

The Role of Home Gardens in Feeding the World & Sequestering Carbon

Michael Pilarski
January 1, 2009

Friends of the Trees Society
PO Box 826
Tonasket, WA 98855
509-486-2672
Michael@friendsofthetrees.net
www.friendsofthetrees.net

This article explores the role of home gardens in world food production. The thesis of the article is that home gardens have the potential to become the dominant food supply for humanity. A case is made that home gardens could grow 50% of humanity's food supply on less than 10% of the world's arable farmland. Home gardens are one of the most reliable, efficient and democratic ways of producing food ever invented. Agriculture has repeatedly degraded its natural resource base and collapsed many societies in the past. Modern, industrial agriculture is not suited to these changing times and is liable to increasing breakdown within the next decade

Who is this article written for? It is written for gardeners, would-be gardeners, garden educators, hunger activists and people interested in local food security. Organic gardeners will be familiar with much of the material. Permaculturists already know most of the techniques and principles outlined here. Most of it is just good, practical, common-sense gardening that gardeners everywhere can relate to.

PART I looks at home-gardens' role in feeding people as compared to agriculture and hunter-gathering. PART II introduces tools, techniques and strategies to maximize home-garden production, while being ecologically-sound, cost- and labor-effective, and with minimal reliance on outside inputs and fossil-fuel. This is a permaculture approach to gardening. Everyone will find things to disagree with. Everyone will find some useful ideas. Pick and choose what is useful to you.

PART I:

We could divide human strategies to provide their food supply into three broad categories. 1) Hunter-gathering. 2) Home Gardens. 3) Agriculture. Currently world food production is obtained from something like 2% hunting/gathering, 15% gardening and 83% agriculture. The purpose of this article is to outline how food production could be shifted to 48% gardening and 48% agriculture in the near future. In the more distant future I think it is entirely realistic to feed a reduced human population of two billion people with 50% reliance on home gardens, 25% reliance on hunting-gathering and 25% reliance on agriculture.

1) HUNTER-GATHERING

Hunter-gathering is the oldest food procurement strategy and has changed little over the years. For most of human history it was the only food source. It has been largely supplanted by agriculture, but a few hunter-gatherer peoples persist, and hunting and gathering is still an important adjunct to diet (and natural resources) for village cultures throughout Asia, Africa, Meso- and South America. Land-based village cultures do not get much press, but they are still a large proportion of humanity. Even in technologically-advanced countries some people still hunt and gather wild foods. In the US there is a growing "primitive skills" movement which teaches hands-on skills including foraging and hunting. Wild foods and game resources are much reduced in most of today's world due to urbanization, development, agriculture, pollution, overgrazing, erosion, etc. A goal of a sensible human race would be to do earth restoration and gradually bring back the abundance that nature once offered. All traditional agriculture societies had their "famine foods" which they turned to in times of crops failures or social chaos. Wild foods as a short-term, stop-gap measure. Most, but not all, cultures have forgotten their famine foods and how to process them. Wild food knowledge is still useful today whether it is forced or a pleasure activity. Gathering wild foods is embedded deep in our genes. Most people instinctively enjoy gathering wild berries and similar activities. It is good for people's mental health. Wild foods compare favorably with gardening and agriculture in terms of calories obtained in exchange for calories expended. If everyone rushed out and gathered everything useful they could find, the resources would plummet. Hunting and gathering must be done in a sustainable manner so as not to kill the goose that lays the golden egg. Sustainability is crucial.

The author of this article is a professional wildcrafter in the Pacific Northwest of the USA. Medicinal herbs are my main harvest and I ship throughout the US. I write and teach how to harvest wild medicinal plants in a sustainable way. I know most of the wild edible plants of my region. I gather small amounts of wild food but rely mostly on gardening and agriculture for food. Wild food sources are little utilized in my area, but could provide a significant dietary supplement if necessary. My permaculture and earth restoration training lead me to believe that wild foods could become a significant food factor again if we restored ecosystems, increased the wild food resource, adapted indigenous knowledge and wild harvested sustainably. I recommend that people study the wild foods and ecology of their area.

2) HOME GARDENS

Home Gardens have been around since humans first started experimenting with planting seeds in their backyards. It was the predecessor of agriculture. Gardens were undoubtedly major food sources throughout the early development of agriculture. Agriculture became more dominant over the centuries but home gardens persist in most farming populations of the world today.

Home gardens have saved many a farm family from starvation when the broad-scale farm crops failed; and continue to do so today. At this uneasy juncture of history, it is like the whole human race should turn to gardening as a survival strategy in case large-scale, industrial agriculture fails. Gardening motivated by need is valid, but come what may, gardening is a healthful practice both physically and mentally. Nurturing plants is good for the human soul. Eating food you grew and harvested with your own hands is good for the human spirit. Gardening can enhance food security and enhance the quality of life. As we go into a period of massive unemployment more and more people will have the time and the need to garden. Helping people get the best yields possible while improving the environment is a worthy aim for gardening educators such as myself. As a result of high food prices, people are increasing their gardening worldwide. Better to start today than tomorrow. Gardens take a while to produce. Gardens improve year by year and gardeners improve year by year. I would like to live in a society where productive home gardens and gardeners abound. Furthermore where the gardens' fertility inputs come from the local area, are produced in a sustainable manner, and are not subject to being cut off. We will look at home gardening in more detail after a brief look at agriculture.

3) AGRICULTURE

Agriculture has many faces. Thousands and tens of thousands of agriculture systems can be delineated, both past and present. Some are very productive and some are not. Some agriculture systems improve the environment, but many gradually destroy the environment they are dependent on through erosion, salting of soils, overgrazing, destruction of nature's checks and balances, etc. The litany of agriculture's misdeeds are long and have led to many a civilization's downfall. The world has been losing arable land at a fast pace due to development and degradation from poor farming practices. One source says that 1/3 of the world's arable land has been lost in the last 40 years. Today's modern societies seem to think that we are exempt from nature's laws, but we have created fragile, agriculture systems almost totally dependent on fossil-fuel inputs. The many dangers of modern, industrial agriculture have been outlined in hundreds of books over the last 100 years. The current world economic crisis is already dragging down agricultural production. It does not take a crystal ball to foresee big trouble ahead vis a vis world food supplies. But let's not throw away the baby with the bathwater. Much of conventional agriculture is useful and good and most conventional farmers are hard-working, highly-skilled, well-meaning people. There are many kinds of sustainable agriculture and they are gradually influencing more people in conventional farming. A sustainable agriculture of the future will likely incorporate organic methods, industrial methods and ancient traditional systems. Agriculture currently supplies most of humanity's food and will continue to be critically needed into the foreseeable future but will be hopefully less needed in a future where home gardening is the norm.

ROBERT HEINBERG AND NON-FOSSIL FUEL AGRICULTURE

This article was inspired by a question raised by Robert Heinberg in his excellent article of November 1, 2008, titled: The Food and Farming Transition. Quote "...we do not know whether non-fossil fuel agriculture can in fact feed a population approaching seven billion ..." Heinberg then goes on to paint a broad outline of how to transition agriculture to a non-fossil fuel basis. It is great news that Heinberg's Post Carbon Institute and the Soil Association of U.K. are jointly preparing a report on this topic which is due out in early 2009. None too soon and we should all read it when it comes out.

I believe that it is possible to answer Heinberg's question in the affirmative. Yes! I am convinced that it is possible to feed the current seven billion human population on a non-fossil fuel basis. It is possible for everyone to have adequate, nutritious and tasty diets from (mostly) locally-grown and locally-raised foods raised in home-gardens and small farms. Furthermore at the same time we can use gardening and farming methods that improve the world's soils, largely stop erosion, and tie up huge amounts of carbon, (thus hopefully averting catastrophic climate change). Furthermore we can feed these seven billion people on a smaller footprint of the planet's surface then we currently use. I have often said that we could feed the world's population on half the land we currently use. Maybe half is optimistic but using best practices of food production we could take a significant proportion of farmland out of cultivation.

This does not mean that farmland taken out of cultivation is lost to human productivity. Taking marginal farmland out of cultivation may actually make them more productive if they are replaced with semi-wild, perennial systems based on local, native plant communities, permaculture and ethno-ecology. Ethno-ecology is the study of how traditional cultures interacted with, and affected their surrounding ecosystems. These new, semi-wild systems can be biologically productive and diverse as well as productive in food and natural resources. A major goal is the accumulation of biomass and the building of soil. These systems end up tying up large amounts of carbon per acre. The harvestable natural resources would be produced with much less effort and inputs than conventional plow agriculture. Native plants are always a part of the mix of species. The concepts and practices of forest gardens, forest farming and paradise gardens are kin to what I am hinting at here, but the topic of how to handle farmland conversion is not the purpose of this article.

Having said all this, even though I believe it is possible to adequately feed all seven billion people I doubt it will happen because of the social ills of greed, oppression, racism, apathy, etc. Technically it is feasible. The problems are more social than physical. In my preferred universe we would figure out how to feed everyone now with the goal to reduce human population to a much smaller number. Starvation is totally unnecessary. The world's "haves" seem all too casual about the starvation of billions of the "have-nots". In this article I focus on methods of home gardening which could feed the world's peoples, largely without fossil fuel use. Home gardening is mostly dependent on hand labor. Local food security will almost certainly become important for increasing amounts of the world's people, even the current haves. Almost everyone can garden and almost everyone would if desperate enough.

The percentage of farming which is currently done without fossil fuels must be small, but is still significant in countries like Nepal, Bolivia, and parts of Africa. I do not see agriculture willingly switching away from fossil fuels because of climate change concerns. Some conventional farmers would change given attractive replacements but most farmers will continue to use fossil-fuel inputs as long as they are available. Ideally, we will have a smooth transition to a non-fossil fuel agriculture; but this is unlikely. Perhaps conventional agriculture will continue on until the climate crisis overwhelms us. Or perhaps economic collapse will reduce farm inputs willy nilly, thus forcing people to consider the home-garden strategy outlined herein.

WORLDWIDE HOME GARDEN STRATEGY

No one knows exactly how much of the world's food production is currently supplied by home gardens (alternatively called household, kitchen dooryard, backyard or food gardens). I would venture a guess of between 10 and 20%. Certainly it is significant. Most subsistence farmers living in villages have large gardens. Many modern farmers have vegetable gardens and many townsfolk do. There has been a significant growth in gardening movements worldwide in recent years including in crowded urban cities of the less-industrialized world. Much of this garden food is grown without machinery or could easily be.

There are historical precedents such as the "Victory Gardens" in the US during World War II. More recently in the Soviet Union collapse, their agricultural production dropped 80%. The home food gardens rallied to produce over half of total food production and largely kept the population from starving. At the same time Cuba's agriculture collapsed due to lack of oil and outside inputs. A huge, organic gardening movement kept Cubans alive. Today Havana produces 60% of its food needs within its urban and peri-urban area. Permaculturists from Melbourne, Australia had a significant influence on this Cuban gardening movement.

Another recent example is Britain during World War II. The government, between 1936 and 1939 when the war began, organized a big surge in home food production. Food imports halved between 1939 and 1944. "Local Authorities set up horticultural committees to advise people on growing food, complemented by a huge programme of promoting the virtues of thrift and economy, as well as teaching practical skills. In 1942, Bristol (for example) had 15,000 allotments, and over half the nation's manual workers had an allotment or garden, producing around 10% of the nation's food. People sometimes remark that during the war, allotments and back yards 'only' produced 10% of the national diet, but the important point is that the 10% it produced was the 10% that kept the nation healthy. While agriculture grew the carbohydrates and the fats, it was the back gardens that produced most of the fresh fruit and vegetables." The Transition Handbook, Rob Hopkins, 2008.

There are literally hundreds of gardening movements in the world today. Each continent, nation and culture have their own gardening styles. Even so, household gardening has many universal similarities. Some of the more known to us in the West are: Master Gardening, organic gardening, Grow BioIntensive, biodynamic, permaculture, square-foot gardening, forest gardening, and non-organic gardening. There is a wide range within each of these types. A massive increase in home gardens could save people if agriculture stumbles. People, everywhere should be allowed/enabled to grow their own food. This means making land available for everyone who wants to grow food. Huge amounts of the current world's hungry would love to grow their own food and have the capability, but they do not have access to land. Nations have varying percentages of its citizens who already own an adequate amount of land to grow their own food on – small to large yards, subsistence farms, etc. Population densities vary greatly in the world and there are places where urban dwellers might have to journey for many miles out of the city before there is land available for gardening. But at this point in time most people live within a reasonable distance of land which could be available for gardening. Lack of land is not so much of a problem as distribution of land. Obviously a certain amount of land reform would be necessary to free up land in some areas. Labor-intensive gardening should take precedence over industrial agriculture for farmland near cities.

CAN MENDOCINO COUNTY FEED ITSELF?

A friend recently brought Jason Bradford's article "Can Mendocino county feed itself" to my attention. It is a well thought out look at what kinds of food and how much acreage would be needed to feed the current population of Mendocino county in northern California. It is a well-researched article and raises many questions that can be applied to every county in the USA. It made me take a much closer look at how much land is needed to feed a person and here are some of my findings.

What size of garden is needed to supply a person with an adequate diet? The answer to this will vary widely depending on the soils, climate, sunshine and rainfall of the area. It is also dependent on the knowledge and skill of the gardener. It is also dependent on what kind of diet. The more knowledge and skill – the less area and labor is needed. The lower on the food chain the diet, the less land is needed.

Few people have tackled this topic with precision. John Jeavons of Ecology Action in Willits, California has done more meticulous research on this topic than anyone else I know. Jeavons is the originator of the Grow BioIntensive gardening system which has been applied widely in many countries, notably in the USA, Kenya, Mexico, Peru, India and Russia. Grow BioIntensive aims to grow a person's food supply on the smallest footprint of land possible and includes soil building crops in rotation to sustain soil fertility. Jeavons claims that a garden 10 feet by 100 feet can feed a person. This is 1/43 of an acre! This is an extraordinarily striking figure which is lower than any other estimate I know of. Perhaps this might be possible given the perfect set of circumstances, but few gardeners would be able to do this well. But it does show the tremendous productivity possible in well-managed home gardens.

A related question is how many labor hours does it take for a person to grow their own food in a home garden. As mentioned earlier this figure will vary widely depending on site factors, level of external inputs available, and the knowledge and skill of the gardener. I would estimate I could grow all my own food in a home garden of 1/10 of an acre with about 8 hours of work per week during the growing season, which is April through October around here.

Current estimates on how much acreage is needed to supply a person's yearly supply of food by agriculture varies with the main factor being the proportion of meat in the diet. It takes a lot of area to produce meat in today's systems. The recent study by Jason Bradford of Mendocino county uses the following figures of land needed to feed a person.

.28 acres for grain.

.10 for dry beans

.03 for oil

.02 for sprouting seeds

.03 acre in vegetables and fruit

.15 acres for dairy

.16 for eggs

8.33 acres are devoted to meat production.

For a total of 9.09 acres of which .76 is for the non-meat part of the diet.

To reach these figures, Bradford looked at conventional systems of agriculture and conventional yields. Home gardens are more productive by far. Another consideration is that he bases his diet on a large share of grains in the diet. Some vegetables such as potatoes and squash produce high yields of carbohydrates on less land than grain. (Grains take 5 to 10 times as much land as potatoes to feed a person). People who are gluten intolerant know that grains are not needed in the diet. I have personally gone a full year without eating grains and was the healthier for it. I substituted root vegetables and seed crops such as buckwheat and quinoa, all of which can be grown in home gardens. Grains such as wheat, rye, grain corn, millet, etc can also be grown in home gardens, but seldom are due to lack of cultural experience. One of the best sources of information on growing grains and dry bean crops in home gardens is Dan Jason of Saltspring Island Seeds. (Saltspring Island is one of the Gulf Islands in southern British Columbia). www.saltspringseeds.com

Another difference between my permaculture/home garden approach and Bradford's study of Mendocino county is that he accepted the official figures of how many acres were available for agriculture in the county. All of the land in towns, cities, yards etc is not considered as part of the equation of land available for growing food. In my eyes, it is precisely the yards and un-used (and under-utilized) land in and around cities that is the basis for a home garden form of agriculture, or "garden agriculture" as David Holmgren calls it. This is a substantial amount of acreage in total and is located precisely where the labor lives and where household-waste fertilizers are generated. It is my contention that home gardens could produce a substantial proportion of food needs on areas currently not classified as agricultural acreage, although in my scenario some of the farmland surrounding cities and towns would be allocated to home garden plots.

HOW MUCH SPACE DOES IT TAKE TO GROW ONE PERSON'S FOOD?

A little internet research found a number of estimates on the size of the garden needed to feed one person. Unsurprisingly there was quite a range of estimates. The smallest amount being John Jeavons's aforementioned very best case scenario of 1,000 sq. ft. or 1/43 of an acre. But Jeavons says that on average it takes 1/10 acre to grow one person's food sustainably, or 10 people per acre. One gardener claimed that he grows all the food for two adults on 1/7 of an acre which is 14 people per acre. Steve Solomon says that he grows all his own food on 1/12 of an acre eating his "vegetabletarian" diet, which is 12 people per acre. Worldwatch Institute estimates 1/3 acre or 3 people per acre. Some sources say 1/2 acre and on up to 2 acres per person. The higher estimates are based on agriculture and acreage for meat production. You will notice that the lower figures are based on home gardens. Looking at this range of estimates, I would estimate an average of 1/10 of an acre (4,300 square feet) of well-tended, intensive garden is needed to meet the food needs for a person (including adequate protein) who ate rather low on the food chain with a moderate grain consumption. I would also be willing to bet that families use food more efficiently than single persons cooking alone.

HOW MUCH SPACE WOULD IT TAKE TO GROW THE WORLD'S FOOD IN HOME GARDENS?

At 10 people to the acre we would need 700 million acres of home gardens to feed 7 billion people. Total land surface in the world is 33 billion acres. Current estimates of arable land in the world range from as high as 6.86 billion acres to as low as 3.7 billion acres (UN World Food Program). These figures indicate that home gardens could feed people on only 1/5 to 1/9 of the world's arable land. These figures are for low meat consumption. There is still lots of arable land as well as non-arable, grazing land which can be used to raise livestock. If we were only aiming to produce 50% of world food needs from home gardens then only 350 million acres would be needed and many of these acres would be in people's yards and cities where the land is currently not classified as arable. This reduces the amount of classified arable land needed by a significant amount. Part of the arable land would be kept in agriculture, but much of the arable land can be retired from production and restored to natural ecosystems. This would result in massive, carbon sequestration.

Arable land is land capable of being cultivated for crops. It is approximately 13% of the earth's surface at this point. Most, but not all, of the arable acreage is in some form of food production, but only a percentage of the arable land is cultivated in any one year. Some of it is in long-term, perennial crops (4.7%) such as fruit, rubber, tea, coffee, oil palms, olives, etc. Other percentages of arable land are in pasture, green manure crops, or various forms of fallow (clean-cultivated or weedy). A much larger part of the earth's land surface is classified as rangeland (circa 40%) and used for grazing livestock. The livestock component of the home gardening strategy outlined here would produce a significant amount of dairy and meat products. Coupled with reducing meat consumption in the affluent world this would enable part of the earth's rangelands to be retired from livestock grazing and allowed to revert to the native fauna.

PERMACULTURE

After 30 years of researching agricultural systems I have not found any system better than permaculture for designing sustainable gardening and agricultural systems. Permaculture is the design and implementation of sustainable human habitats - with the ethics of: 1) Care of the Earth; 2) Care of people; 3) Dispersal of surplus. Permaculture is a design science which can be applied anywhere in the world. Permaculture offers a huge storehouse of strategies and practical techniques gathered from all around the globe and throughout history. Permaculture integrates the design of food production, environment, energy, housing, and even social and financial systems. If permaculture designs were implemented on a global scale in cities, farms and homes, then the world would become a Garden of Eden. There are hundreds of permaculture books and organizations in many countries. A good place to start is www.permacultureactivist.net

10,000 years of gardening knowledge has been accumulated by cultures in all climates of the world. We know most of what we need to know. Unfortunately the best knowledge has often been suppressed or spurned. Permaculturists are among those synthesizing the best information and practices for today's conditions. We may not have all the answers but we know enough to do way better than the current forms of industrial agriculture. Following is practical information on how to create productive, sustainable home gardens which sequester carbon while minimizing labor and outside inputs. Affordable gardening that works.

PART II:

PRACTICAL CONSIDERATIONS FOR PRODUCTIVE GARDENING

This article is not meant to be a complete gardening guide. It outlines some of the main elements needed for a locally-based, broad-scale, home gardening movement with little fossil-fuel inputs. It is influenced by my permaculture training and is based on my personal experience gained through 50 years of gardening and farming. This information is written for gardening in climates with a cold winter. Permaculture gardening in the subtropics and tropics would have some similarities, but there would also be differences.

TOOLS NEEDED

In a pinch you can get by with just a few tools. If I could only have three gardening tools I would choose a kadalo, a hula hoe (also called a stirrup hoe) and a sturdy garden rake (a toothed rake called a bow rake, not a leaf rake). Local tool libraries can be set up to enable folks to share the cost/and use of specialty tools. Individual gardeners tend to build up a tool inventory over time. Tools can be purchased, be locally made from recycled materials, or be home-made by the gardener. Many garden tools require metal but some can be made of wood. I just watched a video of Ladakh traditional farmers winnowing grain with home-made pitchforks made entirely of wood. Their pitchforks were elegant, lighter-weight than metal, and perfectly effective. Absolutely no need of outside inputs with the exception of metal carving tools. Hawaiian agriculturists had no metal and their main gardening tool was the o'o bar. A long, strong, heavy, wooden staff with a fire-hardened tip. Similar digging bars were/are utilized by traditional farmers in other parts of the world.

KADALO. Most of the subsistence farmers in the world favor a short-handled, heavy, metal hoe to turn the soil. This is called a "kadalo" in Nepal. You see versions used by small farmers throughout Africa, Central and South America and in parts of Asia. In Meso-America a version of the short-handled hoe and a machete are the only tools many farmers have. With a Kadalo I can turn ground including heavy sod and tough weeds. It is primarily for tillage rather than for cultivation. These kadalo-type tools are hard to find in the US. I was lucky enough to find one in a 2nd-hand shop 25 years ago and have used it extensively ever since. When the original pick-axe handle breaks I can make a new handle from the stem of a serviceberry, hawthorn or one of our other shrubs with tough, resilient wood. I recently found a US source of a reasonable kadalo substitute. It is called a "scalper" and costs about \$60 from one of the reforestation supply companies in Eugene, Oregon (try TerraTech International Reforestation Suppliers. 1-800-321-1037). A friend just commented that he recommends a kadalo-type tool available for \$18 from Peaceful Valley Farm supply in California. Hmm? At \$18 I wonder how heavy the tool is. Looking at the Peaceful Valley website I see they offer a type of eye-hoe (sometimes called a cotton hoe) for \$16.95. It is only half the weight of a kadalo and has a long handle rather than a short handle. An eye-hoe has its uses but is not as effective or ergonomic as a kadalo. The kadalos of the peasant farmers are heavy tools with pick-axe stoutness and weight. Local, metalworker entrepreneurs ought to be able to turn out kadalo-like tools for reasonable prices. Each neighborhood needs tool-makers who specialize in making tools out of recycled industrial scrap.

RAKES.

You need a rake to work the soil. If you can afford it, buy the sturdiest garden rake available locally, but the cheapest tooth rake on the market will do the job and is good for years. I am referring here to the tooth rake with 2- to 3-inch teeth, not the springy leaf rake. I am spoiled, I have a collection of about 10 different rake sizes. Mostly I have standard-size rakes, but I also have rakes up to four-feet across and grubbing forks that look like pitchforks turned sideways with 8-inch tines. Buy a deep-tined grubbing fork if you can afford it. Serious gardeners will want several tine depths.

HULA HOE.

With the hula hoe I can efficiently weed around garden plants which are unmulched. It glides under the soil surface without turning the soil, cuts off the weeds below the crown, and leaves a loose soil mulch. I find the hula hoe much faster, easier and more effective than other types of cultivating hoes. The hula hoe doesn't work for really big weeds in which case I use the kadalo. Hoes are only needed in unmulched parts of the garden. I never use the standard garden hoe anymore. It requires a chopping or scraping action which moves the soil unduly, is hard on the arms, slow, clumsy and not as precise as the hula hoe.

PRACTICAL STEPS

So you've got your small plot of land and a small collection of gardening tools. What's next?

- 1) Till the ground and add fertility elements.
- 2) Make a garden plan.
- 3) Obtain seeds, plants and propagation material.
- 4) Plant the garden.
- 5) Maintain your garden adequately to obtain good yields.
- 6) Harvest, store and eat.

Let's look at each of these in more detail. I am going to emphasize methods which use no, or little, fossil-fuel inputs and which are inexpensive.

STARTING THE GARDEN, TILLAGE AND SHEET MULCH

1) Turning the soil is called tillage. It is possible to go straight to sheet mulching for starting a garden (no tillage) but if the quickest possible results are desired I recommend tillage and adding fertility elements. In the USA in most cases this will mean using a shovel, since kadalos will likely be hard to come by (and kadalos take a stronger back to use). Shovels for turning soil tend to have a longer head and a straighter blade than the more rounded-shovels used for scooping materials. But you use what you got. How deep to turn the soil? Depends on the soil, the gardener's time/energy and how much fertility inputs you have. The worse the soil is the more inputs you have to add as you deepen tillage. If inputs are scarce then dig shallower. If the soil is already good, or if you have more inputs, then dig deeper. Remember this is the first year instructions only. Each year thereafter you can dig the soil a little deeper until you reach the practicable limit, usually 2 feet max. Of course, you don't have to do this deep, annual tillage in areas that you put into perennial crops. Over time you add lots of perennial plants into the system whose roots penetrate deep into the subsoil. These deep roots build soil and deepen organic carbon storage as well as pull up deep-seated minerals and water. These deep roots are one reason that permaculture systems tie up so much carbon. The perennials bring leached nutrients back into the surface layers of the soil by their leaf and litter fall and by surface-root exudates. The roots of deep-rooted perennials will usually grow until they hit bedrock, a permanent water table or an impermeable soil layer. The world's deepest recorded roots have been found 150 feet down into the soil. The three species recorded with roots this deep are bigbush sagebrush, mesquite and alfalfa. Alfalfa and other deep-rooted species can

be used in gardens. How to incorporate different kinds of organic matter into the garden is a very big subject. Most organic gardening books tackle this topic to one extent or another. A lot of organic matter is too coarse to work directly into the soil, and some is too hot (in nitrogen) and needs to be composted first.

SHEET MULCHING VS. TILLAGE.

Sheet mulching is a gardening technique whereby the entire ground surface is covered deeply in mulch, usually with a layer of cardboard, or newspaper near the bottom to form a temporary barrier to persistent weeds or grasses. Grassy or weedy areas can be turned into gardens without ever tilling the soil. I use both sheet mulching and tillage in my gardens. It is difficult to put in a successful, intensive garden the first year without turning and cultivating the soil. Each year thereafter less of the soil would need turning as more of the area is occupied by perennials and as no-till, mulch systems are developed. It is possible to start with a no-till, sheet mulch system, but by and large the yields won't be as high the first year. The other drawback is that sheet-mulching takes large amounts of biomass and not everyone will have access to enough material and/or time to transport it. Not a small matter if you are hauling material in a wheelbarrow or hand cart from a mile or so away. I will post an article on sheet-mulching on my website.

Please note that there are two main strategies to build up the productivity of your garden soil.

- 1) Household waste and growing fertility inputs in the garden. No outside inputs from off the property. It is possible to grow soil improving crops to till into the soil on rotation and gradually build up organic matter and soil health. But it is hard to do this and take off much food productivity at the same time. At least initially.
- 2) Add outside inputs. Do the above but also bring in outside fertility inputs. These can be gathered locally or purchased if money is available. Carefully selected purchases of fertilizer inputs can give good returns. Local biomass should be the main focus though.

FERTILIZERS

What to fertilize with? Well, what have you? What is available? What is affordable? The range of fertility sources for soils is virtually endless. I am talking organic here. I have had a series of great gardens and farms for 36 years now without using any chemical fertilizer. Many years I relied solely on local, gathered inputs but in recent years I have purchased outside inputs such as rock powders and seaweed. These and some other organic fertilizers consume significant amounts of fossil fuels in harvesting, mining, processing and shipping. If I want to buy fertilizers to supply desired nutrients then I can get any element I need through organic materials, so I don't feel drawn to using non-organic fertilizers.

NON-ORGANIC FERTILIZERS

There is a wide array of non-organic fertilizers. Chemical fertilizers are all poisonous to soil life, but they are not equally poisonous and their damaging effects are dependent on how much is applied and what condition of soil health is already there (or not there). The judicious use of non-organic fertilizers to help kick-start a system, combined with organic inputs and management, can achieve a healthy, productive soil. Small amounts of quick-release chemical fertilizers can also help establish systems in some soils of the humid tropics. Most chemical fertilizers are dependent on fossil fuel for feedstocks, manufacturing and shipping and will become progressively less available and less affordable, especially for people at the lower end of the economic spectrum.

ORGANIC MATTER

Organic matter = soil nutrition = crop yields. Collecting available organic material is one of the main ingredients to garden success. All kitchen waste can be composted (if not first fed to chickens). All lawn clippings can be used (less lawns in my scenario). All leaves can be used. All prunings from yard and street trees can be used. A lot of fertility inputs can come from crop wastes, garden weeds and green manure crops grown in the gardens themselves. Theoretically a garden could produce all the organic matter needed to keep fertility up. This is easier to do in large gardens where adequate area can be devoted to soil building crops and where the soil is already at a high level of fertility. Is it a lot harder to do if the soil is infertile to begin with and/or where the family needs to maximize food production. Most gardening in the world is dependent on inputs from outside the garden.

For the most part our proposed gardening revolution will have to be fueled by local fertility inputs. Vehicles and trucks are real handy for moving bulky materials around and I bring in truckloads of materials to my plantings (in their early years). But in many parts of the world, most gardeners do not have access to motorized transport and must bring all inputs in on foot, bikes, carts, wheelbarrows, etc. I remember visiting an exemplary, agroforestry farm in the Hill country of Nepal where the farmer had spent decades hauling up the waste from butchers and haircutters in a town many miles away and thousands of feet lower in elevation. All of it was carried up on his back. He dug holes, buried the waste and planted trees. After years of effort he had built up a very successful orchard/agroforestry system. This shows the extreme end of bringing in fertility. Another story concerns Hunza land in the Karakorum mountains of central Asia. Hunza land is a valley surrounded by tall rocky mountains and glaciers. Soil is so valuable that farmers actually collect soil with small brooms and baskets and carry the soil home to their gardens. They have very successful home gardens because no effort is spared in tending the crops. Until recently their lives were utterly dependent on the success of their crops.

In some parts of the world organic matter is at a premium and people have to go to extreme measures to get even small amounts. The worst places are crowded cities, desert areas and severely eroded areas. Everywhere I go in the US there is usually a plethora of organic matter available for the picking. Lawn clippings, restaurant throw-aways, cardboard, rags (of natural fiber), old lumber, prunings, weeds, etc. All manners of organic matter are available to the collector who doesn't mind dealing with occasionally gross materials. Of course, we would wish that all our organic matter was non-toxic and un-polluted, but beggars can't be choosers. In a city, pollution is almost ubiquitous to some extent or another. It is amazing what a healthy soil full of life forms can digest, clean-up and de-toxify. In fact, plants and soil life are two of the biggest ways we have of cleaning up the pollution spewed forth by humans. Pretty much every kind of organic matter can be used in some way for fertilizer or mulch. Everyone has to choose their own line that they won't cross as to what materials are unacceptable in their gardens. As more and more people start gardening, the demand for organic matter will increase. People will go to greater efforts to obtain it and eventually organic waste could be fully utilized, but we are a long ways from that now.

COMPOSTING

Gardeners should aim for as many compost piles as can be collected and maintained. Hot compost piles are not feasible for most gardeners because they don't have enough hot (high-nitrogen content) materials such as legumes, green matter, fresh manures at one time to sustain a hot compost temperature. So most gardeners make cool composts. Proper selection of materials and layering is important. Composting is covered in most gardening books. Manures are excellent additions. All compost piles should be inoculated with red wiggler worms. You will have to import them for your first pile, but after that you just have to add some shovelfuls of the mature compost (full of red wigglers and their eggs) to any new compost pile. They will also live in thick mulches.

SMALL LIVESTOCK. City gardening should incorporate small livestock such as chickens, other fowl, rabbits, goats, pigs, etc. They should be integrated into the system in as many ways as possible and give multiple yields and perform multiple functions. Eggs, meat, milk, hides, fur, wool as well as companionship, manure, mowing, brush removal, weeding, insect control, etc. Even a small input of manure can be important to garden fertility. Small livestock can be raised on kitchen waste and garden wastes without outside inputs. Protein is a crucial element of our diet and meat and eggs can be provided in a home garden setting. Small livestock is a common feature of home gardens worldwide. For family consumption first of all, but also as a source of cash or exchange. Some people such as vegetarians, vegans, and people who travel a lot will not want any domestic animals. You can run a garden just fine using the manure of earthworms, red wiggler worms, and the soil life. Integration of small livestock into home gardens is a huge and important topic which I won't go into in this article. Small livestock should be legal in all cities.

HUMANURE

The fertility source most people do not want to talk about. Currently half of the world's land surface is dedicated to providing food for humans, and humans flush almost all of their nutrient stream into the planet's water systems in one way or another; thus polluting the water and spreading human diseases. Composting toilets are the answer, but you have to get the right kind for your situation. First of all, it has to be safe. This inevitably means that there has to be a lot of time involved before handling the composted material - like 6 to 18 months depending on the climate and other factors. There are many kinds of composting toilets out there - good ones and bad ones that are legal and good ones and bad ones that aren't legal. This is a long discussion. I collect books and lecture on the topic of human waste disposal. Worldwide we need to figure out how to keep humanure in terrestrial nutrient loops without endangering human health. The solutions will vary depending on population density, climate and culture. Local research efforts and trial projects can lead to the best solutions. Even if you do everything right to obtain a safe product with minimal nutrient loss then I still recommend putting humanure compost onto tree crops and not into vegetable gardens. Do your research. Two recommended books are: "The Composting Toilet System Book" by David Del Porto and Carol Steinfeld, 1999; and "The Humanure Handbook" by J.C. Jenkins. Del Porto and Steinfeld's book covers a lot more kinds of systems than Jenkins.

OTHER SOIL FOODS

Green manures, lignins and other soil foods. There are a number of pathways to building soil organic matter, humus and carbon.

1) Add pre-digested plant material such as finished compost and manures. The soil life eats this stuff up fast and creates an explosion of nutrients available to crops.

2) Incorporate soft, green plant matter into the soil. Usually called green manure crops, cover crops or soil building crops. The soil life digests this stuff slower but still relatively fast. Most of it is gone after one year.

3) Add woody plant material, straws and mature plant stems to the soil (or the compost from same), either worked in or on top. This class of materials is rich in lignins, tough plant material which is hard to break down. It is decomposed slowly by a series of soil organisms and is long-lived in the soil. It provides most of the material for the humus in the soil. This is why it is important for the gardener to add lignin-rich materials to their gardens. Wood chips from tree trimming services are great additions to gardens. It is best applied on top of the soil as a mulch. It will be digested gradually and pulled into the soil by the soil life. How long it takes to decompose is a factor of chip size, how much life is in the soil, and how much of the time the chips/soil interface is moist versus dry. Wood chip mulches reduce soil compaction, buffer soil temperatures and conserve soil moisture as well as releasing nutrients. Bark is another useful mulch as it has a much higher mineral content than trunk wood. Ground bark is a common decorative mulch and is good, but expensive. Even whole bark chunks are good. Just apply them to areas that have strong-stemmed plants and don't need tillage. Some kinds of smaller-textured material (such as fresh sawdust) which can physically be worked in can only be added in small amounts or it will reduce yields due to tying up nitrogen. Fresh sawdust should not be used a mulch on crops. Sawdust can be used in paths thickly to deter weeds and provide soft walking area and reduce soil compaction. It takes years to break down. Well-aged sawdust has more uses and can be used as mulch and small amounts can be worked into the soil to improve soil texture.

Vermi-composting (worm farming) is an excellent way to break down some kinds of organic material (such as coffee grounds, vegetable waste, leaves, manures, food-processing wastes) and yields a most valuable soil fertilizer. In home gardens people use worm bins or special compost piles. Vermi-composting is also done in agriculture by large-scale operations using long windrows of material. In mild climates, worm bins can be brought into protected locations in garages, sheds or basements and continue their work. They can survive frozen winters at the bottoms of compost piles, and at any rate their eggs will hatch in the spring.

Start a fall, leaf-raking service. Leaves are a great garden resource. You can spread them on top of your garden for a winter mulch, or you can make compost piles. Red wiggler worms love leaf compost piles and help turn it into rich fertilizer faster. If you have a windy site, then you need to prevent leaves from blowing away.

SOIL INOCULATION

Soil inoculation is a handy-dandy way of improving soils. There are lots of ways of doing it. Some of it is simple and easy. Just go out into your neighborhood and look for rich, healthy soils - particularly soil from productive, organic gardens. Bring a shovelful or a bucketful home and add some of it to your compost pile and some to the garden soil directly. If one part of your soil is better than others, add the inoculant to the best soil as the organisms will have a better likelihood of establishing in a healthy environment. Avoid collecting from weedy areas to avoid inoculating your soil with new weed species. I would never bring in soil from a garden that had bindweed. Collect soil from wild environments (less polluted the better). I like going into forests and collecting forest litter, humus layers and a bit of the topsoil. This will contain many beneficial organisms including mycorrhizal fungi. It is well-known horticultural trick that if you are planting trees and shrubs that you can improve their establishment and growth by bringing in some soil/litter

material from underneath established plants of that species. Throw it in the planting hole or work it into the soil around the plant. A majority of plant species form symbiotic relationships with mycorrhizal fungi and do their best where the correct species of fungi are present. Some plants are majorly dependent on these associates (such as conifers and Ericaceae plants like blueberry), others are less so (most weeds).

If you are bringing in buckets of soil from all over the neighborhood and adding it to your garden are you in danger of adding bad guys? Yes you are. There are soil borne diseases and pests such as symphyllums, wire worms and root rots. The weed issue should be seriously considered. A keen gardener will observe carefully, ask questions and avoid a lot of the risks. My point in soil inoculation is that the benefits outweigh the risks, particularly where your garden soil is poor to begin with. If you have a healthy soil, you don't need to worry, but if your soil is pathetic you need to get the fires of life burning brightly within it. I am reminded of the story Scott Davis of Molokai told me about his long-term, aquaculture experiments. Scott said that the more species he added to his ponds the more stable and productive they became. The more habitat niches that can be created and filled the better the whole system functions. I believe this is analogous to the soil system. Hand in hand with inoculation is feeding the soil life. Soil life needs organic matter. Feed the soil-life and the soil-life will feed the crop. A healthy soil has good checks and balances. Pathogens are rarely an issue.

You can also buy soil inoculants. One of the best-known sources right now is EM (Effective Micro-organisms) which was developed in Japan and has a large, international following. You can buy symbiotic Rhizobia bacteria strains for inoculating peas, legumes and many other crops. Commercial preparations based on the free-living, nitrogen-fixing *Azotobacter chroococcum* bacteria have been extensively used in Cuba. Blue green algae are used as soil inoculants and even sprayed on broad-scale crops by planes. Biodynamic preparations are available. The main function of BD preps is to carry astrological influences into the soil but some are also microorganism inoculants. These commercial soil inoculants are relatively expensive and hard to find. We can do a lot with just backyard technology and bringing in local healthy soils. Mycorrhizal fungi inoculants have also become available in the last decade as well as Phosphorus-solubilizing microorganisms. In 1970 the first book was published on *Azotobacter* nitrogen-fixing bacteria that naturally live on leaf surfaces. The leaves absorb some of the nitrogen with a resultant increase in plant growth and health. Inoculants are being developed that boost crop yields. A lot of research and experimentation is needed to develop locally-adapted strains and types of inoculants with an emphasis on native species. Seed pelletization is one method of successful inoculation.

OLD BOARDS

Old boards are great in the garden. Non-splintery boards can be used for garden walkways. If you look under old boards that have been in a garden for a long time, you will see that the soil underneath is soft and literally a maze of tunnels made by worms and other soil macrofauna. The roots from your adjacent crops benefit greatly from this. In western Washington the slugs love to spend their days under the boards. Thus boards offer a way to keep the slug population in check. Just turn each board over every day and collect the slugs for disposal (ducks and some other fowl will eat slugs and turn them into eggs for you). Piles of rotting boards are great habitat areas for critters like salamanders and rats. Management consideration needs to be given to encouraging beneficial species and controlling unwanted species. When I sort freebie lumber piles I separate the boards into ones good enough for construction, others for firewood and the most rotten for garden use.

WEEDS AS FERTILIZER

It is hard to have a garden without weeds. The trick is not letting the weeds get out of hand. I harvest many weeds for food and others for medicines. I encourage some weeds. Some parts of my garden are meticulously weeded. In other parts of my garden I deliberately let the weeds grow in pathways so that I can cut them for fertilizer and/or mulch. Usually I cut them before they set seed. Some are added directly to compost piles. Others are used to mulch paths or to mulch underneath crop plants. My managed weedy areas perform many benefits for me. They are pumping energy into the soil and they add organic matter to the soil. Even if I remove all the tops, their roots decompose. Weedy paths reduce soil compaction from walking and the roots help de-compact the soil. This is not a policy of neglect. It has to be done with thoughtful attention so that the weed growth does not suppress crop yield. I tend to use this strategy next to robust, tall crops and in the latter part of the growing season. For some weed species I have a no-tolerance policy.

WOODY BIOMASS

Woody biomass includes all material from woody-stemmed plants – trees, shrubs and vines. The obvious parts like tree trunks, stumps, roots, branches and twigs -- but also the bark, leaves, litterfall, soil humus, and charcoal (if it is a forest that experiences wildfires). It is all valuable stuff. There are many ways to use woody biomass in gardening and farming. Leaves, needles and finer materials can be used for mulch or composted. I make one kind of compost pile out of garden waste and soft materials that break down in one year. I also make what I call "rough compost piles" out of branches, raspberry stems, rotting boards, sunflower stalks, and other tough material. These piles may take three to five years (even longer) to break down, but more often than that I just re-pile the undigested material and scrape up the good stuff at the bottom and use it for fertilizer. I rotate my compost piles around my garden, using them to kill particularly bad patches of weeds or grassy. The area which has been under a compost pile for a year or two is one of the best spots for gardening. Squash and other runner crops can be planted next to or into compost piles so that the space is still growing crops. Woody biomass in the garden is better than money in the bank. You make a deposit of woody biomass and you know it will pay off with dividends in the long run as it breaks down and fuels your garden's soil life. No one can easily disappear your investment.

I want elements of the forest in my garden so I bring in forest litter, twigs, branches, logs, and stumps and use them in my gardening. I partially bury stumps and logs so that they have good contact with soil decay organisms. Logs and poles can be used to edge raised beds. Branches and twigs are piled or laid under shrubs and trees. Forest litter is used for mulch. Branches are added to soft compost piles to help aeration. The more types of material and habitats you create in your garden the greater the number of organisms which can live on your site. Another way to incorporate woody debris into the garden is to make raised-mound beds called hugelkulturs. This is an old traditional system in Germany which uses rotting logs, branches, twigs, forest litter, manure and soil to create long-term, fertile garden beds.

CHARCOAL

Charcoal can be made from woody material and the charcoal added to the soil. Charcoal is a great soil amendment. It is not full of nutrients itself, but it provides honeycombed apartment houses for soil micro-organisms plus it has great cation exchange capacity which is the ability to hold nutrients in the soil in a form that is easily available to plants. Charcoal reduces nutrient leaching from the soil in high rainfall areas (or under irrigation). Charcoal in the soil improves soil texture and water holding capacity. It also helps improve drainage and aeration in heavy clay soils. Charcoal can be made in the backyard with simple techniques using barrels with controlled air intakes. Some forms of charcoal for agriculture are now marketed as biochar. Charcoal can persist in the soil for hundreds or thousands of years and offers one of the best ways to sequester carbon out of the atmosphere. Search for “Terra Preta” online and you will find a wealth of information on charcoal in agriculture/gardening.

Healthy soil is key to garden productivity. The more life in the soil the better. A biodiverse and healthy soil ecology is one of the main ways we can reduce crop diseases. Plants grow bigger, healthier and have more yields. One of the goals of permaculture gardening is to build soils to a high state of health and then to garden in such a way that this high state of health is maintained. It is well known that continuous cultivation and heavy cropping will deplete soils without the addition of lots of organic fertilizers. Thus we promote food production with minimal cultivation and systems which return a lot of organic matter to the soil. We can also inoculate our soils with beneficial organisms. The end result of these strategies applied worldwide is that gardens become significant carbon sinks.

2) MAKE A GARDEN PLAN.

Small, simple gardens can have simple plans. The larger and more involved a planting becomes then the more time and thought should be put into the design. Intercropping patterns, planting densities and access paths need careful consideration. Here is where permaculture training will come in handy. Places with continuous traditions of home gardens, particularly in the traditional forest gardens of Asia and the Pacific, already have the basic knowledge of how to do this. However even the best of places can benefit from new ideas. As permaculture co-founder Bill Mollison notes “Protracted and thoughtful planning rather than protracted and thoughtless labor”. More gardening education is needed, both formal and informal. The gardens are our best teachers and many gardeners prefer to muddle along by themselves, learning from their mistakes and building on their successes. Some people plan their gardens and some don’t. Planning is great but the actual planning is not as critical as actually taking care of your plants.

3) OBTAINING SEEDS, PLANTS AND PROPAGATION MATERIAL

Currently the gardening stores and supermarkets feature lots of seed racks in the spring. Seed is getting increasingly expensive and most of the trade is controlled by a few, multi-national, seed companies. Thank goodness for the small, organic and alternative seed companies which between them offer an impressive array of vegetable varieties. Great for people with goodly budgets but seed expense deters many of the poorer, would-be gardeners. One of the answers is to grow your own vegetable seed. This is easy for some vegetables and more difficult for others. The mustards and brassicas cross easily and if you want something like the parent you need to keep your seed plants isolated from wild ones or other varieties for a long distance. You can’t grow all your seed but the answer is for local communities to share seed growing among a number of people. Humans have been trading seeds locally and over long distances for thousands of years. By and large, locally-bred varieties for local conditions will be better than those produced for other climates. In reality, we will always be moving seeds around. Bear in mind that most places have “analog” climate areas elsewhere in the world and seed exchange between them can improve local breeding efforts.

VEGETATIVE PROPAGATION

Most people when they think of gardening, first think of little seed packets. It is actually easier to grow crops from vegetative material such as tubers, corms, bulbs, rhizomes, root divisions, slips, cuttings and the like. The value of vegetative propagation is that plants rapidly establish, grow vigorously and are much better competitors with weeds; as compared to tiny seedlings which have to be nursed in the greenhouse or in field-sown rows. In tropical and subtropical gardening the emphasis is more on vegetative propagation and less on seed propagation as compared to temperate gardens. A little-known but particularly relevant publication that brings out this point is “Household Gardens: Theoretical considerations on an old survival strategy” by Vera K. Ninez of the International Potato Center (CIP). 1984. Lima, Peru. (available online at www.cipotato.org/library/pdfdocs/FdSysRes20806.pdf). Even though the subtropics and tropics have a wider array of food plants grown from vegetative propagules, there are many available for cold temperate climates also. The most well-known is the potato. Others include garlic, rhubarb, horseradish, Jerusalem-artichokes, chives, lovage, other culinary herbs, strawberries and many lesser-known food plants. Mediterranean climates can grow all these plus additional species such as sweet potato. The amount of vegetative propagation material available from a garden increases substantially every year. Start small in year one which gives you enough material in year two to expand the garden and so on. After two or three years, there is usually sufficient propagation material to sell, trade or give away to other gardeners. A good resource is Eric Toensmeier’s recent book “Perennial Vegetables”.

PERENNIALS

A home-garden with long-term stability should include asparagus, rhubarb, berries, grapes, fruits, and other perennial, food crops. It is possible in the first year to plant a mixture of annuals; biennials (2-year crops); quick to bear perennials, eg. berries; medium term crops, eg. grapes, fruit; and long term crops eg. nuts. To plant such multi-crop mixtures means access to berry bushes, fruit tree stock, etc. The larger the planting, the more expensive the seeds and planting stock become. Also the more diverse and exotic the species and varieties selected are, the higher the cost. This is one reason most home gardeners will start out small and simple. Local garden clubs should publish resource lists for their area and recommended nurseries, seed companies, etc. Ask the local gardeners. For self-reliance and affordability people can learn how to grow rootstocks from seed and graft on selected varieties as well as propagation from layering and hardwood and softwood cuttings.

4) PLANTING THE GARDEN.

There are tons of tricks to planting. It’s one of the things you gotta do to learn. Some considerations: what to start in the greenhouse (if any), time of planting for each crop, depth of seed placement, spacing between plants; to plant in beds or rows, etc. Most small plants such as carrots, beets, lettuce, etc are best planted in close-spaced rows in beds. Large plants such as potatoes, tomatoes and corn are usually planted in widely spaced rows (not in beds).

SPACING PLANTS

The average tendency is to plant too thickly. Seeds and plants are valuable. Too close a spacing is a waste of money and gives lesser harvests if everything grows. One healthy carrot gives more yield than four, overcrowded, stunted carrots. In a home garden where every inch has to count it is advisable to plant seeds one by one for all but the smallest seeds. For very small seeds you can mix the seeds with sand and carefully spread the mixture with a can. Commercial farms have various kinds of seeding machines which give uniform results. Small seeders are available for home gardeners and can be useful, but most gardeners will find themselves doing most seed placement by hand. Follow the recommendations on the seed packet or whatever planting guide you are using. Be meticulous – not sloppy. Once seedlings are up, thin to the desired density. I thin my beets 5 times, each time getting a marketable harvest. The first thinning is small beet greens, the 2nd is small beets and beet greens, the third is moderate size beets and lots of beet greens, the 4th is large beets and small beet greens and the 5th thinning is large beets and no beet greens. What remains will be widely-spaced beets that will get very large for winter storage, up to 3 pounds each! This progressive thinning strategy works for crops such as beets and carrots.

INTERPLANTING

There are lots of kinds of companion planting. For instance, I plant rows of bush fruits at normal spacing. They are small when planted and don't need all their growing room. So for the first year I intercrop vegetables. The type of vegetable depends of the vigor of the annual crop and of the bush fruit species. Bush beans is my current interplant favorite. The beans fix nitrogen and benefit the berry bushes. I get a lucrative crop of beans the first year. Usually in the 2nd year the berry bushes need all the room in the row and there is no room for this type of intercrop. Alternatively I have planted creeping ground covers between the berries and they creep out to cover the ground under and between the rows. Berry rows have to be planted far enough apart to permit access and picking when mature. So I also grow rows of annuals and biennials between the berry rows for the first year or two. Thus I am double-intercropping. For larger species of shrubs which take two years or longer to fill their space, I plant perennial, medicinal herbs between them. For instance this year, I planted motherwort plants between blue elderberry shrubs. I expect to get many years of motherwort herb harvests even after the elderberry start fruiting as the taller elderberries stand above the 5-foot tall layer of motherwort. I also often plant trees at wide spacing in this system.

Another trick for high productivity is overlapping rotations. The new crop is planted before the previous crop is harvested. (either alongside or underneath). Another is double-cropping. Where the season is long enough, potatoes can be planted early on favorable ground so they will grow fast. They are harvested as new potatoes when large enough and a second crop is immediately planted for late fall harvest. With quick-ripening crops such as radishes and lettuce sometimes even 3 or 4 crops can be obtained on the same ground in one year. Another strategy is consecutive planting which is done to even out production over a long time. Lettuce being an example. Many market gardens seed lettuce every week from early till late in the season, so that a new crop of lettuce is ready for harvest throughout the growing season.

5) MAINTAIN YOUR GARDEN ADEQUATELY TO OBTAIN GOOD YIELDS.

A good many gardens fail on this point. The garden is well prepared and planted with the best of intentions, but there is not enough time devoted to maintenance to carry the crop through and it is smothered in weeds, dries out, or is eaten by pests or critters, etc, etc. An unskilled person can even put a lot of time in, but fail for various reasons due to ill-timing or inadequate work. There are things that can be done to protect plants from particular critters, pests and diseases, but even the best gardeners still occasionally have losses. Lack of thorough and timely weeding is one of the biggest causes of crop loss. The smaller and more delicate the plant, the more often and thoroughly the weeding has to be done. This is why large, robust crops like potatoes, squash and Jerusalem artichokes are so much easier. The goal of a dedicated gardener is to learn from their mistakes and trials; and, over time, bring a higher and higher proportion of their crops to successful completion.

MULCHING

Mulching with an appropriately thick layer of material can eliminate the need for weeding plus be a big soil improver. Permaculturists, including myself, are big proponents of mulch. There are whole books written on the topic of mulch and whole schools of thought such as the Ruth Stout method, etc. One of my favorite books on mulching is a 1949 book by J.R. Rodale "Stone Mulching in the Garden". There are some crops and parts of my garden that I prefer not to mulch even if I had unlimited mulching material. I have brought in whole semi-loads of mulch to my two-acre planting and it was a drop in the bucket. If I lived in the Southwest or more tropical climates I would probably mulch just about every inch of the garden if I could. Of course in the tropics my garden would be almost totally perennial. The colder/shorter the climate the more important it is to get the soil warmed up early in the spring. Hence you may have the garden mulched over the winter to keep the ground (and plant roots) warmer. But in the early spring pull the mulch back to let the sun shine on the soil. The mulch can be reapplied in the summer once the soil has thoroughly warmed up. Another way to get the soil warmed up quicker in the spring is to spread ground charcoal on the soil surface. The black surface will absorb more heat. The charcoal is also an excellent soil amendment once it is worked into the ground.

IRRIGATION. Water is a limiting factor in many gardens. Gardens can rely on natural rainfall, private wells, municipal water, irrigation systems, grey-water, or collecting water on site (water harvesting). Generally speaking more water = higher yields, but too much water can adversely affect yields. One of the most important strategies is to select crops adapted to water availability. The less water available, the more drought-tolerant the crops need to be. Reliable and affordable water is a great boon to gardeners, but is not available everywhere nor to everyone. There are many tricks to stretching limited water in gardening and many books written on the topic. Collecting roof-top water and other run-off water on site and directing it to gardens is an important strategy in permaculture. One of the best books on this subject is Brad Lancaster's 2-volume book "Rainwater Harvesting for Drylands".

Selection of irrigation systems is beyond the scope of this article. Over-irrigation leads to nutrient leaching and can increase plant diseases. Under-irrigation reduces yields. Plant spacing is very important with reduced water availability. Infrequent, deep irrigation is almost always preferable to frequent, shallow irrigation, especially later in the season after crops are well established. If irrigation water is not available then there are many tricks to maximize production in rain-fed gardens. An excellent book which discusses rainfed gardening techniques and spacing is Steve Solomon's book "Gardening When It Counts". I rate this as one of the top most

relevant books on sensible home gardening in temperate climates.

6. CROP HARVEST AND STORAGE

Home gardens are mostly used to produce fresh vegetables and fruits in season. A survival garden would produce harvests for as long a period of the year as possible and crops are processed or stored for periods when the garden is dormant (winter in temperate climates). Winter gardening in the maritime Pacific Northwest enables yields throughout the winter. Carefully designed greenhouses can enable food production even in cold snowy climates.

EDUCATION/INFORMATION DISSEMINATION

The best existing gardeners in every locale and neighborhood should give workshops and garden tours to educate new gardeners. Helping new gardeners to make good garden designs would enable higher yields for many of them. Education is a very cost-effective input. Pay the best garden teachers available locally and bring in outside knowledgeable people who can give culturally and financially appropriate advice. Here are some examples of gardening/agriculture education. All these and similar educational methods need to be drastically ramped up, and from the looks of things, the sooner the better. Gardening information should be focused on household food production with high productivity and low external inputs.

FARMER TO FARMER EXCHANGES

Farmer-to-Farmer Exchanges across national borders have been enthusiastically received by farmer groups in Africa. Groups of 20 or so exemplary farmers from one African country (chosen by local farmer groups) would visit the farms of counterpart farmers in another country, and in turn that locale would send a team to the other's area. The farmers exchange ideas, knowledge, insights, seeds and propagation material. They have a great time. In the USA we have similar events happening at different scales. Most organic farming organizations schedule annual farm tours. Many garden clubs and urban organic gardening organizations sponsor garden tours in the spring and summer

TRAIN-THE-TRAINER

Another education example is the "Train the Trainer" method, used especially for agricultural innovation transfer in Africa, Asia, and Latin America. It goes something like this. A teaching team is assembled of the most knowledgeable people in a particular innovation or new crop. The topic must have widespread applicability among farmers. Farmer organizations (formal or informal) from different localities will select one of their brightest and best to attend the training. The training is usually free with the agreement that the people selected will return to their village area and give a training to local farmers. Thus training 20 people will result in them training 400 or more people in a short period of time. If the training goes out one step further than 8,000 people are trained (theoretically). Emergency home gardening techniques could be taught to a lot of people using this model. I have floated the idea of creating a train-the-trainer curriculum for emergency food gardening based on permaculture. If any readers would like to collaborate on such a curriculum, please contact me.

"Food Not Lawns" is a great example of an ongoing, public-gardening, training movement that is permaculture-savvy. www.foodnotlawns.com

PERMACULTURE EDUCATION

The permaculture educational system has greatly developed in the 29 years since the first Permaculture Design Course was held in 1980. Bill Mollison taught the first tier of teachers. Some of his students subsequently became teachers and they are the second tier of teachers (probably around two hundred teachers by the end of the 1980s). Out of the thousands of students taught by the second tier teachers perhaps 500 are also now teaching (third-tier teachers). At this point Bill Mollison has taught over 100 courses. At an average of perhaps 30 people at each course, he has personally taught over 3,000 permaculture design course graduates in many countries and on every habitable continent. Robyn Francis of Nimbin, New South Wales, Australia recently celebrated teaching her 100th course, mostly in Australia but she has also been a significant teacher in India and Indonesia. Max Lindegger of Mahleny, Queensland, Australia has taught widely internationally and has also broken the 100-course mark. Rosemary Morrow of New South Wales, Australia has taught many courses at home and abroad and has been especially influential at bringing permaculture to Vietnam and Cambodia. Many other second-, third- and fourth-tier teachers are steadily increasing their course numbers. For instance, I have taught 22 full courses since 1988 with two in the works for 2009. Most of my courses have been taught with one or several co-teachers. Some of my 450+ course graduates are now active and respected permaculture teachers. Internationally there must be over 100,000 permaculture design course graduates, of which perhaps one thousand are permaculture design course teachers. Our numbers are growing yearly. Permaculture design courses are one example of how to disseminate information.

CARBON SEQUESTRATION

Imagine a world where 50% of the food is grown in home gardens. Local food for local people everywhere. The gardening is so finely tuned and productive that large areas of farmland have been allowed to go back to natural ecosystems with full complements of native plants and animals. These new "wildlands" are very productive for hunter/gatherer activities and give a space for native plants and animals to live. The agriculture that remains is small-scale, ecologically-sound, socially-equitable and provides a reasonable living. Cities, towns and homesteads are filled with gardens, good food, beauty, flowers, birdsong and a happy human populace.

Garden soils and agricultural soils have been built up to high levels of fertility, humus and organic matter. This type of soil renovation done across nations and continents would contain an enormous amount of sequestered carbon. Healthy forests, prairies and shrublands build up carbon over time. Nature knows how to do it. Humans can get in the way or they can assist the process.

Home Gardens are good for you and they are good for the planet.

We can all do our part to save the planet and eat great food that we grew ourselves.

A carbon-rich soil produces bountiful and tasty harvests.

There is no better food than the food you grew yourself, with love.

Changing the world, one garden at a time.

Michael Pilarski

To be continued . . .

FURTHER RESOURCES in addition to the resources listed in the text.

Garden Agriculture. David Holmgren, the co-originator of permaculture, has recently coined the phrase "Garden Agriculture" to describe a strategy for local food production that relies heavily on home gardens and small market gardens in the urban and peri-urban areas. Go to Holmgren's website to view article. www.holmgren.com.au/

A food forest is a productive, largely self-maintaining ecosystem of fruit trees, berry bushes, vines, perennial plants and self-sowing annuals which yield food and other useful items. Resource: www.edibleforestgardens.com

A paradise garden is a productive, largely self-maintaining ecosystem based on perennial plants and self-sowing annuals which yield food and other useful items. <http://mountaingardensherbs.com/about.html#>

Grow Bio-Intensive gardening offers one of the highest-yielding gardening systems in the world. They research how to grow a family's food supply on the smallest footprint of land possible. John Jeavons is the principal developer of this technique. www.growbiointensive.org

Traditional, rain-fed gardening. Steve Solomon has written a book on family-scale, vegetable gardening which draws on traditional US gardening prior to rural electrification. "Gardening When It Counts: Growing Food in Hard Times". Eminently practical. Steve Solomon. 2005. New Society Publishers.

Biodynamic farming is a sophisticated method of farming which includes animal husbandry, crop rotation, lunar, solar and stellar influences, and biodynamic preparations. Some of their preps and methods can be used in home gardens. www.biodynamics.com/

Page 179-182 in "Sustainable Agriculture and Resistance: Transforming Food Production in Cuba" (2002, Food First Books, Oakland, Ca) has a nice section on legumes successfully used for green-manure crops in Cuba. This is a very useful book for Kauai to study as it is a similar climate and they successfully switched from modern conventional agriculture to local-input, organic agriculture.

Organic. There are innumerable variations of organic farming and gardening. Some of this has been codified by various certification and government agencies. Two great resources are the Rodale website and the ATTRA website (Appropriate Technical Transfer to Rural Areas).

Master Gardeners. Currently the major gardening training in the US. The quality of the info varies but there is much of value. www.ahs.org/mastergardeners/ This site is a portal to master gardener programs nationwide.

"Sustainable Agriculture and Resistance: Transforming Food Production in Cuba". 2002, Food First Books, Oakland, CA. This is a very useful book to study as Cuba recently successfully switched from modern, conventional agriculture to local-input, organic agriculture and a nation-wide, home-garden movement.

www.unu.edu/unupress/food/8F073e/8F073E01.htm

A great collection of articles on home gardens as a world food source. An on-line publication edited by Vera K. Ninez.

FUNCTIONS OF HOUSEHOLD GARDENS

by Vera K. Ninez.

The adaptive functions of household gardens in all the articles in this issue, are:

- * producing relatively large amounts of food with marginal labour on areas of land too small for field agriculture;
- * supplying nutrition lacking in field agriculture production;
- * providing food, including staples, directly in non-farm settings, especially urban centres, thereby cutting costs and obviating distribution problems;
- * making food available during periods of crop failure or disruption of food supplies;
- * providing fodder for household animals, and meeting other household-related needs (handicrafts, firewood, petty cash from sale of surplus);
- * lending convenience and security through proximity to dwelling;
- * enabling experimentation with new plant genetic materials and cultivation techniques before implementation in field agriculture;
- * allowing diffusion of plant genetic materials and maintaining genetic diversity; and
- * guaranteeing households a regular and secure supply of food, petty cash or goods to trade.

Industrial agriculture is not suited to the new millenium. The alternatives are being created.

If you liked this article then read Michael Pilarski's article "Feeding People in Hard Times" at www.friendsofthetrees.net

Kauai take note:

Page 179-182 in "Sustainable Agriculture and Resistance: Transforming Food Production in Cuba" (2002, Food First Books, Oakland, Ca) has a nice section on legumes successfully used for green-manure crops in Cuba. This is a very useful book for Kauai to study as it is a similar climate and they successfully switched from modern conventional agriculture to local-input, organic agriculture.

Jack bean (*Canavalia ensiformis*)
Velvet bean (*Mucuna aterrima* and *M. sp.*)
Crotalaria (*Crotalaria juncea* and *C. sp.*)
Cowpea (*Vigna unguiculata* and *V. sp.*)
Pigeon pea (*Cajanus cajan*)
Soybean
Sesbania rostrata
Lablab purpureus
Lupinus albus
Devil bean (*Phaseolus helvolus*)
Mung bean
Forage sorgum (non-legume) outperformed most legumes.