given the difficult circumstances in 2003, it is not surprising that the yield in 2003 was about 30% lower than in 2002, as shown in Table 9. The lower yield in 2003 could be due to the lack of fertilization, the higher weed density, or more severe disease in this wetter year.

The yield of winter squash at Upper Forty Farm was somewhat lower than that of the other New England NEON farms, even in the better year of 2002. Upper Forty Farm's yield in 2002 of 14,200 lb/acre is about 10% less than the average yield for two years at New Leaf Farm in Maine, where the squash is grown at a similar spacing and similar cultural methods (on black plastic mulch with drip irrigation). The 14,200 lb/acre Upper Forty Farm produced in 2002 is about 30% less than the average yield for two years at Kestrel Farm in Vermont. Kestrel Farm grows its butternut squash very differently, though, without plastic mulch and with a much higher plant population per acre. The result is a lower production of squash per plant, but a much higher production of squash per acre. The production system used at Kestrel Farm would not work at Upper Forty Farm, because it depends on relatively low weed pressure and the ability to carry out frequent, timely cultivation – which is feasible in the rapidly draining soils at Kestrel, but, as we have seen, not always feasible in the poorly draining soils at Upper Forty Farm.

Economics: Winter squash is not a highly profitable crop for Upper Forty Farm. As with all the other focal crops, a relatively high cost of overhead and marketing (combined cost of $9517 per acre) has to be figured into the total cost (See Fig. 22 for cost and labor allocations). In addition, in 2002, there were input costs of $226 per acre and labor costs of $5911 per acre. The largest labor costs were for harvesting ($2748 per acre) and irrigation ($1013 per acre). The irrigation for winter squash involves setting up a generator to run a pump, which required 5 hours of labor each time the field was irrigated (4 times in 2002). Labor costs were much lower in 2003, in part because the amount of time spent harvesting was greatly reduced ($544 per acre for combined cutting and harvesting) and there was no need for irrigation.

The average cost for the two years we studied was $13,700, and the price Kathy got for the squash was $1 per lb. in 2002 and $1.25 per lb. in 2003. The yield required to break even in that price range is 10,900 to 13,700 lb/acre (Fig. 24). Because the costs as well as yields were higher than average in 2002, the winter squash crop lost a little money in that year (Table 10). Surprisingly, in

2003, a difficult year when the yields were reduced, the crop was a little more profitable because the price per lb. was set higher, and the costs were a little lower. But basically, given the range of variability, winter squash is a crop that roughly broke even for the two years of study at Upper Forty Farm.

Conclusions

Upper Forty Farm is distinguished from the other NEON farms by a unique set of challenges, opportunities, and decisions made by the farming family. Clearly, the poorly drained soils were a special challenge in 2003, and have been a continuing issue in planning crop rotations and in the ability to get into the fields and plant in a timely way in the spring. The Carusos have since bought equipment to make raised beds, in order to help them deal with these problems.

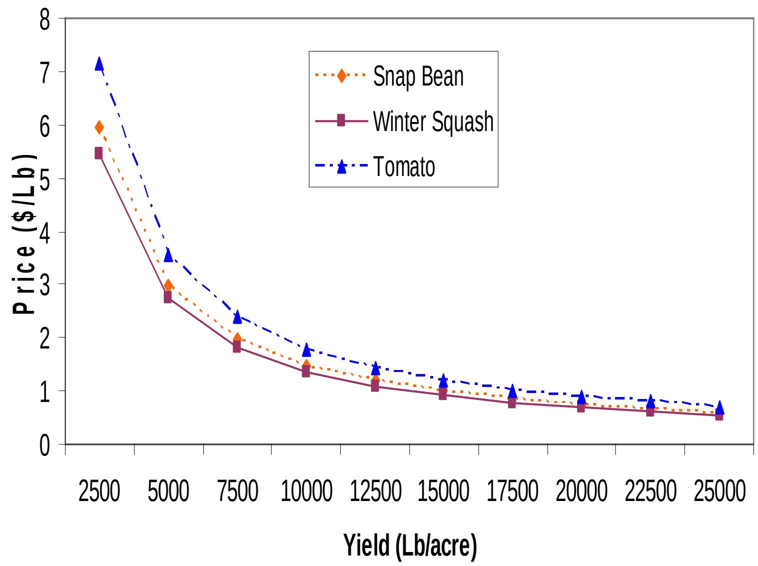

Figure 24. Break-even analysis for focal crops at Upper Forty Farm, using mean costs of production for the two years.

Another challenge is that the Carusos plunged directly into diversified organic vegetable farming without the years of apprenticeship many of the other NEON farmers had. It seems possible that they might have chosen a different piece of land if they had started out with more experience farming on their present scale. The Carusos have learned a tremendous amount through reading and networking with other farmers and scientists, but there has not been a good structure in place to help new farmers get a comprehensive approach to organic farming methods. Because of her strong motivation and networking skills, Kathy has worked closely with researchers on specific insect management issues, but weed and disease management are still difficult.

One special opportunity Upper Forty Farm has seized is that of direct retail marketing through a system of farmers' markets that began to flourish in Connecticut at the same time the farm was getting established. Kathy's ability to fulfill the desires of her customers for diversity and flavor, her flair for marketing, and her persistence in working her way into upscale markets have been rewarded by getting premium prices for Upper Forty Farm's produce. The premium prices, as we have seen, are key to the profitability of the focal crops we studied, in spite of the high costs of overhead and direct marketing, even in difficult years like 2003.

Table 10. Revenues, cost and profit for snap bean, butternut squash, and tomato, Upper Forty Farm, 2002-2003.

Crop	Year	Amount Sold (lbs. per acre)	Average price per lb.	Revenue	Total Cost of Production per acre	Profit per acre
Snap bean	**2002**	7,700	$5.00	$38,500	$15,200	$23,300
	2003	3,500	$6.00	$21,000	$14,500	$6,500
Butternut squash	**2002**	14,200	$1.00	$14,200	$15,700	-$1,500
	2003	9,900	$1.25	$12,400	$11,700	$700
Tomato	**2002**	47,600	$2.50	$119,000	$18,800	$100,200
	2003	19,600	$3.00	$58,700	$16,900	$41,800

New Leaf Farm
Dave and Christine Colson, Durham, ME

Crops:	Diversified vegetables and herbs with emphasis on salad mix
Markets:	6 restaurants, 2 natural food stores, and 40-family CSA
Total Farm Acreage:	105
Cultivated Acres:	9.5 in vegetable production, 1 in fruit trees, 14.5 in hay and pasture
Year at Current Location:	1982
Certifier (1st year certified):	Maine Organic Farmers and Gardeners Association (MOFGA) Certification Services, LLC (1985)
Soil Types:	fine sandy loam
Hardiness Zone:	5b
Frost Free Days:	137 in 2002 (5/19 to 10/3)
Watershed:	Androscoggin River, entering the Atlantic Ocean at Brunswick, ME
Rainfall Average:	42-46 inches per year
Irrigation Sources:	4 wells: 70' for household and vegetable wash water, 12' for greenhouse, 16' and 100' for field irrigation

Situated in the Androscoggin River valley, 25 miles northeast of Portland and 10 miles from the Atlantic Ocean, New Leaf Farm exemplifies years of farmer skill and experience. The Colsons have farmed organically for 20 years and have fine-tuned their system for balanced fertility, sustainable productivity and economic profitability.

New Leaf Farm is well known among Maine organic farmers for expertise combined with good equipment and meticulous record keeping. The farmers are also known for their extensive experience with cover cropping. Soil-building practices are paramount on this farm. The fields are regularly rotated out of crop production into cover crops for years at a time, resulting in high quality crops, maximized profitability per acre in cash crops, and diminished pest and disease pressure. These beneficial soil management practices are a primary contributor to the overall harmonious farm environment.

Figure 25. Dave and Chris Colson

Dave Colson discovered organic farming as a high school student at an alternative Quaker school with a small farm in New Hampshire, and then he pieced together his own education in a variety of settings over the next 10 years. He started out working on a conventional dairy farm in New York and taking general agriculture courses at Canton College, with only a tiny, embattled study group interested in organic. He moved from there to the Institute of Social Ecology at Goddard College in Plainfield, VT. In search of more hands-on experience, Dave moved to the West, where he did an apprenticeship with a diversified small farm in Washington, then an internship in bio-intensive agriculture at the Farallones Institute in California. After getting his degree in biological agriculture from Antioch University in 1979, he worked on another organic farm in California and then started his own gardening and dried flower business in Oregon.

He began looking for a farm to buy, but the price of land was too high in Oregon. His sister suggested that land was cheaper in Maine, so he visited and immediately started looking for a farm. First, he identified the soil types he wanted, and then he drew a circle an hour's drive around Portland, where he planned to market, and looked for suitable soils within that circle. Within a few months, he found New Leaf Farm.

Chris Colson grew up on a small farm in southern New Jersey, helping her family with gardening and preserving the harvest. She has a bachelor's degree in Environmental Education from

Huxley College of the Environment (Western Washington University) and a certificate to teach elementary school. She has worked in carpentry, home remodeling and construction, as well as having taught in both public and Waldorf schools.

In addition to these skills, she brings to the farm an appreciation of the role of food as medicine, as what we eat to stay healthy while maintaining the health of the earth. She belongs to the Weston A. Price Foundation, an organization that promotes eating nutrient-dense whole foods and traditional methods of food preparation as a basis for human health.

The Colsons' primary commitment in farming is to health – their own health, the health of the workers, livestock, land, and community. They evaluate their success by looking at progress toward their goals and toward meeting their challenges, maintaining and improving the infrastructure of the farm, and economic viability of the farm in providing an income for two families (their own household and that of their daughter, Robin, and son-in-law, Steve Sinisi. Steve has become a partner in the farm). Dave and Chris feel very fortunate to be able to keep their family so close.

They feel they have a good handle on the usual challenges of pest management and finding labor. They are more concerned about the challenge of larger industrial farms from outside the region competing for their organic markets and large national chain stores eliminating local natural food stores. What sustains them is their relationship to their customers and their community – people who want to have a connection to the farm and who are willing to pay an appropriate price for the food to support that connection.

Mission Statement

New Leaf Farm was established in 1982 with the purpose of growing and marketing vegetables, herbs, and fruit organically, while developing and teaching a sustainable agricultural system.

Key Features Critical to Success of the Farm

Dave believes that the ability of New Leaf Farm to market locally and to sustain their accounts through relationships to their customers and the community has been and will continue to be critical to their success.

Another key feature is how the crop mix and marketing are planned to provide a target income for the two households supported by the farm. Part of this planning is the balance of production land used for green manures and for income-producing crops. In addition to using cover crops for soil fertility and improvement, weed management, and other production benefits, they are also used to manage the workload of the farm. As New Leaf Farm shifted from producing head lettuce to salad mix, they found that they could produce more income per unit area with the salad mix. That allowed them to put a little more of the production area into cover crops while maintaining the same income. They focus on excellent, intensive management of the area producing income crops, and limiting the area in intensive production helps them to do that.

Community Interactions

Dave and Chris have been leaders in the organic farming community in Maine for over 15 years. Dave has been on the Board of Directors of the Maine Organic Farmers and Gardeners Association (MOFGA) since 1988, and was MOFGA president for two years. In addition, Dave presents 2-4 workshops each year to various audiences of farmers, including the New England Vegetable and Berry Conference and the Pennsylvania Association for Sustainable Agriculture, as well as to organic farming groups. Dave and Chris have also shared their cover crop expertise in research projects with the University of Maine.

Another contribution to the community, and the one that the Colsons enjoy the most, is their apprenticeship program. Working closely with 2-4 young people for a period of several months, they watch the apprentices learn and develop, and the Colsons find that they learn as well as teach. Over the years, Dave has developed a serious educational program that is "much more than how to plant a tomato." It also involves discussions about the role of agriculture and the food system in building community:

"A lot of people, young people especially, are looking for some way of re-connecting with their community, their country, even their world. You go to college now already specializing and looking towards a future job. Many of the [apprentices with a liberal arts education] are trying to figure out how they are going to fit into the world as they see it …..If our culture is increasingly going towards specialization in an industrial model and away from inter-connectedness between people, what do they do? For example, folks can work at home from a computer and don't even need to interact in an office anymore. So, even work as a kind of community is lost….If you need something, you don't look to a neighbor or a community member for it; you go to whatever big box store happens to sell that item. So there is very little need for connectedness….

Even so, we have this burning need in our society for community. Some people understand that and are reaching out, but many are just confused about why they feel lost. So, our discussions center around how do you re-form a community and what does 'community' mean? If the industrial model is pulling us away from community, what would pull us back? Often, it comes down to centralization vs. decentralization…."

Another community directly connected to New Leaf Farm is the Waldorf School that Jeremy, the Colsons' son, attends. The Colsons provide an opportunity for the students to learn about food and agriculture by working on the farm. The third grade class comes out three times during the fall. Each day is devoted to a different crop. After getting some information about the crop and how it is grown, the students go to work. They dig, wash, and pack carrots; harvest potatoes and winter squash; clean dry beans; and pick dropped apples out of the orchard and help to press cider. The community of parents associated with the school also provides farm volunteers and connections in marketing.

Farm Assets

Historically, the farm was in hay and pasture for many years. Dave's parents bought the farm in 1982, making Dave the farm manager. They gradually transferred the property to Dave and Chris, who became full owners in 1998. This gift helped tremendously in establishing New Leaf Farm, allowing the Colsons to operate from the beginning without a mortgage, and eliminating a major burden carried by most young farmers.

The location of the farm is an asset in several ways. It is within a 40-minute drive to Portland, the major market, and a 15-minute drive to Freeport, the secondary market. This proximity to markets is a major convenience, but the burgeoning tourist industry in Freeport creates some competition for labor, particularly for high school students.

The soil types at New Leaf Farm are of the Elmwood and Melrose series, which are both fine sandy loams and fairly well drained. The topography is a gently sloping to level bench of soil deposited by the glacier between two ridges. When the glacier receded at the end of the last Ice Age, the ocean came in and left a four-foot deep layer of blue marine clay on top of 70 feet of sand and gravel. When the ocean later receded, another 3 to 9 feet of sandy soil was built up on top of the clay creating a shallow perched water table accessible to crop roots. These soils are

Figure 26. New Leaf Farm with row cover in the foreground and alternating strips of cover crops in the background

typified by rapid permeability in the mantle and slow permeability in the clay substratum.

The farm uses an overhead irrigation system for the open fields. Dave has put together a snap-on system using lengths of light-weight 1.25" plastic pipe. With the help of a Maine Department of Agriculture cost-share grant program, they put in a deeper well in 2003 with a capacity of 60 gallons per minute, bringing them up to 4 wells supplying water for the household, vegetable washing, and irrigation in the greenhouse and field.

Because of drainage limitations, fully half the 105 acres of the farm are in non-managed land or left wild. Woodlands constitute the bulk of this property, along with hedgerows, streams, ponds and wetlands. About 15 acres are in permanent hay and pasture. In addition to their vegetable business, the Colsons also raise a few steers every year.

The central building at New Leaf is a large, 1 ½ story passive solar greenhouse they built themselves. This is used for seed propagation and fall crop storage. The Colsons have since added four 17' x 96' and one 30' x 96' plastic-covered commercial greenhouses used for producing salad greens, tomatoes, peppers and basil. The small apple orchard, established in 1984, now has about 60 trees on one acre. Nearby is a covered three-bin composting area and an extended array of cold frames for herb production. A newer 40' x 80' equipment barn is set up for efficient access to tractors, tools and machinery and a well organized wash room and packing facility nearby rounds out the vegetable production area.

New Leaf is a family-run farm. Chris is fully employed on the farm, doing the marketing and keeping the books, and also working in the field. The Colson's son-in-law, Steve Sinisi, works alongside Dave from mid-February to mid-December. Steve started out doing seasonal labor, moved up to become a foreman, and now, for the last two years, is more of a partner. Until their recent retirement, Dave's parents also helped a lot on the farm.

The Colsons have 2-4 apprentices working for the summer season, sometimes extending into the fall. They live on the farm full time and are housed in portable yurts and a tent on the property. The rest of the annual labor force consists of two to four local high school students hired for the summer vacation and, at present, a non-farm worker employed to take care of carpentry and other tasks.

In addition to the Waldorf school student volunteers, there are also adult volunteers who work regularly at New Leaf Farm. For them it is a social outlet or a form of exercise (cheaper than belonging to a gym!) as well as a connection to the farm. Volunteers can require skillful management to make sure that they add to, rather than distracting from, the work that needs to be done, but they can also be valuable ambassadors for the farm in the community.

General Crop Marketing and Business Strategies

New Leaf Farm markets its produce to six restaurants, two natural food stores, and through an adapted form of Community Supported Agriculture (CSA) as described below. In 2002-2003, restaurants accounted for 50-55% of the sales; natural food stores 35-40%, the CSA 7%. Other markets accounted for 3% of sales, mainly of meat.

Twice a week during the season, the day before each harvest, Chris contacts each of the restaurant and specialty store accounts, getting exact orders that minimize over-harvesting and crop waste. When demand is greater than what the farm can provide, Chris decides which accounts receive what produce and is able to communicate this to their customers in advance. This customized service keeps their accounts coming back for more. The Colsons keep in touch with their accounts over the winter to gather feedback and adjust their variety selection for the next season. They are strong believers in local marketing and seek to provide a consistently high quality of fresh produce to compete with the national organic brands.

The farm's 40 member CSA is based on a somewhat different model than the standard arrangement, where all members pay up front and get a fixed share of the farm produce. Instead, the Colsons have helped to organize Buyers Clubs that allow the members to sign up for the produce deliveries for whatever weeks during the season desired (and to skip the weeks when the member is away). The Colsons truck the bulk produce every 2 weeks through Thanksgiving to the four club sites where the members break the food down into shares and handle the distribution. Each member pays $20 per delivery. The Colsons are considering changing this arrangement, because up-front payment would help with their early season cash flow.

Even though they have successfully maintained their local markets through high quality and good community relationships, Dave and Chris are concerned about the long-term economic future of New Leaf Farm. They really "rode the wave" of popularity of salad mixes as a fresh, local, organic product, introducing the mixes to local chefs in the early 90's. However, national trends in organic marketing raise questions about whether they will continue to be able to sell salad mix at a profitable price in the long run. Organic salad mix has become an industrial agricultural product, with ingredients grown on a large scale for as little as $0.85 per pound, packaged and sold wholesale for $3-4 per pound, and sold retail across the country at $6-9 per pound.

Given these concerns and their strong focus on planning, the Colsons are trying to anticipate the direction of the organic market and adjust their crop mix, and maybe even the need for off-farm income, to make sure the farm will remain economically viable.

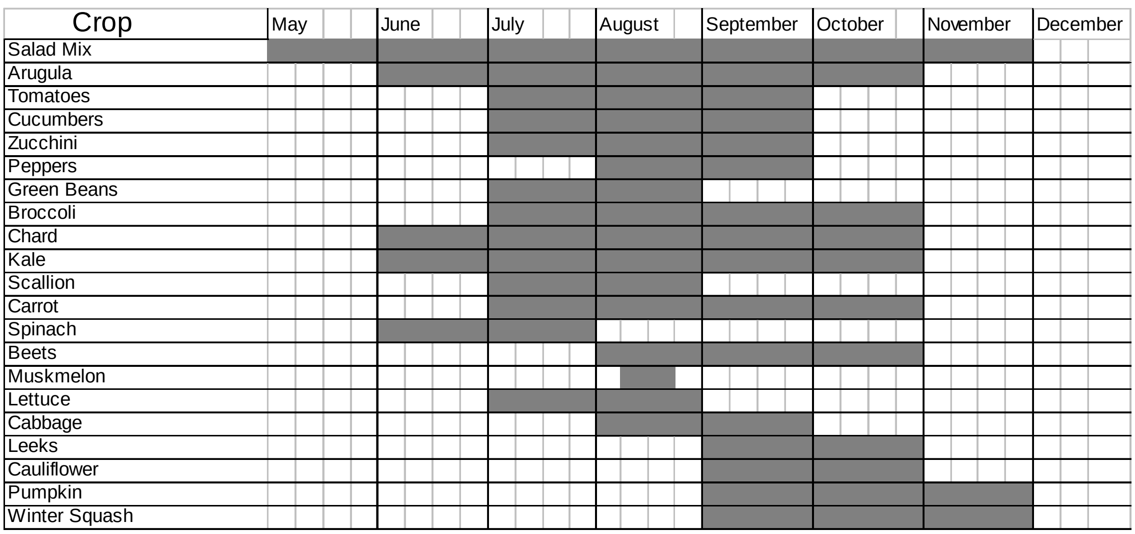

Figure 27. Crop availability at New Leaf Farm.

Crop Management

Although 9.5 acres are used for vegetable production over the 3-year cycle, only 1/3 of those acres are producing vegetables in any given year, with the other 2/3 in cover crops. But New Leaf Farm produces a wide diversity of vegetables and herbs in those 3 production acres plus the greenhouses (Fig. 27). Salad greens are the farm's top crop in acreage (1.0 acre) and economic value, representing 45 percent of the farm's business. Tomatoes are second economically (15%) with most of the production in the greenhouses. Both these crops are grown for wholesale markets and the farm's CSA. The remaining vegetable acreage is highly diversified, producing 30 different vegetable crops and 17 culinary herbs, including cole crops (0.2 acre); spinach (0.27 acre); winter squash and pumpkin (0.75 acre); and cucumber, summer squash and melons (0.15 acre).

Over the years, the Colsons have developed a number of rotations with extensive use of cover crops. During the years of this study (2002-2003), the Colsons were using three-year rotations on fields of 3 acres each. Both of these rotations included only one year of vegetable production per cycle. The choice of which rotation is used on which field is based on whether or not there is a perennial weed problem in that field (Table 11).

The Colsons have discovered that even though keeping a field in clover for two years is beneficial to the soil, it also provides an opportunity for aggressive perennial weeds to become established. To deal with weed pressure, the weed-cleansing rotation (Table 1) uses rye/hairy vetch and oat/Austrian field pea combinations as the primary cover crops. Oats are sown into the vegetable production fields in late summer and fall of Year 1, growing until the ground freezes and they winterkill. In Year 2, buckwheat is sown in early summer, followed by rye/vetch planted in mid August. In Year 3 the rye/vetch is mowed two to three times, then plowed down and followed by a summer fallow. The soil is harrowed weekly during this period for weed control, and then planted to an oat/Austrian field pea combination in late summer. The oats/field peas are winter-killed, the dead biomass protecting the soil from erosion. Vegetables are planted in Year 4.

On fields where perennial weeds are under control, the rotation starts the same in Year 1, with winter-killed oats following vegetables. Then in Year 2, red clover is seeded in the spring with oats as a nurse crop. The oats are mowed at head formation in mid-summer, allowing the clover to fill in and overwinter. In Year 3, the clover is mowed three times, and can be used elsewhere on the farm (e.g. mulch for tomatoes), but is mostly sheet composted in place. In Year 4 the clover is plowed under, followed by vegetables.

Just after this study ended, the Colsons decided that a 3-year rotation with two of those years in some form of green manure was still not enough to manage perennial weeds (principally quack grass and curly dock). In 2004, they divided their cultivated area into 4 fields of 2 ¼ acres and set up a 4-year rotation, with 2 years in green manure (which could be the oats/clover combination, or, if weed pressure warranted, a series of annual cover crops with tilled fallow periods to clean up the weed seed bank). The other 2 years would then be in cultivated crops. The Colsons have been in the forefront of cover crop experimentation, helping to develop innovations on their own and in conjunction with researchers and other farmers.

Table 11. Crop rotation plan at New Leaf Farm, 2002-2003.

	If perennial weeds are a problem:	**If perennial weeds are NOT a problem:**
Year 1	Vegetables-Oats in Fall and winter killed	Vegetables- Oats in Fall and winter killed
Year 2	Buckwheat- followed by Rye/Vetch in Fall	Red Clover and Oats seeded in spring. Oats mowed at head formation (mid-summer)
Year 3	Plow Rye/Vetch-Summer Fallow. Oats and Peas in Fall- winter killed	Red Clover mowed 3 times
Year 4	Vegetables	Spring Plow followed by Vegetables

Soils and fertility management

Crop rotations based on legumes provide the nitrogen for most crops grown in the field at New Leaf Farm. An exception is the salad mix, which gets one application of bloodmeal to provide readily available N to this fast-growing short-season crop. (Bloodmeal was also applied to winter squash in one year.) Colloidal phosphate is applied to all the vegetable crops because soil tests (Table 2) generally indicate that P availability is below the optimum needed for vegetable crops at New Leaf, and Sul-Po-Mag is applied to some vegetable crops.

New Leaf Farm nutrient budget

In order to make rough estimates of the tendency of New Leaf Farm's rotation and fertilization practices to either accumulate or deplete soil nutrients, NEON made a nutrient budget for nitrogen, phosphorus and potassium on a hypothetical field, using a typical rotation and yield and fertilizer inputs as we recorded in this study. The rotation we chose to examine lasted eight years and went through two 4-year rotations: 1) salad mix, 2) clover, 3) clover, 4) tomatoes, 5) winter squash, 6) buckwheat/fall rye-vetch, 7) rye-vetch/summer fallow/ fall pea-oats, 8) salad mix.

Yields and fertility inputs followed those we recorded over the study. Fertility inputs over eight years totaled 2000 lb/ac. of colloidal rock phosphate (12% elemental P, 21% Ca), 654 lb/ac. of blood meal (12% N), 1550 lb/acre dry weight of clover hay mulch (estimated value of 3% N, 0.3% elemental P and 2% elemental K), 2000 lb/acre dry weight of vetch (estimated value of 3.5% N), 1000 lb/acre dry weight of peas (estimated value of 3.2%N), and 1224 lb/ac of Sul-Po-Mag (18% elemental K, 11% Mg, 17% S).

As shown in Figure 28, the New Leaf Farm rotation shows positive balances for all three nutrients studied: nitrogen (+253 lb/ac.), phosphorus (+213 lb/ac.) and potassium (+126 lb/ac.). The positive figure for nitrogen is largely due to the clover and rye-vetch cover crops of two years each, when N would be expected to accumulate in the system through fixation by legumes (years 2-3 and 6-7). The large figure of accumulated N might lead to concerns for nitrogen leaching from this system. However, because fixation by legumes is suppressed by high soil N contents, and because many of the crops grown as green manures are grown in tandem with grasses and other non-legumes, there is probably a good degree of "self-regulation" of the pool of fixed nitrogen which helps to decrease the accumulation of N over time, and thus 253 lb/ac. is probably a high estimate. Nevertheless, after tillage of a clover sod or rye/vetch cover crop, there may be some risk of N loss from soils at New Leaf Farm, which is difficult to avoid.

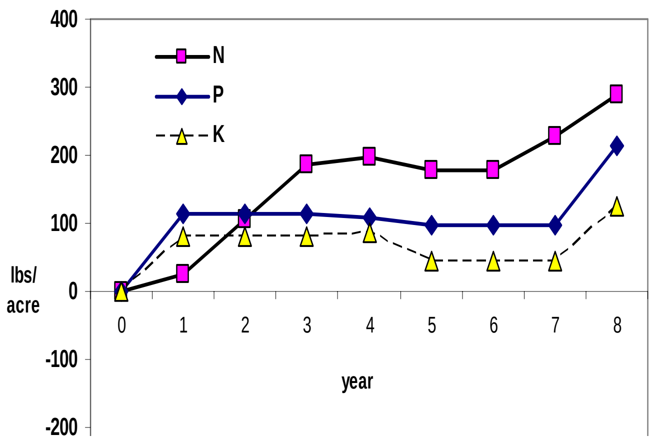

Figure 28. New Leaf Farm nutrient budget. Cumulative nutrient balance (excess of amounts applied over amounts exported as crops) for N, P and K on a modeled field for an eight year rotation at New Leaf Farm, with the following rotation: salad mix, clover, clover, tomatoes, winter squash, buckwheat/fall rye-vetch, rye-vetch/summer fallow/ fall pea-oats, salad mix.

The figure of accumulation for P is also quite high, and mainly due to two large applications of colloidal phosphate across the eight years. This raises questions about where the excess of P applied over P exported in crops is going. The NEON nutrient budget uses the total elemental P applied, not available P, and the availability of P in colloidal phosphate is low, especially when it is applied to soils close to neutral in pH, as is true on New Leaf Farm. The accumulation of total P applied does not show up in soil test results, which show the soils at New Leaf to be generally well below optimum P levels (Table 12). Soil tests do not measure total P, just the P that is extractable with certain chemical procedures, which is assumed to be the fraction available to plants. One possibility is that much of the colloidal phosphate remains sequestered in the soil in forms not extracted in soil. If the soil test levels of P were to rise, the large total inputs of P used by New Leaf would not be justified by the low level of exports in this rotation. Analysis of phosphorus levels in crops could be useful in deciding whether P nutrition is adequate from these soils at present.

Potassium accumulations were lower, but may indicate that levels of K fertilization through Sul-Po-Mag could be reduced without negative effects on yields. However, there is not a concern for effects on the environment with accumulation of K, as there would be for N or P. Potassium and magnesium in soil tests were considered to be in the optimum range set by the University of Maine, based on percent base saturation (Table 12).

Table 12. Soil test results for New Leaf Farm, 2000-2002, analyzed by the University of Maine. Mean (standard error) of 6 fields. Optimum ranges from University of Maine.

	Results	Optimum ranges
Phosphorus (lbs/acre)	7.4 (0.3)	20-40
Potassium (lbs/acre)	180 (6)	See % saturation below
Magnesium (lbs/acre)	164 (13)	See % saturation below
Calcium (lbs/acre)	1606 (98)	See % saturation below
pH	6.3 (0.04)	6.0 – 7.0
Cation Exchange Capacity (meq/100g)	5.1 (0.3)	> 5
Potassium (% saturation)	4.5 (0.2)	3.5 – 5.0
Magnesium (% saturation)	13.0 (0.9)	10 - 25
Calcium (% saturation)	78 (4)	60 - 80
Acidity (% saturation)	5 (5)	< 10

Season extension

The greenhouses and the various field techniques for season extension are essential to the productivity and the long marketing season of New Leaf Farm. Although we chose to study the tomato plantings in the field, most of New Leaf's tomatoes are produced in the greenhouse. Salad mix production is extended into November by moving into the greenhouse late in the summer. Peppers, particularly colored peppers, are a local specialty item produced entirely in the greenhouse.

Season extension materials used in the field have multiple purposes. Row covers, made of Reemay™ or of plastic sheeting held up with PVC hoops, also protect against insect and pathogen colonization, in addition to increasing air temperature. Black plastic mulch serves to increase soil temperature, and also to suppress weeds and protect plants from diseases transmitted by soil splash.

Figure 29. Erin Sturgis-Pascale (NEON research assistant) with plastic tunnels covering tomatoes at New Leaf Farm.

Tillage and Weed Management

The Colsons rely on timing, strict cover crop rotations and cultivation to control weeds (See Table 13 for their equipment list). The primary window for long-term weed control is during the fallow periods in the crop rotations. Periodic harrowing of sprouted weeds on open ground helps to deplete the weed seed bank and create a stale seedbed for the following crop. This is used in the cover crop rotations designed with a summer fallow, such as the rye/vetch rotation that leaves a fallow period between buckwheat and the fall planting of the rye/vetch cover and again between the plow-down of the rye/vetch and the planting of the oat/field pea cover in the fall. The stale seed-bed technique is also used in the salad mix field, where empty beds are disked weekly until they are prepared for crop production, and then flame-weeded one final time just before seeding the crop.

The cover crops themselves are valuable for smothering weed growth and starving out weeds through competition for sunlight and nutrients. In order to keep weeds from going to seed, crop beds are turned under soon after the final harvest and seeded with a cover crop. For example, the beds growing short-season salad greens are followed by buckwheat or oat cover. Black plastic is used for growing weed-free tomatoes and winter squash. The aisles between the black plastic-covered beds of tomatoes are also mulched with clover hay.

Table 13. Equipment list for New Leaf Farm.

Tractors	**Cultivation and mulching**
1981 Allis Chalmers 50HP	1990 Basket cultivator
1981 Kubota L245 High Clearance 25HP	1986 Mulch Layer
Soil and bed preparation	**Mowing and Haying**
1960 John Deere 2 bottom plow	1989 Woods Rotary Mower
1999 Woods Rotovator	1962 Kuhn Sickle Bar Mower
1989 Troybilt Rototiller	1969 New Holland Hay Baler
1981 Woods Disc Harrow model U100	1976 Hat Tedder, Two Gang
Roller	**Other**
Spreaders	1993 Worksaver Posthole Digger
1974 New Holland Manure Spreader	1951 John Deere Combine
2002 Gandy Fertilizer Spreader	1987 Hardi Boom Sprayer
Seeders and planters	Backpack propane flamer
1983 Cole Planet Jr. 3 row vegetable seeder	
1979 Brillion Seeder	
Two-seat transplanter (home-built)	

Pest and Disease Management

The Colsons avoid the use of botanical insecticides as much as possible because of the negative impact on the farm's beneficial insects (See Table 4 for list of sprays used on focal crops). They strive to find alternative methods of pest and disease management. Mostly they use row cover as a physical barrier to insect pests and some pathogens. Arugula and other greens highly susceptible to flea beetles are kept under row cover all the time, except for the brief periods when they are being weeded or harvested. Cucurbits (squash, melons, and cucumbers) are kept under cover for the first month to protect them from cucumber beetles.

Plastic tunnels (Fig. 29) and greenhouses have also been important in pest and disease management of tomatoes. The Colsons found that raising tomatoes under plastic tunnels reduced early blight and other diseases compared to the field without covers. Disease is also reduced in the field-grown tomatoes by growing them on black plastic and using clover mulch in the aisle, so that no soil is exposed to splash up on the plants, a major source of disease inoculant.

Table 14. Pest management materials applied to focal crops at New Leaf Farm, 2002-2003. No sprays were applied to winter squash or to the salad mix components studied. (Lettuce in salad mix was sprayed with Pyganic™ in both years.)

Brand name	Type of material and labeled use	Crop and target pest
Dipel DF™	*Bacillus thuringiensis* subsp.*kurstaki*. Insecticde for use against caterpillars	Tomato for tomato hornworm (8/17/2002)
Plantshield HC™	*Trichoderma harzianum* Rifai, biological fungicide	Tomato for early blight and other diseases (7/2/2003, 7/15/2003)
Champion WP™ combined with fish oil	Copper hydroxide fungicide and bactericide	Tomato for early blight and other diseases (7/25/2003)
Entrust™	Spinosad Insecticide	Tomato for tomato hornworm (8/1/2003)
Storox ™	Hydrogen dioxide fungicide and bactericide	Tomato for early blight and other diseases (8/13/2003)

The pest management issues are different when growing tomatoes under movable tunnels, which are part of the rotation scheme, rather than in non-movable greenhouses. Since the greenhouses are used for production year after year, with only limited options for rotation, a problem with *Sclerotinia* wilt (white mold) has built up. The Colsons have been experimenting with managing *Sclerotinia* with applications of hydrogen dioxide fungicides (Oxidate™ or Storox ™) and with the biological control agent Contans™. They use the ability to control the opening and closing of greenhouses to exclude moths of tomato hornworm and tomato fruitworm in late summer and fall. Open during the day for ventilation, the houses are closed at night to prevent these nocturnal moths from laying eggs.

An example of habitat management is the Colsons' technique for managing tarnished plant bug, an insect that feeds on a wide range of plants, but can cause direct cosmetic damage to lettuce. Observing that the biggest influx of tarnished plant bug comes when neighbors are disturbing the pest's environment when cutting hay, Dave tries to have a red clover cover crop come into its most succulent growth stage when his neighbors will be cutting hay. This produces a more delectable alternative habitat and minimizes damage to the lettuce planted nearby.

To prevent deer damage on the farm, the Colsons installed a portable fencing system that can be moved around to fit the crop rotations. The half-inch nylon/wire tape is installed 28" off the ground around the perimeters of the fields. It is powered by connections to a central livestock barn that has electricity.

Focal Crops - *Brassica* greens for Salad mix

Cultivars:	Arugula, Tatsoi, Mizuna, 'Red Russian' kale, 'Red Giant' mustard
Fertilization:	2002: Plow-down of winter-killed oat/pea, colloidal phosphate (1000 lb/acre), bloodmeal (327 lb/acre) 2003: Plow-down of red clover, colloidal phosphate (1000 lb/acre), Sul-Po-Mag (440 lb/acre), bloodmeal (250 lb/acre)
Planting:	2002: Seeded 13 times from 5/17 to 8/14 2003: Seeded 16 times from 5/13 to 9/3
Spacing:	Beds 33 inches wide, with 33 inches between beds. 2 rows per bed, 15 inches apart. Rows are seeded thickly.
Harvest:	Twice weekly, 50% of each 200' bed is harvested for salad mix. In 2002, plants were allowed to regrow and harvested a second time for sale as arugula or as a braising mix of greens. The market for the second cut products disappeared in 2003.
Acreage:	2002: 14,300 sq. ft., 0.33 acre. 2003: 17,600 sq. ft., 0.40 acre

New Leaf's salad mix is 50-60% lettuce, 20-25% arugula, and the remaining percentage divided up among tatsoi, 'Red Russian' kale, mizuna, and 'Red Giant' mustard. The lettuce is grown in separate beds and using some different techniques from the rest of the components of the salad mix. For purposes of the NEON study, we focused on the beds growing the salad mix components other than lettuce. All of these crops are grown together in the same beds and are in the same plant family (Brassicaceae, the cabbage family), so they share the same nutrient and pest management requirements.

Crop establishment and management: From mid-May through August, successions of these greens for salad mixes are direct seeded in the field. Beginning in August or early September, the greens are sown into high tunnels to extend the harvests into mid-November. All the beds in the field for salad mix get their initial preparation at the same time in late April, just after the preceding cover crop is plowed and disked. The slow-acting soil amendments, colloidal phosphate and, in 2003, Sul-Po-Mag, are applied to the whole field and the field is disked again. Then, all of the beds are set up. As each bed is scheduled for the final steps of preparation for production, the short-term fertilization with bloodmeal is applied and the bed is rotovated and rolled. Then, the bed is allowed to sit for 1-2 weeks while the weed seeds exposed by the fieldwork sprout (the "stale seedbed technique").

Figure 30. Dave Colson using a propane flame weeder to kill weeds in beds prepared for planting salad mix.

After this period, a backpack propane flame weeder is used to kill these newly sprouted weeds (Fig. 30), and then the bed is immediately seeded and the row cover applied. Meanwhile, in 2003, all of the empty beds waiting to go into production were disked periodically (every nine days, on the average) to kill off sprouting weeds and deplete the weed seedbed.

The row cover remains in place until the bed is hand-weeded four weeks later. Hand-weeding can take anywhere from 1 1/2 to 10 hours for a bed 200 feet long. The row cover is then put back until the harvest begins 5-12 days later. Overhead irrigation is used weekly as needed. One row of the 2-row bed is harvested at a time, with the two harvests being 3-4 days apart. In 2002, the beds were re-covered and allowed to re-grow a crop of arugula and Asian greens for a braising mix, cut to order. In 2003, the market for these products was gone, so the beds were turned under after the two harvests for salad mix.

Each bed is planted with the same proportions of each crop, so that the proportions of the components of the salad mix are standardized. Each 200 ft. bed is seeded with 85 ft. of arugula, 30 ft. of 'Red Russian' kale, 30 ft. of tatsoi, 25 ft. of 'Red Giant' mustard, and 30 ft. of mizuna. The resulting mix of greens is then combined with an equal volume of lettuce (mixed red and green cultivars), grown in separate beds.

The farm's efficient packing shed is another key to maintaining the high quality of the salad mix. The mix is cut, harvested into baskets and brought to the shed for through washing by a crew of 5 to 6 people. It is then packed in clean boxes and stored in the walk-in cooler overnight for the next day's delivery (Fig. 31). Salad mix is primarily a crop for sale to restaurants and natural food stores – the CSA uses only 1% of the total harvest.

Figure 31. Apprentices and crew pack washed salad mix into bags for delivery

Pest and disease management and sampling: At New Leaf Farm, row cover is used to exclude flea beetles, the principal pest of these cabbage-family greens, and it excludes all other pest and beneficial insects, too (see photo – on front cover). This barrier method was extremely successful at New Leaf Farm. In two samples for insect pests and disease in 2002 and four samples in 2003, only one adult flea beetle and three larvae of an unknown beetle (perhaps an unusual species of flea beetle) were observed. Insect damage was also minimal, as reflected by the very low percentages of culls due to insect damage: none at all in the four harvest samples in 2002, and none in the first two harvest samples in 2003. Only in the third harvest sample in 2003 were any leaves culled due to insect damage, and this was less than 0.5% (averaged over all 5 species).

Farmers report a wide variation in effectiveness of row cover against flea beetles, but the results at New Leaf Farm show that good quality row cover, effectively sealed, will exclude insects very well. In addition, a critical factor to the success of row cover is the intensive program for weed management, which limits the amount of time the cover has to be removed for hand-weeding, and thus limits the time that the crop is exposed to insect colonization. No diseases were observed in the salad mix beds and none of the harvest was culled due to symptoms of disease.

Weed sampling: Weed density and biomass were very low in the salad mix in both years, as shown in Table 15, and no weeds went to seed in either year. Weed management is critical to the efficient production of high-quality salad mix. As discussed above, the stale seedbed method of weed management reduces the amount of time spent hand-weeding, reducing the time the row cover is off and the crop is exposed to insects, and also greatly reducing the amount of hand labor required. The average time spent hand-weeding a bed was 3.7 hours in 2002 and 4.2 hours in 2003. Weed management also reduces the hand-labor involved in harvesting the crop and in sorting the harvested leaves to make sure that no weeds are included in the mix.

The downside of this intensive weed management system is the large number of times the soil is worked in a season, especially in the late-season beds. The first beds used were plowed, disked 4 times, rotovated, and then flame-weeded and planted. The late season beds were disked up to 7 additional times before being rotovated, flamed, and planted. Management this intensive could be damaging to the soil if it occurred in a short rotation, but in New Leaf's system, this field went in the fall into 2 years of cover cropping, and it would be about 4 years before it returned to the production of salad mix.

Table 15. Weed density, dry weight, and species in focal crops at New Leaf Farm, 2002-2003.

Crop	Year	Weed density, all species (plants/acre)	Weed above-ground dry weight (lb/acre)	Main weed species	Important weed seed producers
Brassica greens for Salad mix	2002	6,300 (3,300)	2.2 (1.8)	Lambsquarters Hemp nettle Clover	No seed production
	2003	5,200 (2,800)	0.4 (0.2)	Witchgrass Lambsquarters Corn spurry	No seed production
Tomato	2002	6,600 (1,300)	3.2 (0.2)	Annual ryegrass Cultivated mustard	No seed production
	2003	22,000 (3,000)	11.9 (0.2)	witchgrass Unidentified grass Foxtail	No seed production
Butternut squash	2002	0 (0)	0 (0)	No weeds in sampled areas	No seed production
	2003	190,000 (100,000)	440 (150)	Crabgrass Corn spurry Wormseed mustard	Crabgrass Corn spurry Wormseed mustard

Yield: The figures from the farm records are much more reliable than from the field sampling because NEON sampled only 4 times in 2002 and 3 times in 2003 and the variability among harvest samples was very large. In both years, the highest yield per bed was in early September, with the yield in mid-summer (late June or early July) less than half the September yield. Farm records should even out this bed-to-bed and month-to-month variability over the whole season. In 2002, New Leaf Farm sold 4,100 lb/acre of salad mix (first cutting), and 1200 lb/acre of the second cutting braising mix. For 2003, the average yield of the 3 NEON field samples was 8,400 lb/acre of salad mix. Because there was no market for the braising mix, no second cuttings were harvested in 2003. As indicated by the very high % marketability, the salad mix was very high quality as harvested, requiring little sorting. Nearly all of the cosmetic loss recorded was due to early flowering or yellowing leaves. As mentioned above, insect damage was found at a very low level in only one of 7 harvest samples, and no disease damage was found at all.

Economics: At New Leaf Farm, overhead and marketing costs were actually higher than the costs of crop production in both years for the salad mix (and also for the winter squash both years and tomatoes in 2002, Figure 32). Overhead costs were $8097 per acre in 2002 and $7422 in 2003, including equipment, fuel, taxes, insurance, memberships and fees, building repairs, phone, electricity, office expenses, etc. Marketing expenses of $2210 per acre for both years include mileage, labor, and packaging. Most of the marketing expense was in labor – time for Chris to call all of the accounts twice a week and time for someone to deliver the product.

Of the production costs, the major expenses were harvest labor ($1987 per acre in 2002 and $1057 in 2003) and the purchase and laying of the row cover (purchase for $1158 per acre, labor for laying $348 per acre in 2002 and $900 per acre in 2003).

The break-even analysis (Figure 33) shows the relationship between the marketed yield and the price required to cover the total cost per acre. At the average yield of the salad mix of 6,250 lb/acre, the Colsons would need to get a price of $2.50 per pound to break even. Looked at the other way, at their average price of $7.48 per pound, they need a yield of 2,100 lb/acre, a little more than half the yield of mix alone in 2002, when the yield was lower.

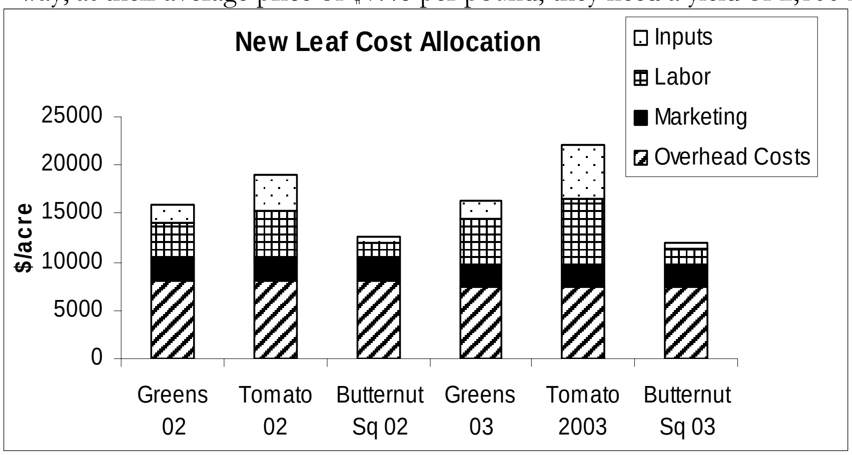

Figure 32. Overall cost allocation for focal crops at New Leaf Farm, 2002-2003.

Table 17 shows the projected revenues, based either on the Colsons' records of sales or on NEON measured yields, and actual average prices. Our calculations of cost per acre are then subtracted to get the profit per acre. These figures show that on a farm like New Leaf, with a small, intensively managed production area, the costs per acre are high, but the revenue and profit per acre can also be high when the product sells for a premium price. The salad mix is the major source of income for the entire farm.

It is important to remember that the costs we have are for production of half of the components of the salad mix, but the product is sold mixed with an equal volume of lettuce. We did not collect information on the cost of production of lettuce.

Focal Crop - Tomatoes

Cultivars:	2002: 'Daybreak' and 'Red Sun' 2003: 'Red Sun'
Fertilization:	2002: Plow-down rye/vetch, Sul-Po-Mag (440 lb/acre) 2003: Plow-down red clover. Colloidal phosphate (1000 lb/acre), Sul-Po-Mag (440 lb/acre)
Planting:	Transplanted 4 week old seedlings. 2002: 5/29. 2003: 5/27.
Spacing:	Beds 29" wide with 43" between beds. Two rows per bed, 12" apart, with 18" between plants in a row. Beds are approximately 100' long.
Harvest:	Twice weekly. 2002: 8/22 – 9/12. 2003: 8/21- 9/29.
Acreage:	2002: 1800 sq. ft., 0.041 acre. 2003: 1128 sq. ft., 0.026 acre

Crop establishment and management: Field preparation for tomatoes begins with plow-down of the preceding cover crop in late April – early May, followed by disking, fertilization (Sul-Po-Mag both years, colloidal phosphate in 2003), and disking again. After waiting about two weeks (another opportunity for weed seeds to sprout in a stale seedbed, before killing them with cultivation), the beds are rotovated, then the black plastic mulch is laid, and the 4-week old transplants go in. Plastic covers on a frame of PVC pipe go over the plants right away. About 3 weeks later, cages are set up, and the aisles between the beds are weeded, as needed, and mulched with clover hay. In 2003, Dave also set up a basket-weave system with stakes and twine. Any irrigation needed is done by hand with a wand. Tomatoes are harvested twice weekly, with 90% of the crop sold to restaurants and natural food stores, and 10% going to the CSA.

Pest and disease management and sampling: As mentioned above, Dave's system of growing tomatoes under plastic covers and mulched with black plastic and hay in the aisles reduces the exposure of the tomato plants to disease inoculum (as well as having benefits for season extension and weed management). In 2002, Dave did not spray at all for disease management on tomatoes, but did spray Bt once for management of hornworms (Table 14). In 2003, he did spray the tomatoes several times with a variety of organic materials for disease management, and once with an organic insecticide for management of hornworms.

In NEON sampling, we never found any significant numbers of pest insects (just a few flea beetles and one tarnished plant bug) and few beneficial insects, too. We never saw hornworms on the tomatoes because Dave sprayed for them as soon as he saw them.

We rated disease symptoms on the tomato plants 3 times in 2002 and 4 times in 2003. In both years, there were symptoms of early blight on every plant sampled during harvest in August, and in 2003, the symptoms were rated as "moderate" on 64% of the plants in early September. But only 20% of the plants had symptoms of disease on any of their fruit, and all of those plants were rated "light" for fruit disease. So, the combination of cultural methods, supplemented with sprays in the wetter year of 2003, kept tomato diseases from causing much loss of fruit yield until the end of the season. Dave estimated a cull rate of 25% for the tomatoes from all causes in 2002.

Weed sampling: As shown in Table 15, weed biomass was minimal and no weeds went to seed in either year of sampling. Dave's whole-farm system of weed management, combined with the use of plastic and hay mulch in the tomato beds, allowed him to achieve this level of weed control with a modest amount of hand weeding – 6 hours of combined hand-weeding and mulching in 2002 and 2 hours in 2003 for our study plots of 1800 and 1128 sq. ft., respectively.

Yield: We were not able to take direct measurements of yield and culls at New Leaf Farm. We are relying on figures from the Colsons for yield and sales of tomatoes. Yields per acre are given in Table 16.

Table 16. Yields per acre for focal crops at New Leaf Farm, 2002 – 2003. (na = not available).

Crop	Year	Cultivar	Stand count (plants/ acre)	Yield from farm records (lbs/acre)	Neon sampled yield (lbs/acre)	Marketable number per acre	% marketable yield by wt	Average wt per fruit (lb.)	Yield per plant (lbs)
Tomato	2002	Daybreak/ Red Sun	4840	24,900		41,000	na	0.6	3.7
	2003	Red Sun	4840	22,600		54,300	na	0.5	5.6
Brassica greens for salad mix	2002	Mix of Arugula, Tatsoi, Mizuna, "Red Russian" kale, "Red Giant" mustard		4,100 (1st cutting for salad mix)	5,800 (1000)		98.7% (1%)		
				1,200 (2nd cutting for braising mix)	na				
	2003			na	8,400 (2000)		99.94% (0.02%)		
Butternut Squash	2002	Waltham	1,800	16,600		7,800		2.1	9.1
	2003	Waltham	1,800	11,100	15,100 (3100)	4300 (400)	88	3.4 (0.4)	8.3 (1.7)

Economics: Tomatoes had the same overhead and marketing costs per acre as given above for salad greens, and these were 54% of the total costs in 2002, and 44% in 2003 (Fig. 32). The largest production costs were: purchase of plastic row cover materials ($1525 per acre each year), hand irrigation ($1452 per acre in 2002, $726 per acre in 2003), and purchasing and setting up cages (in 2002 purchase for $907 and set up for $881 per acre, in 2003 cages were combined with basket weave and stakes for a materials cost of $1724 and set up cost of $661 per acre). Other significant costs were spraying (in 2002 $484 per acre for labor, in 2003 materials for $690 and labor for $1089 per acre), labor in transplanting ($661 in 2002, $413 per acre in 2003) and harvest labor ($440 per acre in 2002, $1387 in 2003).

The graph for break-even analysis is given in Figure 33. For tomatoes, at the average yield of 23,750 lb/acre, the break-even price would be $0.86 per lb. At the mean New Leaf price for the two years of $2.38, the break-even yield would be 8,590 lb/acre, 36% of their average yield.
Table 17 gives the projected revenue per acre for these plots, based on New Leaf records of yields and average prices and NEON calculations of the cost of production. Keep in mind that these calculations were for field-grown tomatoes, which are both a tiny fraction of an acre (0.026-0.041 acre) and a small proportion of New Leaf Farm's production, most of which happens in the greenhouse. We did not calculate the cost of production in the greenhouse.

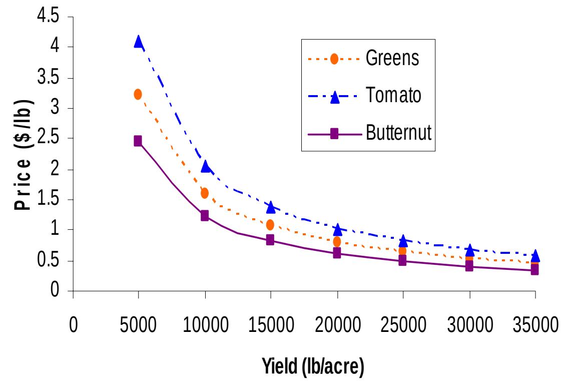

Figure 33. Break-even analysis, New Leaf Farm, 2002 – 2003, using the cost of production for each focal crop averaged over two years.

Focal Crop - Butternut Squash

Cultivars:	Waltham Butternut
Fertilization:	Plow-down winter-killed oat/pea cover. Colloidal phosphate (1000 lb/acre). In 2003 only: Bloodmeal (327 lb/acre).
Planting:	Transplanted 4-week old seedlings. 2002: 6/6-6/7. 2003: 6/3.
Spacing:	Rows 12' apart, plants spaced 2' apart in row.
Harvest:	2002: 9/14-9/17, assisted by 3rd grade class at Waldorf School. 2003: 9/24. Fruit allowed to cure in greenhouse until delivered to orders.
Acreage:	2002: 4416 sq. ft., 0.10 acre. 2003: 5688 sq. ft., 0.13 acre

Crop establishment and management: The small planting of butternut squash was part of a larger field (0.46 acre both years) of miscellaneous squash varieties, including Baby Blue Hubbard, Buttercup, Red Kuri, Delicata, Acorn, pie pumpkins, and Kabocha squash. All of these winter squash and pumpkins are grown in the same field with the same methods at New Leaf.

Field preparation began with either plowing and disking or just disking the preceding winter-killed oat/pea cover crop in late April. In both years, the field was fertilized with colloidal phosphate and disked, and in 2003, it was also fertilized with bloodmeal and rotovated. Then, the black plastic was laid in late May, the aisles were disked and transplanting of 4-week old plants began in early June.

The beds are covered with Reemay ™ immediately after transplanting. Dave covers the squash with row covers that were already used once on the salad greens, saving considerable expense. The covers stay on for about a month. When the covers are removed, the aisles are rotovated and the beds and edges of the plastic are hand-weeded (Fig. 34). In 2002, overhead irrigation was used twice, but there was no irrigation in 2003, a wetter year. In 2003, Dave set up a deer fence, using soap as a repellent. At harvest time, the fruit are cut and piled on the black plastic, and the vines are mowed in the aisles. Then, the tractor can travel down the aisles for the harvest, making the fruit easier to collect, especially for the Waldorf 3rd grade class.

Pest and disease management: As discussed above, row cover was used for the first month after transplanting to exclude insect pests. Protecting the plants for the first month excludes cucumber beetles for the most critical period, during the cotyledon stage and early seedling growth. It also keeps out squash bug adults during the time most of them fly into the field. Nothing was sprayed on the winter squash in either year. The NEON sampling found that there were very few insect pests in either year, certainly not enough to affect yield or quality. There were also very few beneficial insects. Powdery mildew was not assessed at the end of the season in 2002, but in 2003 it was widespread at a level that was rated "moderate" in the last weeks before harvest. This might have affected the quality (sugar content) of the squash, but would not have affected yield.

Figure 34. Squash planted on black plastic mulch at New Leaf Farm

Weed sampling: There were radically different levels of weeds in the winter squash in the two years of sampling (Table 5). In 2002, there were no weeds found in the sampled areas at all. In 2003, there was a high weed biomass and density, and all of the major weeds went to seed. This was the only time at New Leaf that we saw any significant weed biomass at the end of the season or any weeds at all allowed to go to seed. It is unclear how much the weeds would have affected yield because if they were mainly in the aisles, the squash plants may have been protected from competition by the plastic mulch.

The difference in weed growth in the two years was also reflected in the farm records for the amount of time spent hand-weeding. In 2002, Dave's records indicate that his apprentices spent 7 hours hand-weeding, mostly along the edges of the black plastic, an amazingly low number for the entire winter squash field of 0.46 acres in which there were essentially no weeds at the end of the season. In 2003, the apprentices spent 87 hours hand-weeding a field of the same size, and there was still high weed biomass and weeds that went to seed. We do not know why the weed pressure was so different in the two years because the timing of cultivations and laying black plastic was similar. Perhaps the difference lies in differences in the history of the two fields, or in the wetter weather in 2003.

Figure 35.. Butternut squash curing on shelves in the passive solar greenhouse

Yield: The yield of butternut squash was similar in both years, despite having virtually no weeds in 2002 and considerable weeds in 2003. Another cultural factor is that the first batch of seed in 2003 germinated poorly, so the Colsons had to replant with a second batch. Thus the transplants may have been younger and smaller when transplanted to the field. But again, this made little difference in the yield.

Economics: Even more than the other focal crops above, most of the cost of producing and selling the winter squash at New Leaf was due to overhead and marketing. These two categories combined accounted for 82% of all costs in 2002, and 81% in 2003 because the input and labor costs were low in both years. The major expenses in crop production were: packing ($874 per acre in 2002, $476 in 2003) and hand-weeding, especially in 2003 ($595 per acre in 2003, but $60 per acre in 2002).

The revenue analysis (Table 17) shows that winter squash was not a profitable a crop for New Leaf in either year. The costs of production (labor and inputs, Figure 32) for winter squash were lower than for the other crops, but the revenue was lower, too. At the average price for the two years of $0.72 per pound and the average cost of production, New Leaf Farm needs to get a yield of 17,000 lb/acre to break even, and they came close in 2002, but didn't quite get there. At their average yield for the two years (15,850 lb/acre), they would need a price of $0.77 per pound to break even (Fig. 33).

Conclusions

Over 20 years the Colsons have worked out a system that works for them, using cover cropping systems to control weeds, provide nitrogen, build soil, and manage their workload. Then, they focus intensive effort on their greenhouses and 3 acres of fields producing vegetables in that year. These intensive operations in a small area have to pay the overhead for the entire farm and income for 2 families, as well as wages for the workers, so they really have to produce high yields and as high value as possible. The Colsons put a big effort into marketing, with Chris spending most of 2 days per week calling all of their accounts. This supports the premium prices that they get, reflects their business philosophy of local marketing through relationships, and also reflects their personal philosophy of working with and serving their local community.

Since they have a short field season, the Colsons rely on season extension through use of permanent greenhouses, high tunnels, black plastic mulch, and both clear plastic and woven row covers to be able to serve their markets from May through Thanksgiving. They have also creatively exploited the side benefits of many season extension techniques for pest and weed management, using plastic mulch against weeds and row covers of Reemay™ and plastic to exclude insect pests and to reduce exposure to disease. They look to cultural methods of pest management first, with little use of sprays, but some organic sprays are still used, especially for disease management in tomatoes.

Their cover cropping system was generally successful in managing weeds without excessive hand-labor. Among the NEON farms, there are some farms that try to manage the weed seed-bed, taking on the challenge of trying to keep any weeds from going to seed, with the hope of reducing weed problems for years into the future. New Leaf Farm illustrates both the benefits of this approach (in the relatively low amount of hand-weeding required to get excellent weed control in most crops in both years) and the consequences when it doesn't work – the higher hand-weeding, with weeds still going to seed, in winter squash in 2003. The nutrient budget indicates that major nutrients were well-supplied, with some possible excess N and P but not so much that there would be a risk of pollution from leaching or run-off.

Table 17. Revenues for greens, tomatoes, and butternut squash at New Leaf Farm, 2002-2003. Note that we do not have data for the lettuce, which is 1/2 of the salad mix.

Crop	Year	Amount sold (lbs per acre)	Average price per lb.	Revenue	Total cost of production per acre	Profit per acre
Brassica greens for salad mix	2002	4,100 mix 1,200 2nd harvest	$7.45 for mix $4.50 for 2nd harvest	$30,800 $5,400	$15,800	$20,400
	2003	8,400 (NEON sampled yield)	$7.50	$62,500	$15,500	$47,000
Tomato	2002	24,900	$2.57	$63,900	$18,900	$45,000
	2003	22,600 (based on 586 lbs)	$2.20	$49,700	$22,100	$27,700
Butternut squash	2002	16,600	$0.69	$11,500	$12,500	-$1,000
	2003	15,100 (NEON sampled yield)	$0.75	$11,300	$11,900	-$600

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