Year-round Backyard Mini-Farming:
Food with the Least Fossil Fuel and Footprint

Pennsylvania Association for Sustainable Agriculture
PASA Conference Workshop, 2008, 2009, 2010
Gene Bazan, Ph.D. and Tania Slawecki, Ph.D

Intro slide: these two dissimilar insects on our raspberry cane caught Gene's attention. Tania came quickly with camera to capture the image and then looked them up in our insect books – lo and behold, they were the dreaded peach borers! …and our peach tree sat mere feet away at the head of the raspberry bed!

PART 1. INTRODUCTION

This winter we enter our 14th year as Biointensive Mini-farmers. It has been quite a ride. Our adventure started in March of 1997. We attended a weekend workshop on biointensive minifarming, as it was then called, given by John Jeavons, founder of Ecology Action (http://www.growbiointensive.org/). Steve and Carol Moore, then running the farm at Wilson

College in Chambersburg, organized the workshop. We took the workshop with the Moore's and fifty or so other attendees.

The two of us already had several years of organic gardening experience. The previous year I had completed Master Gardener training through Penn State Extension. Tania's father was a devotee of Bob Rodale, and my grandfather, an immigrant from Poland, had a separate garden lot to which he would walk in the summer with his wagon. Sometimes he would take me along.

But Tania and I were unprepared for the depth, breadth and richness of the school of thought Jeavons leads. He blew us away.

This training underscored in our minds the distinction between a school of thought, of which biointensive is one example, and the collection of practices which each gardener throws together, more or less haphazardly and idiosyncratically over a lifetime.

What counts with organizing frameworks or schools of thought is the integration these have achieved among many practices. These frameworks or schools answer not only **what** to do, but **why, how and when** in a way that prevents confusion in the novice and serves as a basis for improving practice among the accomplished.

I fell to double-digging in our backyard as soon as we returned from the workshop. Tania was shocked, because I had sworn earlier that I was not going to dig another bed in our heavy and rocky clay on the slope of Mount Nittany. We finished the first six beds by that winter, adding more over the years until we reached our present number of 26 beds.

As we gained experience and read about other schools of thought, we folded in elements of permaculture, and the winter harvest principles Eliot Coleman has perfected.

Our integration of these three schools of thought has enabled us to achieve the following:

1. Reduce our dependence on the fossil-fuel based and increasingly destructive industrial food system;
2. Reduce our ecological footprint by getting our food from a much more local source – our own backyard. We pick our food fresh. Totally organic.
3. Grow 90% of our vegetables and 40% of our fruit. Our 26 beds comprise 2,600 sq.ft. of improved soil.
4. Spend time in the great outdoors, with each other and with our plant and animal friends. Beats working out in an air-conditioned gym doing reps.
5. Create a place of beauty.
6. Build friendships with others.
7. Grow intellectually. We didn't anticipate how much growing our own food would challenge us. The beauty and complexity of our garden ecosystem still catches us by surprise. We've become fully engaged in watching the drama in which we participate unfold.

In **Part 2** we will describe the features of three schools of thought that we have integrated in our

own practice: biointensive, permaculture and Eliot Coleman's winter harvest
In **Part 3** we'll provide more detail about how we implement these methods in our backyard mini-farm.
In **Part 4** we describe our yields, experiments and what we do with our produce.
In **Part 5** we summarize the lessons we have learned over the past 13 years.

PART 2. DISTINGUISHING FEATURES WE HAVE INTEGRATED FROM BIOINTENSIVE, PERMACULTURE AND ELIOT COLEMAN'S WINTER HARVEST

Above: Early July view across the mini-farm towards the house. You can see the two sets of solar hot water heating panels on the roof of our 1938-built home which we have been gradually retrofitting to reduce our fossil-fuel dependence.

2.1 Distinguishing Features From Biointensive

Above: 1997 Biointensive Mini-Farming Workshop at Wilson College. John Jeavons is the beared man kneeling on the far right. His wife, Cynthia Raiser Jeavons, is standing in front at the far left. Gene is standing in the center of the group photo wearing a bright yellow jacket. Tania is behind the camera (as usual).

John Jeavons is a systems analyst who learned the biointensive method from Alan Chadwick, the British Shakespearean actor and English horticulturist. Chadwick was a student of Rudolph Steiner who developed biodynamic farming, but Chadwick had ideas of his own. He moved to UC Santa Cruz in the mid 1960s to establish an organic garden.

Chadwick experimented with and combined best features from biodynamic and the French intensive methods to create his own biointensive method. Biointensive also draws upon a rich agricultural heritage that includes the intensive practices of 4,000 years of Chinese farming, about which F.A. King wrote in “Farmers of Forty Centuries.” In addition, biointensive draws upon the sustainable practices of indigenous cultures in Latin America, Europe, and other parts of Asia.

Above: This early season view of our home mini-farm reveals both the order and beauty of Chadwick's approach.

His highly attractive gardens attracted many students, among them, John Jeavons. Jeavons reported to us that while Chadwick's methods had created a rich and seemingly sustainable paradise, he had difficulty communicating exactly what he did or how he did it to his students. Jeavons, with his background as a systems analyst, immediately realized the value of organizing Chadwick's discoveries and understandings into a practical, teachable framework.

Biointensive minifarming comprises seven practices or features integrated in a complete approach for growing your own food for personal self-sufficiency. We introduce them here and they will be addressed in detail in **Part 3**:

1. Deep soil preparation – the permanent double-dug bed;
2. The use of compost for soil fertility
3. Close plant spacing (hexagonal close-packed arrangement optimized for each kind of plant)
4. Companion planting in time and space
5. Carbon-efficient crops (e.g., cover crops of oats or attractive Japanese millet)
6. Calorie-efficient crops
7. Open-pollinated seed so that you can save your own seeds, and adapt them to your own soil and climate conditions.

Using these practices, Jeavons claims you can achieve the following:

- Build soil 60 times faster than in nature
- Reduce water use per unit of production by 67-88%
- Reduce purchased fertilizer by 50% or more
- Reduce energy used by 99% per unit of production
- Double soil fertility
- Double to quadruple caloric production per unit area.

At his workshop, Jeavons drew a careful distinction *not* between biointensive and industrial food growing, which is obvious, but between biointensive and organic. Large scale organic agriculture is every bit as industrial as its larger cousin. In these cases, it comprises acres of monoculture, relies on fossil fuel in production and distribution, compacts the soil with tractors and machinery, and depends on imported inputs such as organic matter, fertilizer, amendments, and pesticides. In short, so much of organic agriculture, Jeavons asserted, was simply not sustainable.

Above left: Our first exposure to the beauty and abundance of biointensive beds at Steve and Carol Moore's greenhouse at Wilson College in 1997. Above right: A view across part of the biointensive mini-farm developed at the Center for Sustainability (2003) while Tania was director.

Biointensive mini-farming is sustainable and widely applicable, especially in the 3rd World, for several reasons:

- Once you build soil fertility, then as long as you properly recycle all wastes back into the system, no further external inputs are required. The biointensive method utilizes natural regeneration principles to sustain it, e.g. recycling of specific soil-building crops back to the soil.
- The method utilizes hand tools – far more affordable than complex machinery
- High yields can be achieved in small spaces.
- Including foot path space, a complete, healthy vegan diet for one person could be produced on less than 1/8 of an acre.
- Consequently, biointensive is being taught to tens of thousands of people in the 3rd World: Mexico, Kenya, Russia, Afghanistan and other places where eating is not taken for granted.
- By contrast, here in the U.S., biointensive is not very glamorous to we Americans: there's not much to "sell" – except, perhaps, future food security. As energy prices increase, the cost of water-laden foods will likely go up more than dry-weight goods since you are using extra fuel to

ship all the water. For the suburban backyard, then, it makes more sense to grow high water-weight crops (vegetables and fruits) and import calorie-rich dry-weight grains, legumes as well as the dairy, eggs or meat produced from animals that require such crops as food.

The *resilience* of biointensive practices is readily apparent when you learn that citrus crops have been successfully grown using triple-dug beds in arid regions of Kenya and, to the other climate extreme, the biointensive farmer in Honduras was the only farmer whose (deeply rooted) crops did not wash away when the fury of a hurricane hit. In light of climate change and unpredictable weather severities, biointensive has proven resilient and seems like the best way to "grow"!

Above: Penn State graduate David Lettero shows off the first crop of giant mangels (sugar beets) harvested from the mini-farm at the Penn State Center for Sustainability – this impressive crop and yield inspired a number of students to take an interest in biointensive.

Biointensive also has a well-founded track record for successfully feeding the poor. As one example, in Kenya, after 5 years of practicing biointensive: farmers provide 3 nutritious meals/day for their families and earn $30/month selling excess food crops. The average income in Kenya is $20/month. At the start, most of the farmers did not have enough food for 3 meals a day. The Manor House Agricultural Center in Kenya has spawned NGOs to further the training of others in biointensive. In 2005, Manor House graduates trained 10,000 farmers in Biointensive.

There are caveats to adopting biointensive minifarming:

1. Unless practiced carefully, biointensive minifarming can deplete the soil much more quickly than conventional agriculture. Thus, the 60-30-10 rule acts as an important guideline for keeping within the bounds of sustainability. This rule states that 60% of your garden bed time is in carbon crops (grains, corn); 30% in calorie crops (root crops such as potatoes, burdock, garlic, parsnips); leaving 10% for income crops that can be sold off-site.

<table>
<tr><th>Bed #</th><th>Mar 15</th><th>April</th><th>May</th><th>June</th><th>July</th><th>August</th><th>Sept</th><th>October</th><th>Nov</th><th>Dec 15</th></tr>
<tr><td>1</td><td>o/v</td><td colspan="6">Root crops: carrots, beets, mangels, onions, turnips</td><td colspan="3">Rye/vetch</td></tr>
<tr><td>2</td><td>R/v</td><td>FAVAS</td><td colspan="5">Tomatoes, Peppers, Basil & Parsley</td><td colspan="3">Rye (Winter)</td></tr>
<tr><td>3</td><td colspan="2">Rye</td><td colspan="4">Oats/peas/vetch</td><td colspan="4">Oats/vetch</td></tr>
<tr><td>4</td><td>o/v</td><td colspan="4">Early crops: peas & greens</td><td colspan="2">Buckwheat</td><td colspan="3">Oats/vetch</td></tr>
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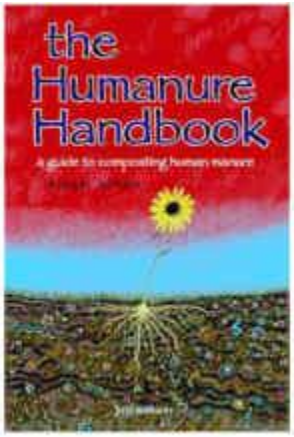
Above: This color table provides you with a sense of what it means to employ the 60-30-10 rule. If we look at four garden beds (say, each 100 square feet in size) during the course of a 9-month growing season (from mid-March to mid-December), that gives us 4 garden beds x 9 months = 36 garden bed months total. Of that, in green, are all the soil-building cover crops which fix nitrogen in the soil, provide carbon in the form of root mass in the soil and provide carbon for the compost that will get returned to the soil. If I total up the number of months of green area, I get 23 garden bed months. If I divide this by the 36 garden bed months total, that tells me that 64% of my "garden bed time" is in the proper soil-building crops and I've met (even exceeded) the 60% Jeavons recommends for sustainability. Similarly, the root crop bed time and tomato-pepper-herbs bed time combined are roughly 30% while the early peas and greens section is about 10%. If you didn't need to export anything for income, than you would have 40% of your garden bed time available for food crops.

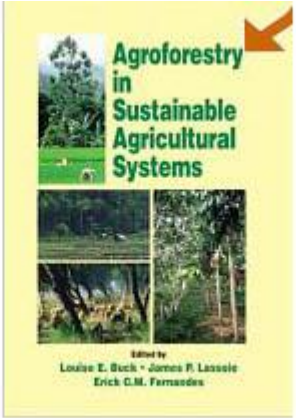
2. To create complete sustainability, all wastes must be recycled. The biggest leakage from minifarming operations is the practical inability to return human wastes to the soil (though Joe Jenkins, author of *The Humanure Handbook* has paved the way). The second biggest leakage is sending produce off the farm, which is why Jeavons limits income crops to 10% of the planted area.

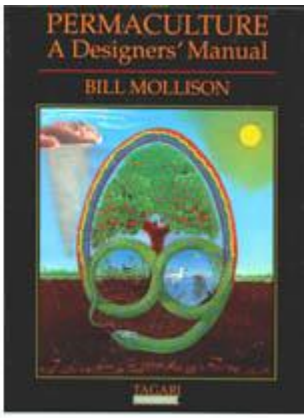



Above: Joe Jenkins' handbook provides you with the best information on composting toilets and how to properly compost human waste in outdoor bins, as depicted above. Photos are from http://josephjenkins.com/index.html - be sure to visit!

3.Biointensive minifarming is only one aspect of a sustainable agriculture. Other aspects include:

- Agroforestry (e.g., the Permaculture of Bill Mollison)
- No-till Fukuoka food raising
- Traditional Asian blue-green algal wet rice farming
- Natural rainfall or "arid" farming
- Indigenous farming



Above: At left is Masanobu Fukuoka (photo from http://www.permaculture.com/drupal/node/140 - be sure to read Larry Korn's articles). The books are staples in this field.

2.2 Distinguishing Features We Have Taken From Permaculture

Bill Mollison, founder of the Permaculture school of thought, coined the term to stand for a "permanent agriculture." He defined Permaculture as "the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability and resilience of natural

ecosystems. It is the harmonious integration of landscape and people, providing their food, energy, shelter, and other material and non-material needs in a sustainable way." Permaculture can include the sustainable practices of biointensive minifarming, but its focus includes *the broader context of the entire property and how it functions*.

The goals of Permaculture design are to:

- Minimize use of manufactured energy
- Return nutrients to soil, rather than mining it.
- Conserve water - using it sensibly
- Optimize use of nature's gifts
- Restore and increase biodiversity
- Live within the limits of Nature (including population limits): Reduce ecological footprint!
- Aim to put 70% of your land in "forage" crops (for suburban context: "edible" landscaping)

In our suburban context, we can realize at least the first five. The last two require some further elaboration.

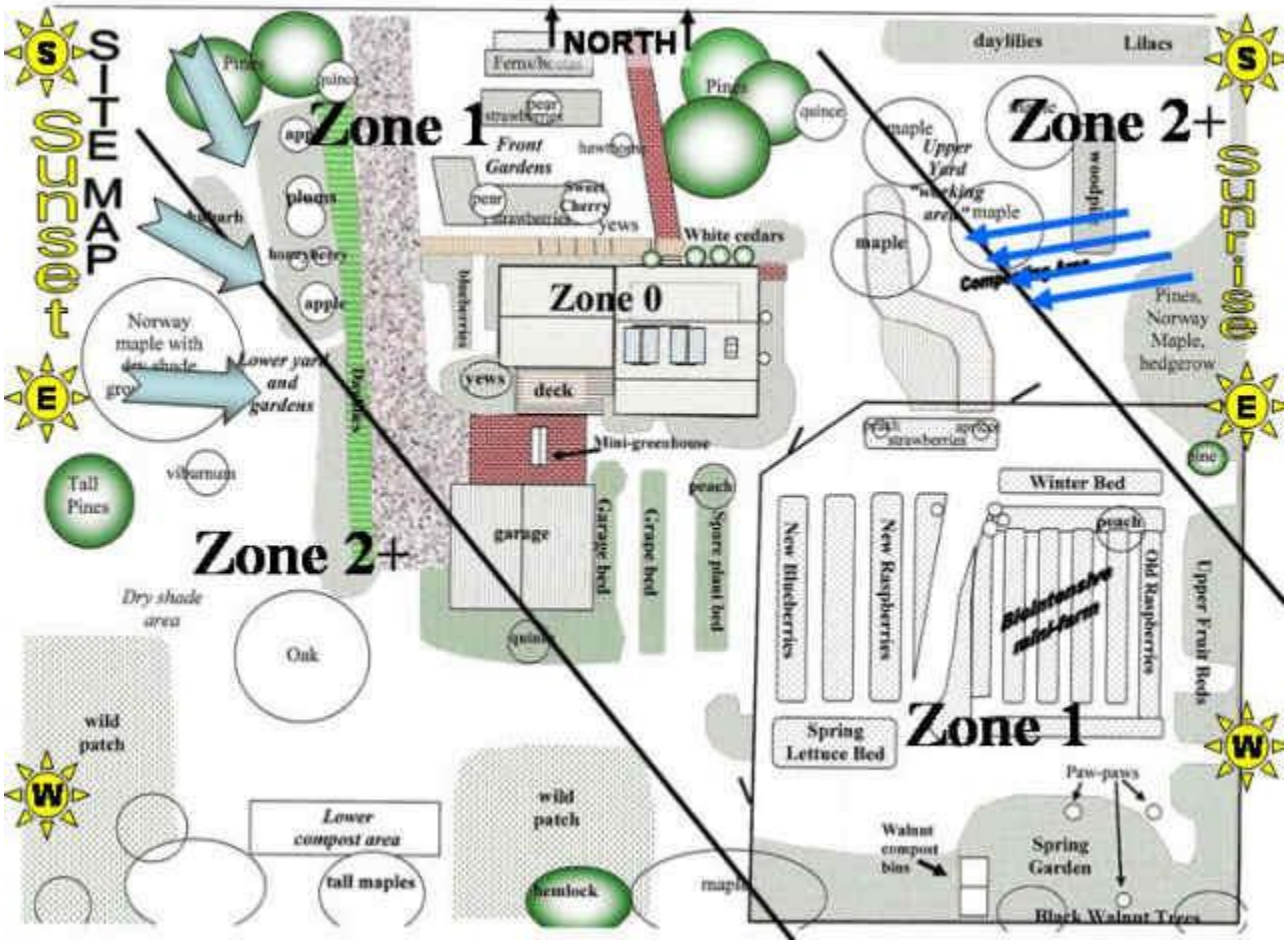
<u>With regard to forage crops</u>, Mollison had in mind putting pasture animals out to graze and forage on larger farms, as well as to ensure adequate vegetation for some wildlife. In suburban settings, we change the meaning of forage to encompass edible landscaping. Building a rich, biodiverse edible landscape can provide food for wildlife and possibly some extra berries and nuts for we humans to enjoy as well. We've peppered our own yard and mini-farm with such plants: hawthorn, nannyberry, Joy bush cherry, for example. [Robert Kourik's book *Designing and Maintaining Your Edible Landscape, Naturally* is an excellent reference on this topic and exemplifies the application of many Permaculture principles.]

<u>How do we know if we are living "within the limits of Nature?"</u>
At our previous PASA talk (in 2006), we used Ecological Footprint Analysis to look at the amount of land needed per capita to sustain our activities and consumption. The average American requires approximately 25 acres of ecologically productive land to provide *all the resources* and to *absorb all the wastes* associated with their lifestyle – food, housing, transportation, consumer goods, etc. Here in Centre County, PA, if we take all of the ecologically productive land available and divide it by the current population, there are only 4.5 acres per person available. Our ecological footprint is more than five times the area available locally, which means we're "borrowing" ecological services from other countries, other species, and from future generations.

Our 25-acre footprint looks even worse if we consider the entire state of PA. Taking the entire state of PA as ecologically productive land (which is being generous) and dividing by our population, we physically have roughly 2 acres per person available, which is 12.5 times less than the area of land needed to truly sustain our lifestyle and activities. There are two parameters that can be tweaked here: the area of land needed to ecologically and functionally support each of us, and the population size. *The main point here is that most of us in suburbia are living well beyond Nature's limits and have plenty of room to downsize our footprints!*

Transforming your suburban property into an edible landscape and mini-farm could significantly reduce your food footprint and somewhat reduce your transportation footprint. Applying the principles of biointensive and Permaculture around your home would reduce your overall ecological footprint.

In Permaculture you pay close attention to the natural patterns and flows on the land to learn how best to work with them.



Above: Our property site map overlaid with Permaculture zone and natural flow information (see Appendix below for symbol key).

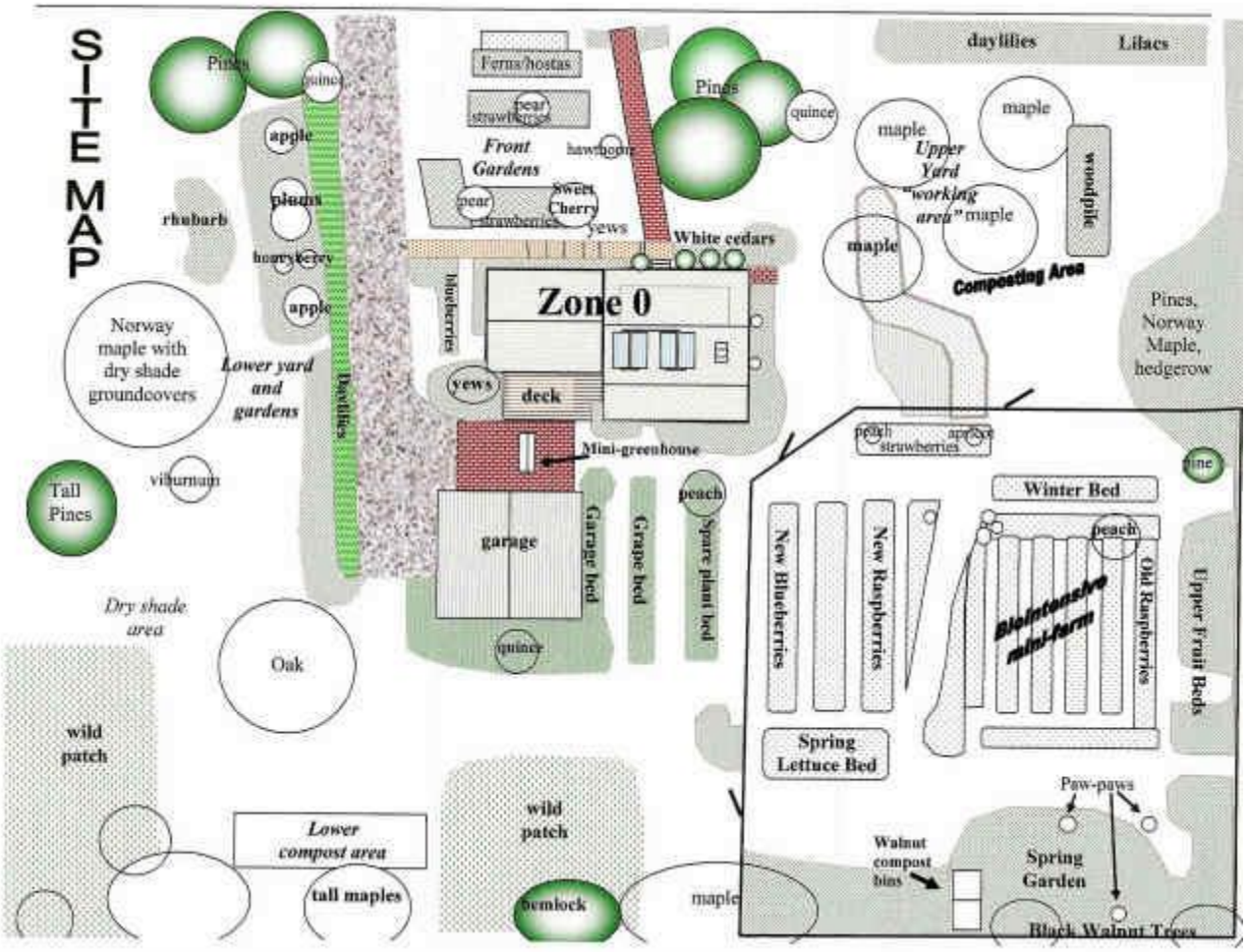
Imagine a circle around the house (zone 0) and note the sectors for prevailing winds, solar access and water flow and how these natural flows change in the course of a year. A Permaculture design for a site strives to meet the goals listed above *in harmony with these flows*. To clarify functions on a site, there are a gradation of Permaculture "zones" from the region of most human activity and influence (e.g. zone 0 = the home) to the region of the least human activity and influence (e.g. zone 5 = "wilds").

Our 0.8 acre site steps down from the foothill of Mt. Nittany in roughly three tiers: an upper level, middle level (on which house and garage sit), and lower level. It was fortunate that there was already a nearly ideal Permaculture-like layout of the house and landscape upon purchasing it in 1989:

- The house had the longest side and most roof area facing south for optimal solar access
- Tall pines and cedars buffered the north side of the house and backyard gardens from the prevailing north and northwest winter winds
- Mature maple trees to the east and tall pines to the northwest reduced the oppressive summer heat on the house
- Two wild patches serve as our token Permaculture “zone 5”: rabbits take refuge and deer will bed down there sometimes
- Unlike our neighbors, we kept a porous gravel driveway to capture and reduce rainwater run-off.

To clear up the solar corridor for improved solar hot water heating in winter and increased sunlight on our mini-farm, numerous trees were removed from the backyard, most recently a 70-feet tall hemlock and a large Norway maple (November 2006). We used much of this biomass as mulch and firewood.

<u>Note</u>: more detail about the symbols on the map above are provided in the Appendix at the end of this section



Above: Our property site map. There remain a large number of mature conifers, maples and cedars along with lilacs, Japanese honeysuckle and other shrubs and trees. Our main contribution to Permculture design of the site has been building our biodiversity around this existing vegetation.

We have been working diligently to build biodiversity and to provide some edibles for wildlife. We grow some 49 herbs, 34 fruit and nut plants, about 27 vegetable crops and hundreds of different flowering plants among the remaining numerous shrubs, maples, pines, cedars, yews, two black walnuts, a single hemlock and an oak tree. We planted hawthorn, nannyberry (a viburnum) and Joy bush cherries for the birds; chipmunks steal our gumi berries; we share our hazelnuts with the squirrels, eventually harvesting the lot before they take them all!

Above: Sampling of our biodiversity - clockwise from upper left: Echinacea in full bloom, curing our butternut squash after harvest, purple balloon flowers, and Sea Buckthorn “seaberries” (known for their medicinal value and exceptionally high vitamin E content).

We’ve built a biodiverse vegetable community in our main mini-farm and biodiverse plant communities around the rest of the property.

Above: Our biodiverse vegetable community.

Below: Biodiverse plant communities fill our yard and landscape.

Signs that we are successfully building a healthier, biodiverse ecosystem come to us mainly in the form of fewer insect pest problems and quite a few new insect friends.

Above: Sampling of our biodiverse insect community includes the predatory wheelbug (upper left), the blue blister beetle (lower left chomping on our Japanese anemone leaves), and other insects we have yet to identify! We're always pulling out Cranshaw's *Garden Insects of North America* to learn more about our insect friends (or foes!).

Note: One British permaculture site, replete with publications, is http://permanentpublications.co.uk/

Appendix: Applying Zoning and Sector Analysis to our own Home Mini-Farm

On our own home mini-farm, a 0.8-acre lot which steps down the mountain in roughly three ¼-acre tiers, the Permaculture zoning was not planned, but rather has evolved in tandem with solar access, working with existing tree stands, and with how easily areas can be accessed from Zone 0, the house. From sector analysis, we see note that the sun rises far to the northeast at the summer solstice and sets far to the northwest at that time ("S" sun graphics). At the spring and fall equinoxes, the sun rises due east and sets due west ("E" sun graphic). By the winter solstice, the sun rises far to the southeast and sets far to the southwest ("W" sun graphic). Our prevailing

winter winds are from the north and west (wide blue arrows), while water draining down the slope must be diverted away from the foundation of the house (thin blue lines).

The areas outside of Zone 1 are labeled “Zone 2+” because they are regions of dry shade that do not require much management and but still host our compost piles, wood stacks and other debris piles that are used in various ways. Two patches are intentionally kept “wild” but don’t exactly fit the Zone 5 criterion for “wilds” since they border the neighbors’ yards. Still, deer will sometimes bed down for the night in one of the wild patches; rabbits seek them out for cover and coolness in summer.

In general, Permaculture is geared toward working with, rather than against, Nature, restoring and rebuilding biodiversity. Before you can undertake conscious design, then, it is important to become familiar with the natural flows and processes of a giving parcel of land – *a study that requires at least a full year to understand seasonal variations and to design accordingly.*

2.3 Distinguishing Features We Have Taken From Eliot Coleman

Eliot Coleman is best known for his *The New Organic Grower* and *Four Season Harvest*, as well as for his *Winter Harvest Manual*. Because of his success in farming throughout the year in the cold northeastern U.S., there are a number of valuable lessons for the serious backyard mini-farmer. Those we have found useful to integrate into our practice include:

Optimal crop rotations. Over the years, Coleman has found certain vegetables do better or worse if they are planted in the same location where, the previous year, a different crop was grown. Through careful record-keeping of yield, plant/soil health and insect populations, he noticed patterns (See Ch. 7 of *The New Organic Grower*) out of which he developed his various plant rotations:

- We built on his 8-year rotation: potatoes follow sweet corn, which follows cabbage-family plants, which follows peas, which follow tomatoes, which follow beans, which follow root crops, which follow squash, which follows potatoes
- Coleman provides sufficient information to aid you in developing crop rotations that may be more suited to the crops you want to grow.

Above: Our garden beds are divided into three sections each into which different crops are planted each year according to our rotation scheme adapted from Coleman's.

Winter Harvest – Coleman, *without the use of heated greenhouses*, produces winter greens for market in Maine. Four points we employ in our practice are as follows:

- Plant the winter crops in late July or early August so that they reach maturity before the light levels drop and the cold sets in. Thus, crops are not grown in winter, only harvested.
- Cold-tolerant crops are the only ones planted, which include a wide variety of greens and root crops
- Two layers are required to adequately protect the plants: an outer single-layer greenhouse shell (or high tunnel) and a lower-level poly-weave cover over the row or bed (low-tunnel). More than two layers restricts daylight access to the plants and is not healthy for them (or for us).
- Harvesting is best done at post-peak light times of a sunny day, e.g. 2pm-3pm, so that the greens have the lowest levels of nitrates in them.

Above: How we have adapted Coleman's winter harvest principles in our backyard. Gene designed and constructed our 10' x 28' greenhouse from ½" EMT conduit, giving the structure the flexibility to be erected on our 12-degree land slope and to flex in strong winds without damage. We erect the greenhouse by mid-October and take it down in mid-March, depending on the weather. This prolongs the lifetime of the plastic, since it does not endure the summer's heat. It also allows the winter garden bed to be rejuvenated by the summer rains, natural insect populations and our summer soil-building cover crop. The inner low-tunnels are constructed of 9-gauge wire hoops, a poly-weave fabric to allow diffuse light transmissivity while ensuring heat retention, and clothespins to hold it in place on the hoops. The bed is located in the center of the greenhouse so that the surrounding paths act as a thermal buffer to the outdoor cold – it takes much longer for ground-freeze to reach the winter bed. Above right: Gene begins to harvest some root crops in January. Note the full-coverage of the garden bed and how the matured crops are now ready for winter harvest.

We have integrated wisdom and practical tips from Coleman, Mollison and Jeavons to produce our own year-round backyard mini-farm. The next section gets down to specifics of what we do and how we do it.

PART 3. HOW WE DO IT: THE PRACTICES OF BIOINTENSIVE, PERMACULTURE AND WINTER HARVEST

We mentioned earlier the seven features of biointensive minifarming. Here we give some details:

First – deep soil preparation – the permanent double-dug bed. Jeavons describes in is “How to Grow More Vegetables” alternative procedures for double-digging garden beds. The benefits are three-fold: (1) deep root penetration, which provides maximum volume for roots to grow; (2) improved drought-resistance; and (3) absorption of excess water during heavy rains without soil washing away.

You may not get down to the 2' Jeavons recommends. We did well to get down 1' in our heavy clay and rocky soils. Over time, soil texture has improved dramatically, and humic acids from our compost have percolated downward to break up subsoils. Deep divers such as root crops, especially Jerusalem artichokes and burdock have further broken up deeper soils.

Above left: Gene double-digging new beds using digging board, spading shovel and fork.
Above right: Tania double-digging bed – the first trench.

Second – improving soil fertility. Biointensive growers improve soil fertility by planting cover crops for carbon and nitrogen. We grow grasses for carbon and legumes for nitrogen. We crop both, leaving the roots in the soil to break down, and compost the tops. Cropping the tops while green allows us to add nitrogen to our compost pile, the “greens” are mixed with the “browns.” We compost our garden plant debris unless it’s diseased or going to seed.

Below is the chart of cover crops from Bountiful Gardens (www.bountifulgardens.org). You can also find informative tables on cover crops at FEDCO Seeds: (http://www.fedcoseeds.com/ogs/covercrop_chart.htm) and Peaceful Valley Farm & Garden Supply (www.groworganic.com) – click on “Seeds” tab, and then on the bold “Cover Crop” category label. This brings you to another page. Scroll down this page until you find Solutions Chart with red Download PDF and click on that for table display.

Compost Crop Applications

	Legume - fixes N	Tolerates poor drainage	Germinates in cool soil	Cold Hardy - to 25° F	Drought tolerant	Good for heavy soils	Plant: Spring, Fall, Either *	Competes with weeds	Good for erosion control	Quick growth	Low growing - under 12"	Medium - 13 to 36"	Tall - over 36"	Invasive	Oz. per 1,000 sq. ft. Bio **
Alfalfa	●		●	●	●	●	S						●		0.85
Buckwheat						●	S	●		●		●			26.0
Barley			●	●	●	●	E		●	●		●			24.0
Beans, Moth	●				●	●	S	●		●	●				9.5
Cardoon					●	●	E						●	●	0.4
Clover, Alsike	●	●		●		●	E		●			●			5.5
Clover, Berseem	●	●	●	●	◑	●	E		●	●		●			1.5
Clover, Crimson	●			●			E	●	●	●		●			6.0
Clover, Red	●		●	●		●	E	●	●			●			0.8
Clover, Subterranean	●		●	●	●	●	E	●	●	◑		●			5.7
Clover, Sweet White Blossom	●		●	●	●	●	E	●	●				●		0.3
Clover, White	●	●	●	●		●	E	●	●		●				0.3
Fava, Banner	●			●			F	●					●		172.0
Mustard, Agricultural		●	●	●		●	E	●	●	●			●		8.5
Oats			●				E	●	●	●		●			12.5
Pea, Austrian Field	●		●	●	◑	●	F	●	●	●		●			31.0
Radish, Fodder			●	●	●	●	E			●		●			15.0
Rye, Cereal		●	●	●	●	●	F	●	●	●			●		24.0
Crownvetch	●		●	●	●	●	S	●	●			●			1.4
Vetch, Hairy	●		●	●	●	●	F	●	●			●			55.0
Vetch, Wooly (Lana)	●			●	●	●	F	●	●			●			55.0
Wheat			●	●	●	●	E	●	●	◑		●			24.0
Sunflower					●		S						●		7.6
Sorghum					●	●	S	●	●	●			●		6.6
Corn					●		S			●			●		9.0
Phacelia tanacetifolia				●	●		E	●		●		●			0.5
Tyfon			●	●	●	●	E			●	●				5.0

* Plant: Fall planting may not survive in cold climates.
**Planting rate for GROW BIOINTENSIVE® spacings.

From Bountiful Gardens 2007 Catalog

Below: 4-shot sequence showing cover crops – rye, young fava, mature fava, full summer garden.

Above left: fava plant going to flower. Above right: exposed roots of fava showing nitrogen fixing nodules.

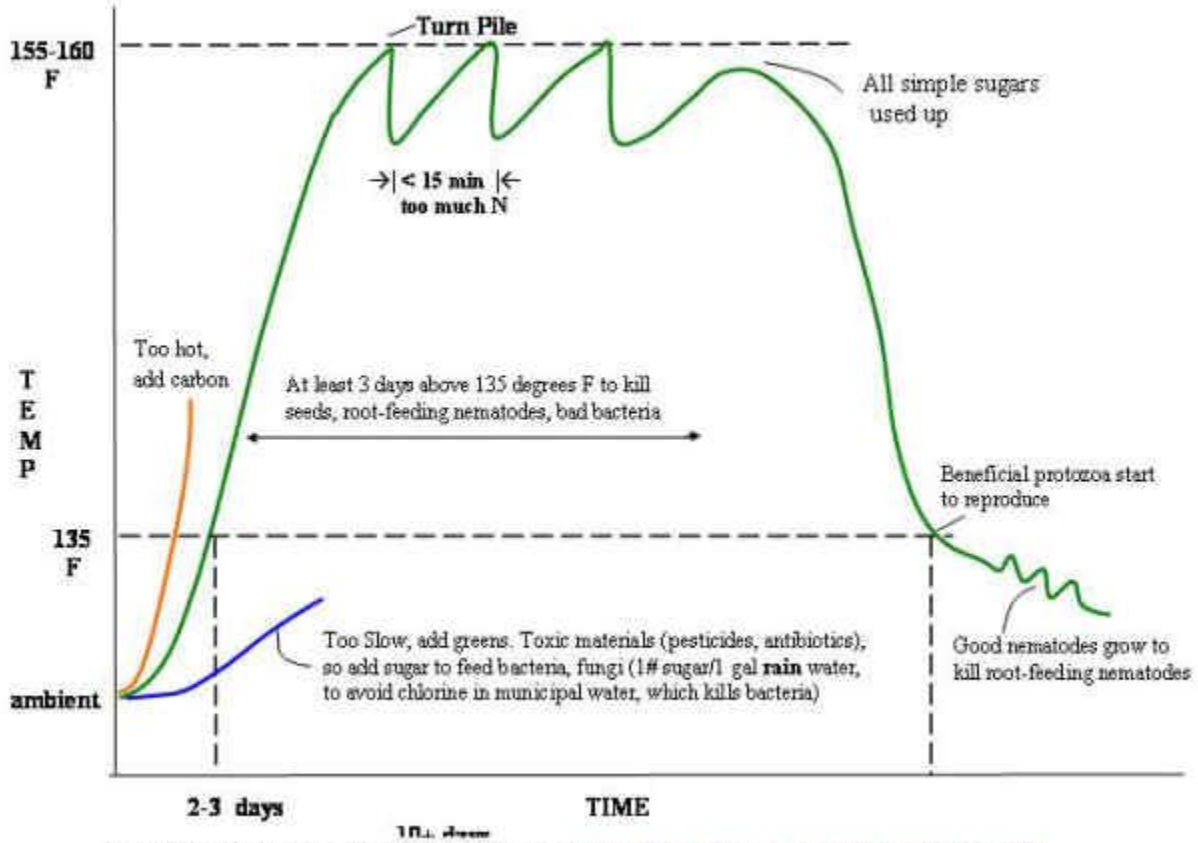
Above: cutting compost – rye and vetch – prior to “skimming” the bed to sever the grass stubble from its roots. These thin sod-like squares that are skimmed off will be stacked in a pile to compost and generate soil for our potting mix.

Above: Tania is watering the pile a bit after turning in cut fresh rye and vetch, and covering when done to prevent drying.


Above left: turning compost on second and final turn onto tarp to prevent shallow-rooted maples from growing into compost. Above right: finished pile on tarp.

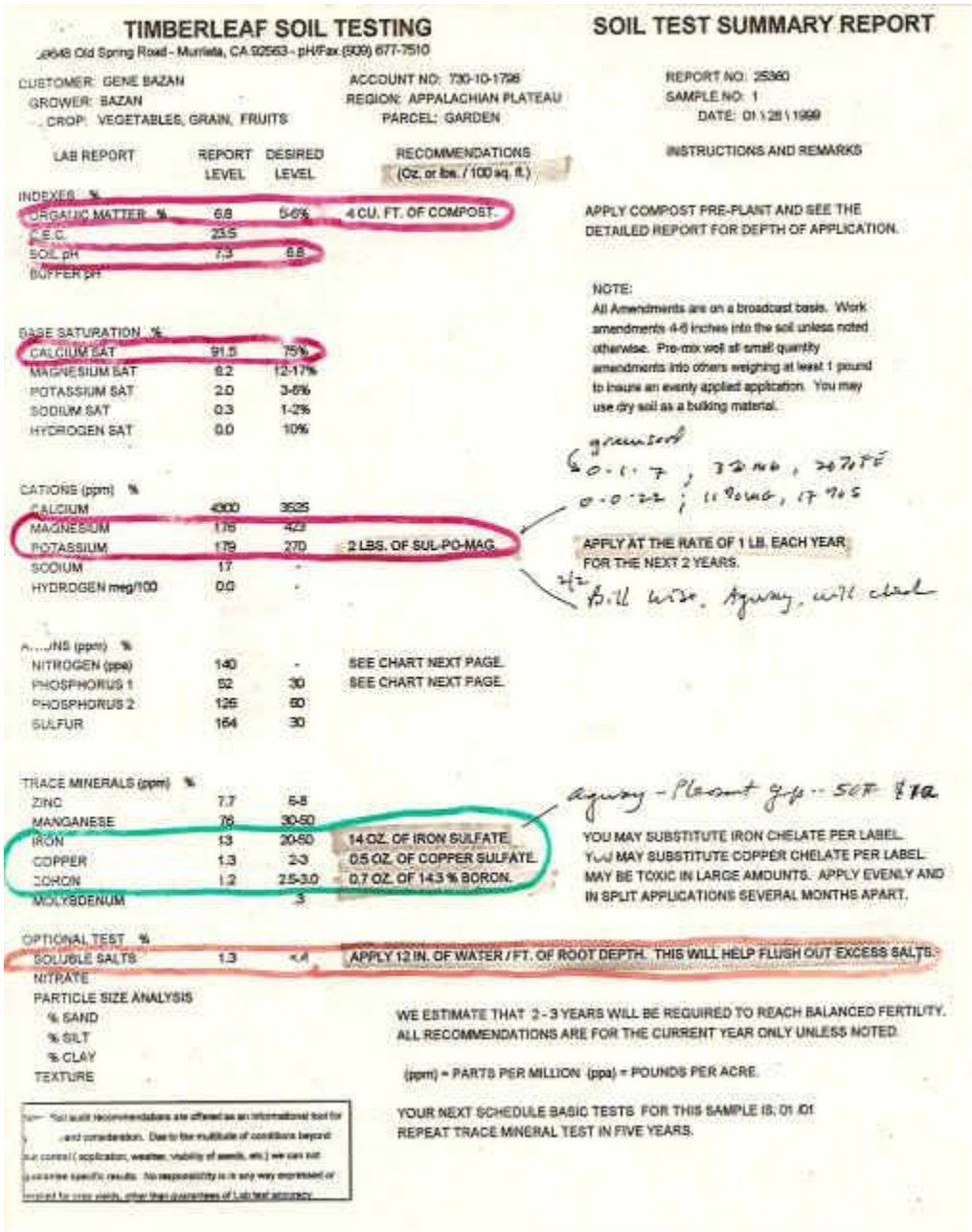

Above left: making a tent with tarp to keep rain off and allow air to circulate, as micro-organisms respire and require oxygen. Above right: composting turf.

Below is Elaine Ingham's chart on compost, which accords with the latest PCO recommendations. Elaine spoke at PASA in 2000.



From PASA talk given by Elaine Ingham, Feb. 2000 (www.soilfoodweb.com, www.growingsolutions.com)

Below: Soil Test. It is important to test the soil to correct deficiencies. We use www.timberleafsoiltesting.com which is easy to read, gives amendments per 100 sq.ft., and recommends appropriate organic amendments. You want the basic plus trace minerals combination. For more information on organic gardening open our **Organic Gardening Primer** .



TIMBERLEAF SOIL TESTING — **SOIL TEST SUMMARY REPORT**

26648 Old Spring Road - Murrieta, CA 92563 - pH/Fax (909) 677-7510

CUSTOMER: GENE BAZAN
GROWER: BAZAN
CROP: VEGETABLES, GRAIN, FRUITS

ACCOUNT NO: 730-10-1798
REGION: APPALACHIAN PLATEAU
PARCEL: GARDEN

REPORT NO: 25360
SAMPLE NO: 1
DATE: 01\28\1999

LAB REPORT	REPORT LEVEL	DESIRED LEVEL	RECOMMENDATIONS (Oz. or lbs. / 100 sq. ft.)
INDEXES %			
ORGANIC MATTER %	6.8	5-6%	4 CU. FT. OF COMPOST.
C.E.C.	23.5		
SOIL pH	7.3	6.8	
BUFFER pH			
BASE SATURATION %			
CALCIUM SAT	91.5	75%	
MAGNESIUM SAT	6.2	12-17%	
POTASSIUM SAT	2.0	3-6%	
SODIUM SAT	0.3	1-2%	
HYDROGEN SAT	0.0	10%	
CATIONS (ppm) %			
CALCIUM	4000	3625	
MAGNESIUM	176	423	
POTASSIUM	179	270	2 LBS. OF SUL-PO-MAG
SODIUM	17	-	
HYDROGEN meq/100	0.0	-	
ANIONS (ppm) %			
NITROGEN (ppa)	140	-	SEE CHART NEXT PAGE.
PHOSPHORUS 1	52	30	SEE CHART NEXT PAGE.
PHOSPHORUS 2	126	60	
SULFUR	164	30	
TRACE MINERALS (ppm) %			
ZINC	7.7	6-8	
MANGANESE	78	30-50	
IRON	13	20-50	14 OZ. OF IRON SULFATE.
COPPER	1.3	2-3	0.5 OZ. OF COPPER SULFATE.
BORON	1.2	2.5-3.0	0.7 OZ. OF 14.3 % BORON.
MOLYBDENUM		3	
OPTIONAL TEST %			
SOLUBLE SALTS	1.3	<4	APPLY 12 IN. OF WATER / FT. OF ROOT DEPTH. THIS WILL HELP FLUSH OUT EXCESS SALTS.
NITRATE			
PARTICLE SIZE ANALYSIS			
% SAND			
% SILT			
% CLAY			
TEXTURE			

INSTRUCTIONS AND REMARKS

APPLY COMPOST PRE-PLANT AND SEE THE DETAILED REPORT FOR DEPTH OF APPLICATION.

NOTE:
All Amendments are on a broadcast basis. Work amendments 4-6 inches into the soil unless noted otherwise. Pre-mix well all small quantity amendments into others weighing at least 1 pound to insure an evenly applied application. You may use dry soil as a bulking material.

APPLY AT THE RATE OF 1 LB. EACH YEAR FOR THE NEXT 2 YEARS.

YOU MAY SUBSTITUTE IRON CHELATE PER LABEL. YOU MAY SUBSTITUTE COPPER CHELATE PER LABEL. MAY BE TOXIC IN LARGE AMOUNTS. APPLY EVENLY AND IN SPLIT APPLICATIONS SEVERAL MONTHS APART.

WE ESTIMATE THAT 2 - 3 YEARS WILL BE REQUIRED TO REACH BALANCED FERTILITY. ALL RECOMMENDATIONS ARE FOR THE CURRENT YEAR ONLY UNLESS NOTED.

(ppm) = PARTS PER MILLION (ppa) = POUNDS PER ACRE.

YOUR NEXT SCHEDULE BASIC TESTS FOR THIS SAMPLE IS: 01 /01
REPEAT TRACE MINERAL TEST IN FIVE YEARS.

We work in compost and minerals using a U-bar, also called a broadfork (shown in picture below). This aerates the soil. We do not use a rototiller. We can aerate a 5x24' bed in about 1 ½ hours. The design is from John Jeavons. Contact us for a copy of the design, which you can take to a

machine shop. Locally, we have gotten ours and two more made for friends at Miller Welding in State College (contact Bob Miller at 238-2950).

It is also important to test your compost, particularly if you either import it, or make it yourself using leaves or other materials. Because our trees grow in high pH soil, adding their leaves to our compost produces a high pH compost, thus slowly increasing the pH of our garden soils. You can avoid this problem by using cover crops exclusively, and composting your own garden matter once you get your beds double-dug. However, for the initial dig, you will most likely have to import compost to add organic matter to your soil. To decrease high pH soils, two remedies: sulfur in

small amounts, esp. for your vegetable beds. For woody plants, such as cane, fruit-bearing shrubs, fruit trees, peat moss is preferred, as sulfur can kill soil fungi, and woody plants rely more on these. Avoid use of horse manure; it is high in salts, and antibiotics added to the feed to control diseases. Asparagus is the exception, as it not only tolerates salt, but does better with modest amounts of it.

An important detail is how much cover crop seed and compost we use. We have worked out a table, taking recommendations from Jeavons and Fedco, adding a margin for lower germination from broadcasting, chopping in, older seed. We show this table below.

Garden Metrics

file=c:garden/metrics.doc

Spacing Relationship

In Bed Spacing	Max # Plants/100sf	In Bed Spacing	Max # Plants/100sf	In Bed Spacing	Max # Plants/100sf
2"	5894	7"	432	15"	84
3"	2507	8"	320	18"	53
4"	1343	9"	248	21"	35
5"	833	10"	201	24"	26
6"	621	12"	159	30"	14

Compost Requirements

Amt	Per 100 sq.ft.	Per 125 sq. ft.	Per 40 sq. ft.
1" w. soil	8 cu.ft/60 gals/ 12 5-gal buckets	10 cu.ft/75 gals/ 15 5-gal buckets	3.2 cu.ft/24 gals/ 4.8 5-gal buckets
1/2" wo soil	4 cu.ft/30 gals/ 6 5-gal buckets	5 cu.ft/38 gals/ 7.5 5-gal buckets	1.6 cu.ft/12 gals/ 2.4 5-gal buckets

Cover Crop Weights

Cover Crop	BG:amt/ 1000 sf	Fedco:amt/ 1000 sf	Amt Chosen	100 sf wt	100 sf cups	125 sf	40 sf
vetch	3.4 lbs	1lb	6.8 lbs	11 oz	1.75 c	13.5 oz	4.5 oz
rye	8 oz	3-4 lbs	8 lbs	12.8 oz	1.25 c	16 oz	5.1 oz
oats	12.5 oz	3-4 lbs	8 lbs	12.8 oz	1.25 c	16 oz	5.1 oz
field peas	1.6 lbs	4 lbs	4 lbs	6.4 oz	1 c	8 oz	2.6 oz
buckwheat	26 oz	2-3 lbs	6 lbs	9.6 oz	1.5 c	12 oz	3.8 oz
fava 8"	4 lbs		320 seeds	6.3 oz	1 c	7.9 oz	2.5 oz
fava 6"	7.5 lbs		620 seeds	12 oz	1 7/8 c	15 oz	4.8 oz

In col. 4 1 doubled max. recommendation from BG or Fedco. If use mixture (e.g., oats, peas, vetch soil building mix), then cut each seed amount to 1/3.

Seedling Flat Mix Recipe (fills 2.5 flats)

10.0 gallons compost
2.5 gallons peat/sand
2.5 gallons turf loam

0.5 cups azomite
0.5 cups greensand
0.5 cups fish meal or alfalfa (nitrogen boost)

1 cubic yard – 200 gallons; 1 cubic foot – 7.5 gallons

Conversion of cow manure weights to volumes:

-- cow produces 20T manure/yr
-- 2.5 tons wet manure → 1 ton dry compost
-- weight compost: 25 lbs/cu. ft. or 675 lbs/cu. yard
-- 100 sq.ft. bed @ 1" requires 208 lbs compost or 1 ton compost will handle 10 beds 1" deep

Neo-Terra 4/3/2009

Third – we practice close plant spacing using the whole bed. We do not plant in rows. There are two reasons for close space planting.

1. First, to maximize yields. Yields per unit area in biointensive are up to 4 times higher than in conventional row gardening. In biointensive, we plant in triangles. Through considerable research over a thirty year period, Jeavons has worked out the optimal spacing for vegetables, cover crops and other plants to maximize yield per unit area. These extensive tables are available in his famous book, “How to Grow More Vegetables”, now in its 7th edition. We recommend the spiral bound edition; it lies flat, and will take more abuse.

Above: Set of planting triangles.

Above left: using planting triangle to plant mache. Above right: planting triangle with more mature mache, showing improved coverage of the living mulch.

2. Second reason for close space planting: to grow a living mulch, which has three benefits:
- reduces water evaporation;
- shields the soil from the sun;
- reduces weed germination.

Below: early planting showing triangular pattern. Our total weeding time in the beds for each of us is about an hour or so all summer.

Above: later in season, showing how crops have filled in creating living mulch.

Above: early planting of carrots and beets at 3”; above these is a planting of turnips already showing living mulch property

Of course, we produce clean compost!! This means we do not compost weeds or plants with seed heads. We learned this lesson the hard way after waiting too long to crop and compost our forget-me-not debris, lemon balm stalks, and wonder berry debris!

Close space planting using the whole bed rather than rows depends on supporting practices:

- Planting in flats rather than direct-seeding in the beds; and
- Transplanting seedlings. No thinning, and you maximize yields.

Below: Gene planting corn in flat. We use chicken wire secured taught in a rectangular frame that overlays the wooden flat as a hexagonal planting grid. A dibble hole (for the seed) is placed at the center of each hexagon yielding approximately 300 seedlings spaced on 1-inch centers in each flat. Gene is skipping some of the holes to provide additional room for the large corn seeds to germinate.


E / GRAND
RBE DE
AIGNE
107 dm³

Above: Mini-greenhouse following Jeavons design as detailed in his *Backyard Homestead.*
Below: flats inside mini-greenhouse.

Above: Gene transplanting spinach into winter bed while Tania transplants lettuce.
Below: completed winter bed with row cover to protect crops from summer sun.

The Fourth feature of biointensive is companion planting in time and space. Many of you are familiar with traditional companion planting as put forth in such books as “Carrots Love Tomatoes” by Louise Riotte. Basil, chives, mint, horseradish and gooseberry also like tomatoes, so we have choices here. This is “companion planting in space”, and gardeners can improve yields and reduce pest and disease pressure by placing certain plants next to each other. Two other books on companion planting in space: Pamela Allardice, “A-Z Companion Planting” and Bob Flowerdew, “Complete Book of Companion Gardening.”

Companion planting in space relies on some beneficial effect arising from propinquity. The effect could arise from a chemical secretion, some physical property, or an indirect effect through attracting beneficial insects. Thus, root exudates from dahlias and some marigolds repel certain nematodes. Nasturtiums control aphids. Borage helps suppress fungus infections in strawberries and improves their flavor. Broad beans will help shade spinach. The pollen of caraway flowers attracts beneficial insects early in the season when vegetable seedlings are most susceptible to pests and there are few other plants blooming.

There is a second kind of companion planting we backyard gardeners would do well to emulate. John Jeavons calls this companion planting in time. Traditional and organic farmers know this practice by the term “crop rotation” (e.g., corn-oats-wheat-hay).

One of the most important benefits of companion planting in time is adding nitrogen to the soil. Thus, nitrogen-fixing plants such as alfalfa, clover and bell beans are planted before other crops such as corn and tomatoes, which are heavy feeders and require lots of nitrogen. Remember to plant your nitrogen-fixing crops with the appropriate nitrogen-fixing bacteria (Fedco has a nice selection of cover crop seeds and inoculants).

A second benefit of companion planting in time is disease and pest suppression. Bell beans (vicia faba) suppress verticillium wilt fungus. Plant bell beans in early spring (1st-2nd week of April); chop stalks and turn under when you plant your tomatoes. Barely and rye roots immobilize the carrot root nematode, which causes forked carrots. Plant barley in the late spring before a fall planting of carrots, or in the fall before a spring planting of carrots.

A third benefit of companion planting in time is adding carbon to the soil. Gardeners can follow on a small scale what farmers do on a large scale: broadcast oats or winter rye in the late summer or early fall, or buckwheat during the summer. Oats and rye produce large amounts of carbon, both in the tops (stalks) and in the root mass left behind to decompose in the soil. Both cover crops may be combined with a nitrogen-fixing crop such as Madison Hairy Vetch (which is not the invasive crown vetch of highway slopes). The combination of oats, vetch and field peas is also a great soil builder when planted in spring (mid to late April).

You can realize a fourth benefit of companion planting in time by using dynamic accumulators. These act by bringing up through their roots minerals in the subsoil. These minerals are stored in the plant’s stem and leaves and released when you harvest and

compost the plants and return the compost to the soil. Of course, plants cannot concentrate minerals that are not in your subsoil, so get your soil tested if you suspect deficiencies. Robert Kourik has a good chart on accumulators in “Designing and MaintainingYour Edible Landscape Naturally.”

In the hands of organic vegetable farmers growing a diversity of crops, companion planting in time can acquire considerable sophistication. Eliot Coleman (“The New Organic Grower”) has determined sequences of vegetables that improve yield.

Not all effects in time and space are beneficial. Avoid planting members of the sunflower family among other vegetables, as their root exudates retard the growth of other plants. In our garden, we restrict our Jerusalem artichokes to one small corner of the garden. Wormwood is a great small animal repellant, but its root exudates also retard growth. Therefore, plant wormwood in a border. The sunny buttercup exudes a substance that destroys clover in dilutions as low as one part in a billion. Most of us have heard of the injunction against planting tomatoes, potatoes, eggplant or raspberries near black walnut trees (or near their drifting leaves!).

In applying the principles of companion planting in time and space, you will want to experiment and note what works for your soil, growing conditions and crops. For our own garden, we have created a one-page chart synthesizing companion planting in space and time. We show this below.

Planting Scheme: Rotation/Companion/Antagonist/Cover Crops

Gene Bazan & Tania Slawecki

1/23/2004 f=c:garden/rotation1

Cover Crop	Main Crop	Companions	Antagonists
fava (bell beans) reduces wilts, fixes nitrogen	Tomatoes, peppers ⇓ (follows)	basil, chives/onions, carrots, asparagus, parsley, *marigold, nasturtium*	potatoes, cabbage, kohlrabi
Bell beans < corn (fixes nitrogen)	Corn ⇓ (follows)	peas, bush/pole beans, potatoes, squash, cucumbers	
not vetch or legumes < legume – may transmit disease; alfalfa: plant in fall, turn under 2 weeks < beans	Bush beans.....	peas, corn, potatoes, radish, cucumber, strawberry, *marigold, summer savory*	onions, garlic
	Pole bean	corn, *summer savory*	onions, beets, kohlrabi, garlic
	cabbage, collards..... kale, chard, radish ⇓	*dill, hyssop, mint, chamomile, oregano*	tomatoes, pole beans, strawberry
barley, rye	Roots: onions.....	beets, *chamomile (sparsely), summer savory*	beans & peas
	carrots.	tomatoes, lettuce, parsley, onions, radishes, peas, *chives, flax*	*dill*
	beets	lettuce, cabbage, onions, radishes,	pole beans, potatoes
	turnips ..... ⇓	peas	
	Greens: lettuce ⇓	carrots, radish, beets, cilantro	
no oats! (scab); soybeans (reduces scab); rye	Potatoes ⇓	bush beans, corn, eggplant, *flax, marigold*	peas, squash, tomatoes, cukes, *sunflowers*, raspberries
Bell beans<corn (fixes nitrogen)	Corn ⇓	peas, bush & pole beans, potatoes, squash, cucumbers	
Not vetch, not legumes<legume	Peas ⇓	bush beans, corn, radish, turnips, cucumbers	potatoes, onions, garlic, *glads*
	Broccoli, cauliflower ⇓	potatoes, celery, beets, onions *dill, chamomile, sage, peppermint, rosemary*	strawberries, tomatoes, pole beans
	Squash, melons ⇓	Corn, *nasturtiums*	

1. Guidance from Jeavons, "How to Grow More Vegetables" and Coleman, "The New Organic Grower"
2. Plant names in italics are herbs or flowers, non-italics other vegetable crops

Fifth Feature of biointensive – using carbon-efficient crops. Carbon-efficient crops produce a lot of carbon per unit area, and are therefore desirable in providing carbon to the soil and carbon for your compost pile. If these produce edible crops, you can grow food and carbon at the same time (e.g., sweet corn). From the Jeavons tables, low yields, we find the following carbon content per 100 sq.ft. for the top ten crops (see table below left). Keep in mind that annual grasses (oats, rye, barley) produce as much or more biomass below the surface in their roots as they do above the ground.

The way Jeavons incorporates this carbon into the soil is skimming the top or turf and composting that in piles, and letting the root mass decompose. For heavy root crops like

rye, this takes about three weeks in the spring, and produces a wonderful loamy soil texture. For fall-planted crops such as oats, the winter kills the plants, and the roots decompose over the winter and early spring. The soil is ready for early spring crops such as lettuce and spinach. [For additional cover crop yields, see Fedco page (http://www.fedcoseeds.com/ogs/covercrop_chart.htm)]

Best Crops for Carbon Dry Weight Tops Per 100 Sq.Ft.	Pounds carbon per 100 sq.ft.
Vegetable Crop	
Alfalfa (perennial – 5/6 cuttings)	44
Sorghum	25
Clover, medium red	25
Field corn	24
Cardoon (perennial)	20
Fava	18
Quinoa	18
Rye	12
Oats	12
Barley	12
Sweet corn	12

Top Ten Crops for Caloric Yield Per 100 Sq.Ft.	Calories per 100 sq.ft.
Vegetable Crop	
Rutabaga	35,400
Parsnips	34,867
Leeks	29,520
Potatoes	27,900
Swiss chard	20,800
Lima beans	17,998
Collards	17,200
Onions	15,700
Cylindra beets	15,070
Brussel sprouts	13,348

Sixth feature of biointensive – using calorie-efficient crops. Here, the object is to produce the most calories per unit area. The best crops for this tend to be root crops. From the Jeavons tables, low yields, we find the caloric content per 100 sq.ft. for the top ten crops in the image above right.

Seventh and final feature – using open-pollinated seeds so that you can save your own seeds, and adapt them to your own soil and climate conditions. Jeavons' goal here is to help food growers reassert their independence from the growing control of seed companies over the genetic stock of what we eat.

To continue with PART B of the Biointensive Minifarming tutorial click on the link below, or return to the "Biointensive Minifarming" subpage and click "Biointensive Minifarming PART B" there.

http://neo-terra.weebly.com/uploads/2/5/6/4/25644359/backyard_minifarming_part_b.pdf