Well, I don't suppose any of us is fool enough to think that we can save the world. But if each of us were to look at some of the directions we'd like to see the world go in and then put our little bit of force behind one of them... and to have a hell of a good time while we're doing it, well then, that's what we should do.

Bill McLarney
The New Alchemy Institute
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DESIGNING A SUSTAINABLE AGRICULTURE:
A Senior Creative Project.

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IN PARTIAL FULFILLMENT:
Of the requirements for achieving the degree of Bachelor of Landscape Architecture.

FURTHER:
The author would like to offer special thanks for professor George Young's encouragement throughout the project, professor Dave Ferguson's insight and companionship, brother Nathan's shared interest and fellowship, and wife Michelle's love and patience throughout the course of his education.
The major focus of this two-part study will be to identify employable technologies for application in establishing a sustainable food-producing system. Part One: Research will explore the realm of sustainable agriculture—from mini-farming, to appropriate technologies, to deep ecology—in an attempt to relay its concepts and portray a design methodology for bringing about a comprehensive, wholly functional, food-production program as an agriculturally-oriented means of sustainability. Part Two: Application will demonstrate the results of employing these concepts at various levels of a sustainable community in Henry County, Indiana. It is important to note that the application portion of the study will be a team effort—a charrette headed by the Department of Landscape Architecture at Ball State University. And while my emphasis in the research portion of the study will be single, small-scale, self-reliant, predominately vegetative, food-producing systems; the objectives of the charrette have been predetermined, and will ultimately exceed those of the research portion to include three different scales and orientations towards sustainable agriculture—community demonstration site, sustainable farmstead site, and research-housing site.
INTRODUCTION

Modern Agriculture is based on the heavy use of chemical fertilizers, herbicides, and pesticides. This system has produced one of the most productive food systems the world has ever seen. Yet this productivity has come at a high cost. Today, tons of soil are lost annually to soil erosion. Groundwater is being contaminated. Many farmers--with unbearably high production costs--are being driven off the land. And despite all this productivity, hunger still remains a problem in this country and abroad.

Many authors state that there will be a worldwide shift from an agriculture based on natural resources to one that is based more on biology and scientific information. Supplies of land, water, nutrients, and energy are limited; so the emphasis will be to increase production while cutting back on inputs--especially synthetic applications. The future will see an inevitable shift from highly-mechanized, energy-intensive agriculture to one that exploits biological opportunities and utilizes a more diversified set of resource-conserving, energy-recycling, production systems. The availability of contingent technologies will depend on the level of support that is provided for agricultural research. And the fact that our world is moving through a transition from a demand-driven economy with perceived unlimited resources, to one which recognizes that the well-being of future generations depends on our willingness to utilize the resources at our disposal in a responsible way should facilitate the rallying of necessary support (Anderson p.22).

It is important to realize, though, that there is no simple solution. "What we face in agriculture is not a problem in the normal sense of the word. Problems are situations that contain a fairly well-defined set of known factors and a limited number of unknowns. Solutions emerge when people skillfully deduce the unknowns and place them into the correct relationship with what is known" (Sampson p.14). In other words,
the right information rightly applied solves the problem. But agriculture is complex—
involving many interactive, interrelated, constantly changing problems. History has
proven that solving one problem may inadvertently cause other detrimental, perhaps
even more stubborn, problems. It is clear, then, that the approach to this puzzle should
not be an individual one. Yes, the ultimate responsibility should be the individual’s;
and indeed, one can make great strides in remedying the situation. But this global
problem is much larger than any one person can tackle, and it demands the attention
and input of thousands of experimenting minds—from experts to green thumb laymen.
Only in this way, with the sharing of information, can the changes be made to
reinforce and supplement each other so that the end result is to move the entire
system in the desired direction.
The problem, then, appears to be two-fold: (1) We are not using our land responsibly; and (2) there is a lack of cooperation and sharing of ideas that would show us how to reach an effective state. However, it is important to realize that the two seemingly inherent road blocks in most situations, technology and economics, are not at work here. True, the lack of funding does impede scientific research; but sustainable techniques have been proven cost-effective in the field for some time now. Therefore, I suggest that #1 is subordinate. The real solution rests in #2. If one were able to acquire adequate knowledge of the concepts and available techniques and how they might be implemented, we would all be one step closer to sustainability. It is my hypothesis that there exists a method of food production that can accommodate the nutritional needs of a mobile society, comply with the sustainable motifs of our ecological systems, meet the challenge of a restrictive land base contingent upon ever-increasing populations, and can be relayed to the public in a comprehensive, useable format.
1 DESIGN ETHIC

Through my reading, I have come to realize that many of the ideas presented in this chapter are shared by at least a handful of what I would call cutting-edge research institutions—Ferlones (sp?) Institute, The Land Institute, and Rodale Research Center. But I would like to bring special attention to the New Alchemy Institute and what they call emerging precepts of biological design: "...it became evident to us that we were creating a series of precepts for biological design that could serve both to teach such concepts and to make them replicable in different settings. The formulation of these early precepts as they are applied and tested will contribute, in time, to the creation of a science of applied biotechnology which will serve in turn as a foundation for future design" (Todd p.19). I call attention here, only for the fact that the Todds present these ideas in a comprehensive, concise, understandable way; and that their words set the tone for the following ethic.

The Living World is the Matrix for All Design. This statement suggests that everything we need to know about design exists in and around us. We simply need to adjust our perspective. For instance, we have long come to think of ourselves as above and beyond our environment; when in reality, we are an intricate part of the total natural system. "The Earth together with its surrounding atmosphere constitutes a continuum, an entity which, taken as a whole, exhibits many of the properties of life. [And] this living entity, made up of billions of interlocking, mutually interdependent, nonhuman lives surrounds us, contains us, and yet is one with us" (Todd p.19-21). In this light the earth becomes Earth--man as a part of the whole living system—a single evolutionary system. Although many may have a hard time thinking in this fashion, I believe it makes perfect sense. If we keep to our currently destructive path of growth and development, the Earth won't cease to exist; true, the human factor may be reduced to all of nothing; but what we call earth will still be here—even in the event of a
nuclear holocaust. The Earth will adjust and new systems will evolve. We may simply not be around to witness it. Therefore, it should follow that if we wish to remain a part of this Earth, then we should learn how the natural systems around us work and how we can be a healthy, contributing element. Sure, we can put our synthetic patches on the wounds, but the Earth knows what is best for itself; it is self-regulating and self-correcting. The Earth is our model for design—not a static blueprint—but a living, changing entity that requires understanding to accommodate flexible patterns of human-including systems.

**Design Should Follow, Not Oppose, the Laws of Life.** Having designated the living Earth as the context for our thinking and for our ideas of design, we can begin to look at what makes this entity work. Perhaps the model that best emulates the workings of the natural world is biology. And by observing the natural world, we can better understand its contingent systems.

The basic unit and building block of life is the cell. All the basic functions of life are carried out at the microscopic level—food gathering, feeding, excretion, respiration, purification, and reproduction. As such it is an entity in itself. However, the cell also interacts/cooperates with other cells to ensure the functioning of the entire organism of which it is a part. This independent-dependent relationship among cells in organisms is a paradox to basic life and does not stop at this level; rather, there is an unbroken continuum—from cell to organism, to ecosystem, to bioregion, to biographical province, on to the whole planet.

Beyond the organism, then, the next level of organization is the ecosystem—an interacting system of living organisms and their non-living environment. The Todds speak of the environment as the home within which organisms live. However, an ecosystem is not merely a container. Like the cell and the organism, the ecosystem is an entity with an independent-dependent personality.
Next, is the bioregion—a cluster of ecosystems with similar topographic and climatic attributes. These bioregions then blend outward to comprise a biographical province (eg. the hardwood forested land east of the Great Plains extending southward from southern Canada almost to the Gulf of Mexico), which in turn span entire continents and water masses to form our planet.

To complete this thought, we must now add the elements of change and time. Nature is not static. While these entities are interacting, they share resources—information, nutriments—to accommodate structural changes occurring over time. However, time in nature is more complex than we experience it:

It [time] is marked by the seasons which are linked to the time of year and contains life spans that may range from minutes for some microorganisms to centuries for certain trees. Beyond this is ecological time, called succession, which is usually measured in decades—although the range here can be enormous too. Beyond the ecological time is evolutionary time, usually measured in time frames ranging from centuries to millions of years, which describes the appearance, changes, and often the extinction, of life forms. Finally, we reach geological time, which overlaps with evolutionary time. This huge yardstick measures major physical events such as the formation of mountains and the drifting of continents, as well as the major climatic epochs (Todd p. 28).

Succession is a powerful conceptual tool for thinking about, designing, even reshaping communities. In this context, we are allowed to address change creatively and quite possibly steer it. In an ecosystem, succession brings an increase in numbers and diversity and, more importantly, the kinds of potential relationships between organisms. As such, this complexity decreases the amount of dependent links, thereby increasing stability, protection from external change, variety, and overall system efficiency. Ultimately, the result is greater order and information flow.
Biological Equity Must Determine Design. Biological equity refers to the just access to and distribution of basic resources. This concept might seem simple enough for our democratic society, but the relative degree of individual authority afforded us by our federal system of government and the basic human freedoms afforded us by our Bill of Rights does not prevail throughout the remainder of the globe. Francis Lappe in *Diet for a Small Planet* writes about how the agricultural self-sufficiency and nutritional basis of Third World peoples is undermined by their lack of power to demand political assistance. The exploitation of these peoples and their resources by the controlling elite and multinational corporations has helped to stifle the elimination of world hunger. Lappe seems to put emphasis on liberation through political channels; however, another method for gaining power is to explore the potentials of biotechnology—that is, design methodologies/blueprints should be flexible enough to accommodate variations in bioecosociopolitical regions (resources, economy, culture, government).

Design Must Reflect Bioregionality. Bioregionalism is closely related to biotechnology. However, biotechnology places the responsibility upon the designer to consider different levels of organization while bioregionalism places the responsibility upon the inhabitants to think in a different, more integrated, comprehensive and responsible way. A bioregion has been defined as a cluster of ecosystems arranged topographically and climatically so as to delineate a distinct region. But with bioregionalism, we must introduce the human element—a rooting of human communities within their natural communities. Here, the inhabitants allow the bioregion to dictate how resources are to be distributed, by kind and quantity, and how they are to be used. In fact, bioregionalism may suggest that other aspects of our lives be dictated by bioregions as well—customs, trade, transportation, population growth, even political boundaries. The human element will learn to give and take from the flow of information. In this way, the needs of the entity will be met.
Projects Should Be Based on Renewable Energy Sources. Although many people pretend that it does not exist, the pervasiveness of our energy dilemma is impossible to overlook. Our massive dependency on non-renewable sources of energy, fossil fuels, and on nuclear energy, is one of the prime symptoms of the lack of resiliency that characterizes the developed countries at present. As the pitfalls of a society based on nuclear and/or fossil fuels become increasingly apparent, we look to alternative sources of energy--renewable sources that harness sun, wind, water, and biomass or wastes. The shift to a society based on such renewable sources will eliminate the need for oil, coal, gas, or uranium and all that goes into their extraction and the production, transportation, storage, and redistribution of the contingent by-products. As a result, we may rid ourselves of the burden of dependence on the nations and institutions which extract, process, and sell them (Francis Lappe would applaud). In addition, renewable energy can be tapped directly and is therefore ultimately more efficient and cost-effective. Perhaps most important, however, is the impact, or lack of impact that renewable energies have on the Earth. Ecosystems will remain intact, and the flow of information will continue uninterrupted.

Design Should Be Sustainable through the Integration of Living Systems. You may have heard of the saying One man's garbage is another man's treasure or Getting the most for your money? Well, these concepts are indicative of integrated systems. Just as the entities mentioned earlier share in the flow of information, design, too, should integrate design and function whenever possible. We often think in terms of single-functionness. For example, a pond is a place to swim. Right? But it can also be seen as a food production unit, a water storage unit, a nutrient storage unit, a waste filter unit, and a heat storage unit. The idea is to realize how many different uses an element has--whether it be a machine, a nutrient, or an energy source--and then design to facilitate efficiency. Recycling is at the heart of integration.

Design Should Be Coevolutionary with the Natural World. Too often we have witnessed the ill effects of the quick-fix mindset. How many times have you
attempted to put together the contents of a box without first reading the directions, only to find you are left with extra pieces and a product that falls apart shortly after construction? The point here is that an area as comprehensive as a landscape can't be manipulated too many times by random design without incurring a failure. We should be quick to think and slow to act--understand what really needs fixing before prescribing treatment. As we learn how natural systems operate, we can adjust our design strategies. That same landscape can in many cases be restored with a wise use of scientific information and biological tools in place of capital-intensive methods. And that's good news! For I'm not suggesting a suppression of our inquiring minds, rather giving license to creative, flexible design--which means exploiting all the information systems our computer-age society has to offer. Just as natural systems are successional, so should our designs be successional.

**Building and Design Should Help To Heal the Planet.** By planetary healing, I mean reversing the destructive policies and actions of industrialized countries that continue to disbelieve that we are all ultimately dependent on the unimpaired functioning natural world for survival. This precept is a call for action, not simply accepting the concepts of Earth and bioregionalism, but ceasing our destructive habits and taking measures to restock the planet's resources. It calls for stewardship. Seen through the eyes of the steward the land and countryside are living, vital entities held in sacred trust, to be nurtured and protected for the good of all things. He lives in the harsh economic realities of the day, but struggles for the delicate balance between ecological necessity and economic prudence. The steward strives to be a healer of the land. The wounds inflicted by machines, poisons and bad land practices then become the raw materials of re-creation. This means eliminating the loss of topsoil due to massive deforestation, doing away with non-biodegradable and toxic substances; This means planting trees, saving endangered species, rebuilding the soil, and growing our own food. This means restoring waste places. This means providing for present and future human generations.
Design Should Follow a Sacred Ecology. Sacred ecology may be likened to a
religion—an acceptance that there is a wisdom greater than our own. And with that
wisdom comes a way of thinking and acting—a metapattern for living. It is the
foundation and the summation of all the preceding precepts of design. One may find
answers in Christianity, in Buddhism, in Muslim, in Confucianism, in Feng-Shui, or
others. The point here is that the necessity of a sacred attitude is one of remembering
—remembering the larger context of one’s existence, one’s duties to one’s environment
and to the invisible principles that regenerate life constantly.
2. CONVENTIONAL AGRICULTURE REVIEWED

In this chapter we will take a brief look at conventional agriculture to compare its status with the precepts established in the previous chapter. The purpose here is not necessarily to explain how we've come to arrive at our current dilemma, not even to attempt to add any new insight into the situation; rather, I will simply offer a few relevant findings and let the statistics speak for themselves.

**Ecology.** Considerable concern exists about the effects of modern agricultural production practices on the long-term capacity of our soils to produce adequate food and fiber to meet the needs of future generations. Soil erosion, destruction of soil structure, decline in soil organic matter content, and loss of soil biota are all points of concern. The use of monocultures and wide use of plant materials with narrow genetic bases have led to concerns about disease. The introduction of sediment, plant nutrients, pesticides, and animal wastes into ground and surface waters is also a cause of serious concern. The following statistics from John Quinney's *Designing Sustainable Small Farms* may help to illustrate some of these concerns:

**Erosion.** At least one-third of our topsoil has been lost to erosion, and soil on existing cropland is being reduced at an average annual rate of eight tons per acre...and on 23% of the total cropland, soil losses average 21 tons per acre.
Habitat Destruction. Productivity has been maintained by increased fossil fuel input in the forms of cultivation, fertilizers, and synthetic pesticides...and the resulting soil erosion and over-fertilization are responsible for the serious degradation of our aquatic ecosystems.

Toxins. Each year, approximately one billion pounds of pesticides are used in U.S. agriculture, yet losses to insect pests, pathogens, and weeds exceed a third of the potential crop. In addition, pesticide abuse is responsible for environmental and public health problems, such as human poisoning and fatalities, groundwater contamination, the destruction of nontarget organisms, and the development of pesticide-resistant weeds and insects.

Water Depletion. Agriculture accounts for at least 81% of our nation's water consumption, and in some areas, salinization and aquifer depletion are apparent.

Energy Use. The food system absorbs 16% of all the energy used in America. Food production, distribution, and processing can be sustained only as long as fossil fuels are available and affordable.

Economics. Today, corporate control of food production is expanding at an alarming rate, to where a handful of corporations control a very large percentage of the American food supply. The technical term for this deliberate shift from farming to FARMING is agribusiness. It is estimated
that a mere fifty corporations now reap 90% of the profits of the entire food industry. However, it doesn't stop here. These same corporations are increasing their sphere of control into other areas such as seed production, manufacturing of farm equipment, fertilizer and pesticide production, harvesting, processing, packaging, distribution and marketing, and are increasingly trying to control data on alternative approaches—thus further removing control and input from the smaller-scale, local sector (Britz p. 3). From the same source we are shown the immediate impact of corporate control of food production:

**Control.** Corporate control removes control of food quality from the consumer. The consumer has no choice as to what goes into the food, or what is removed from it, during production, processing, distribution or marketing.

**Competition.** It controls a market that the small farmer cannot compete with, thus forcing him to sell out, often at urban development prices which are far above the market value of agricultural land. Between 1960 and 1976, fourteen hundred farms folded *each week* in the United States.

**Costs.** It is responsible for unnecessarily high food costs to the consumer. The hidden costs involved in the operation of mechanized agriculture and increasing costs (and scarcity of) petroleum fuels for production, harvesting, processing, packaging and transportation to markets will continue to show up in the cost the consumer pays for his food. Of the increases in food costs in the
supermarket from 1954 to 1975, only 6% of that increase went back to the farmer, while the other 94% filtered into the corporate structure to pay for processing, marketing, advertising, etc. It is further estimated that the corporate monopoly of food manufacture costs consumers and additional $15 billion each year in added hidden food costs.

Waste. It is a wasteful system. This accounts for a portion of the hidden costs mentioned above. According to a recent general accounting office study, some 137 million tons of food valued at $31 billion wasted in 1974 alone. Of this amount, 47% disappeared before it reached the consumer. 'In rounded figures, 16% was lost at harvest, 20% at the food distributor level (wholesale and retail), 7% during storage, 2% during processing, and 1% during transportation. The combined loss of U.S. produced food grains, meat, sugars, oilseeds, vegetables, fruits and nuts in 1974 could have fed an estimated 49 million people. In addition to this, approximately 66 million acres of land, nine million tons of fertilizer and the equivalent of 461 million barrels of oil were used to produce food that was ultimately lost.'

Nutrition. Because food production has become so centralized and monocultured, everything is being done to promote longer shelf life in our grocery stores. Produce is picked way before its natural maturing time--before the nutrients and flavors have had a chance to develop. To compound the effect, once the produce has been picked, it begins to lose
its nutritional value (about 12 minutes after liberation). Furthermore, many nutrients are washed away when cleaned. However, the biggest insult comes when the produce is treated with chemical stabilizers, waxes, preservatives, and color retainers to improve texture and maintain quality (Fritz p. 5).

Centralization and monoculturing represent a flaw in the system. Yet, part of the problem rests in our own consumptive habits. So many of our most dreaded diseases are related to the foods we now eat. In her book *Diet For a Small Planet*, Francis Lappe puts our dietary situation into perspective by expounding on eight radical changes in the American diet:

**Protein from Animals instead of Plants.** Contrary to what I thought, the dramatic change is not in our protein consumption. The change is in how protein is packaged. Sixty-five years ago we got almost 40% of our protein from grain, bread, and other cereal products. Now we only get 17% of our protein from these sources. In their place, animal products, which then supplied about half of our protein, now contribute two-thirds.

**More Fat.** Americans eat 27% more fat than did our grandparents in the early 1900s. And more that one-third of that increase has come just in the last ten years. As a result, fat's contribution to our total calorie intake climbed from 32% to 42%, though there are sign that the average may be lowering.
**Too Much Sugar.** Since the turn of the century Americans have doubled their daily sugar dose; just since 1960 it's gone up 25%. One-third of a pound of sugar is now consumed each day for every man, woman, and child in America.

**Too Much Salt.** Americans now eat 6 to 18 grams of salt a day—10 to 30 times the average human requirement, and as much as three times the recommended level. *Dietary Goals for the United States* recommends that we eat no more than one teaspoon of salt (5 grams) a day (about 2,000 mg of sodium). Since the average human requirement for salt is probably one-twentieth the recommended maximum of one teaspoon, there is virtually no danger of insufficient salt even if we never add salt to any food ourselves.

**Too Little Fiber.** Until very recently, most of us did not know that lack of fiber in the diet was a risk; most of us didn't even know what fiber was. Scientists define dietary fiber as the skeletal remains of plant cells that are not digested by our bodies' enzymes. As significant as any other change in the human diet over the last 20,000 years is the *fiber revolution*. The diets of our early ancestors probably contained ten times the dietary fiber of contemporary diets. Our long digestive tract undoubtedly evolved to handle this higher-fiber diet. The antifiber revolution has taken its most extreme form in the United States, where today 70% of our calories come from food containing little or no fiber. The fiber in fruits, grains, beans, seeds, and vegetables differs, and serves different beneficial functions. Some, for example, shorten the time
it takes food to pass through the intestines; others promote the growth of bacteria useful in altering potentially harmful substances. So it is important to eat a variety of fiber.

Too Much Alcohol. Ever since Prohibition, Americans have been drinking more alcohol. They drank the equivalent of 2.69 gallons of pure alcohol per person in 1975, 24% more than during the 1961-65 period. Of course, this figure is misleading, because while many people drink little or no alcohol, others drink far more than their share. The biggest increases have come in wine, with 490 million gallons sold in 1979, and beer, up from 28 million barrels in 1950 to 175 million barrels in 1979. (Some 25% of the cereal grains directly consumed in the United States are used to make alcoholic beverages.) Alcoholic beverages offer us few nutrients but lots of calories--210 calories per day in the average adult diet in 1975. (Again, this is misleading: since many Americans drink no alcohol, others must get 500 or even 1,000 calories a day from alcoholic drinks.)

More Additives, Antibiotic Residues, and Pesticides [Although] 'it is impossible to know exactly how many pounds of artificial colors, flavors and preservatives we ingest annually'...the suggested increase has been elevenfold since 1940. Livestock consume nearly half of the 25 million pounds of antibiotics produced in this country every year, an output that has shot up 400% in the last 20 years. Livestock eat most of these antibiotics in their feed, which contains low-level doses to enhance growth and prevent
disease. Pesticide use doubled from 1966 to 1976, reaching about 600 million pounds of active ingredients. When livestock eat tremendous volumes of treated grass and grain, pesticide residues concentrate in their tissues. Not surprisingly, a Food and Drug Administration study of our diet found the most (22%) pesticide detections in meat, fish, and poultry. Oils and fats were next, with 18% of all detections. It is estimated that 90% of all the cancers we endure are related to the foods we eat.

Too Many Calories. I probably don't have to present evidence to convince you of one of the key consequences of the new American diet. A government study confirms what our scales are telling us; as of the early 1970s the average American man was six pounds heavier and the average woman seven pounds heavier than their counterparts of 15 years earlier. Twenty percent of all Americans are either clinically overweight or obese.
SUSTAINABLE AGRICULTURE DEFINED

As one can see from the previous chapter, our current system of food production is failing—neither ecologically, economically, nor nutritionally sound. And although this continues to be the dominant trend, a very different form of agriculture is appearing on the horizon—one that is restorative, ecologically inspired, and applicable to the design of future settlements. It is an agriculture based on the values of stewardship and involves both modern and ancient knowledge. Rather than exploding outward into massive, centralized, corporate, monocultural systems, with biology as its model it will implode, turning inward and moving in the direction of integrated, self-sufficient, miniaturized communities.

Yet, if we are to pursue a more sustainable, and sustaining, agriculture, what will be its attributes? A sustainable agriculture must be profitable and internationally competitive. It must provide for the conservation of soil and the protection of the quality of water resources. A sustainable agriculture must deliver a plentiful and wholesome food supply while providing for the health and safety of farmers, must contribute fully to the economy and to the quality of life in rural areas. And it must insure the stability, integrity and beauty of the environment.

Agriculture is a natural resource based industry. The same resources must provide abundant and high quality forest products, as well as recreation, fish, wildlife, grassland, wetland and range resources.
THE NATURE OF FOOD

NATURE PRODUCES A BALANCED SYSTEM

EVERYTHING IN IT IS MADE UP OF THE SAME ELEMENTS WHICH ARE PRESENT IN AIR, WATER, AND EARTH TO BE USED AS NEEDED FOR CONTINUATION OF LIFE

SO WE EXIST ON A LEVEL OF CONSCIOUS CHOICE AND DO NOT CHOOSE OUR FOOD INTUITIVELY

BUT TO RETURN TO A STATE OF OPTIMUM HEALTH, WE MUST CHOOSE TO UNDERSTAND AND RETURN TO THE IDEA

---from The Edible City Resource Manual
list is long; and if we are to provide for all these needs, then we must establish priorities. But there appear to be conflicts. There are conflicts between some approaches to soil conservation and water quality. And there are the basic conflicts between natural resource use and conservation. What compromises are we prepared to make?

Priority setting depends on individual perspective. What would be the highest priority for an environmentalist? For a farmer? A conservationist? A consumer? An agricultural input supplier? A non-farm resident? The mayor of a small rural town? A landscape architect? In this context, who represents the public interest? The list of attributes cannot be prioritized. Attempts to do so will have us chasing rabbits as we pursue first one, then another of these objectives. What has been lacking is an overarching philosophy consistent with all these characteristics.

A philosophy is exactly what has been established through the design ethic in Chapter One. Inherent in this ethic is a hierarchy—a proper order—to these matters. As we focus on a long term perspective, some of the conflicts disappear. As we look for connections between long term economics and ecology, others disappear. Environmental stability, integrity and beauty must be at the center of our philosophy. This places soil conservation, water quality, genetic diversity, endangered species and similar topics at the forefront of our concern. Surrounding this center is the circle of wholesome and abundant food, health, safety, recreation, profitability and competetiveness, and a dozen other desirable attributes.
As I began researching the concept of sustainable agriculture, it became very clear that nothing was clear. No two authors seemed to agree exactly on how to go about fulfilling this ethic. Instead, I was left with the task of stumbling through innumerable sources of varied topics—organic farming, low-input agriculture, tilth farming to name a few. In order to make clear the material for myself, and hopefully the reader, I have used the following breakdown to organize and interpret the ethos of sustainable agriculture.

Mini-farming: Agriculture As a Food Production System. Related terms or subjects include: biodynamic farming, biofarming, biological agriculture, Chinese-style farming, French-style farming, Italian-style farming, low-input agriculture, natural farming, organic farming, raised bed farming, regenerative agriculture, square-foot gardening tilth farming, etc.

Mini-farming consists of agricultural techniques that make food-raising by small farmers and gardeners more efficient. Mini-farms can flourish in non-agricultural areas such as mountainous regions, arid areas, and in and around urban centers. Food can be produced where people live. With adequate knowledge and skill, output per hour can be high without the expensive machinery and chemical input that is indicative of our current system:

Our initial research seems to indicate that the method can produce an average of four times more vegetables per acre than the amount grown by farmers using mechanized and chemical agricultural
techniques. The method also appears to use 1/8 the water and purchased nitrogen fertilizer, and 1/100 the energy consumed by commercial agriculture, per pound of vegetable grown. The flavor of the vegetables is usually excellent and there are [strong] indications that their nutritive value [is] higher (Jeavons p. XI-XII).

Mini-farming boasts soil-building, space and time and energy-saving, high-yielding, nutrition-saving techniques. But more importantly, mini-farming is available to everyone. Below are some of its components.

**Raised Beds.** The preparation of the raised bed is perhaps the most important step in mini-farming. In conventional farming one may plant a single crop on acres and acres of land. But in mini-farming the idea is to grow as many varieties of plants as possible on as limited acreage as possible. I've already mentioned that mini-farming techniques can produce as much as four times the amount per acre of conventional methods. In addition, common estimates indicate that a complete diet for a family of four is possible on as little as 1000 square feet. I've even heard that by utilizing vertical space and using successional planting techniques, the same amount of food can be produced on a mere six 4'x4' raised beds.

This mass production is possible because of ease of access, not only in terms of the small plots—usually three to five feet wide—but in terms of their relative location to the dwelling. Because of their size, the labor-intensive beds can be just a few steps from the kitchen. In addition, the application of composts and mulches can create an ideal growing medium.
DOUBLE-DIG METHOD from How To Grow More Vegetables

1.

2. 

3.

4.

5.

6.

7.

8.
Furthermore, the close proximity and diversity of the polyculture promotes a symbiotic relationship between the plants—thus facilitating a healthy harvest.

*Double-Dig Method.* Double-digging is the term used for the process of preparing the soil two spades deep, or about 24 inches. Begin by marking out a bed three to five feet wide and at least three feet long. (Jeavons says most people prefer a bed 5, 10, or 20 feet long, but the maximum is up to you.) Then, follow the method outlined below (and refer to diagram on next page):

1) Spread a layer of compost over entire area to be dug.
2) Remove soil from upper part of first trench and place at far end of bed.
3) Loosen soil an additional 12 inches.
4) Dig out upper part of second trench and throw forward into upper, open part of first trench.
5) Loosen loser part of second trench.
6) Continue double-digging process (repeating steps 4 and 5) for remaining trenches.
7) Place soil in mound at end of bed into open, upper part of last trench.
8) The completed double-dig bed.

After you have planted, you do not need to walk or carry equipment across the beds. All of the watering, weeding, and harvesting can be done from the sides. In this way, the beds can remain uncompacted—allowing for proper movement of air and water through the soil. In addition, once the
ROAMING BED METHOD from Gardening for All Seasons

first spring

early summer

late summer

fall

second spring
beds are established, they are used year after year with an annual application of compost and/or mulch. The drainage of the beds is superior, the soil warms up sooner in the spring, and allows the gardener or farmer to plant earlier.

*Roaming Bed Method.* The second method of making a raised bed is similar to the previous method, but with a 12 inch, single dig instead of a 24 inch double-dig. And with the roaming bed method, you mark off all the beds at once, spread the manure over each of the beds, and then begin to dig. (Follow steps below and refer to diagram:)

1) First Spring—dig trench for pathways to a depth of 12 inches, throw the dirt on the bed on one side of the trench, and plant.
2) Early Summer—over the season fill trench with layers of organic material (leaves, hay, grass clippings, manure, compost, weeds, etc.).
3) Late Summer—include vegetable wastes after last harvest.
4) Fall—dig new trench spreading soil over old path and existing raised bed.
5) Second Spring—growing beds include last season's sheet-composted pathway; repeat process by filling new trenches with layers of organic material.

The advantages to this method are: less digging, less compaction of soils since paths are dug up each year, a trench for irrigation or water storage purposes, and no need for stockpiling of compost in a separate location. (However, I would recommend that you compost the materials before adding to the trenches.)
NO-DIG METHOD from Rain

"SEED-FREE"
MULCH

NEWSPAPER/CARDBOARD

SHEET
COMPOST

COMPOST, SAND, GRASS CLIPPINGS

WELL-OVERLAPPED

MANURE

GRASS CLIPPINGS

LEAVES

MANURE

ROCK PHOSPHATE, BONE MEAL, GRANITE DUST, OYSTER SHELL FLOUR

SOD

SOIL

© 1983 ROBERT KOURIK
No-Dig Method. In *Rain* magazine Robert Kourik gives a recipe for a no-till method of creating a raised bed:

You start without tilling, right on top of whatever is there already--lawn, weeds, bare soil. First, apply a one-time application of organic fertilizers--slow-release rock powders such as colloidal phosphate and granite dust, which nourish strong growth for years. If necessary, balance the pH with lime for acid soils or sulphur for alkaline soils. Now, add layers of raw materials (leaves, clippings, manure, hair, sawdust, and so on), mixing the layers to achieve a carbon-to-nitrogen ratio of between 20 and 30 parts carbon to one part nitrogen....If you start on top of dense sod the first layer should be manure, because fibrous material needs more nitrogen to decompose. Put down as many layers as you have the time or materials for. The result is like a flat, mini-compost pile, which is why this method is called sheet composting.

Some of the raw materials you use will be full of seed. Left to sprout, these renegade seeds may out-compete the plants you're trying to establish. To smother them, put down a layer of newspaper or cardboard. This same biodegradable weedkiller helps to make sure no noxious weeds survive that were originally present. The newspaper and cardboard are temporary barriers. In a season or two, when they're no longer needed, they will have decomposed, and even added a small amount of organic matter and nutrients to the soil. The more vigorous the lawn or native plants below your layered garden, the thicker the sheet compost and the paper layer needs to
Plants for Hanging Baskets

Try combining edible plants with flowering plants over the sides of the container. Flowers that can be used in combination with the edible plants are named in parentheses.

- Cherry tomato ('Big Cascade' variety)
- Cucumbers (cucumis sativus)
- Dwarf snow pea, in a large container (sweet alyssum)
- Mint (Italian balsam or lemon)
- Oregano (purple or pink alyssum)
- Royalty bush bean, in a large container (purple alyssum, or pink or white cascading petunia)
- Parsley (yellow or orange viola)
- Peppers (dwarf nasturtium)
- Strawberry (white lobelia)
- Thyme (purple bee and pink alyssum)

---from Edible Landscaping
be. Five to fifteen sheets of newspaper or one to three sheets of cardboard are usually sufficient, but you should experiment with the thickness. Be sure to greatly overlap the edges to prevent vining, runner-rooted plants from twisting up through the layered sheets. Try soaking the newspaper briefly, or soak the cardboard for an hour or so—it makes layering them easier. The safest paper to use is plain stock or paper printed only with black ink. Other colors of ink may contain toxic elements such as lead, cadmium, and mercury, which can be absorbed by your plants...(Kourik p. 12-13).

Once the pile is completed, planting takes the form of cutting an X through the paper or cardboard, placing a small quantity of loamy compost in the hole, and sowing a seed or transplanting a seedling into the compost.

The advantages of the no-dig method are very significant in that the beds can be constructed virtually anywhere, there is no digging—the soil is never disturbed, weeding is nearly eliminated—seeds may be translocated by birds or wind, and it offers a chance to recycle some of your household paper products. (Hirshberg and Calvan describe a similar method in which you can replace the paper layers with old clothes.)

Container Method. Containers can play an important part in food production—especially where garden space is limited. And although they are not really considered beds, flower pots, window boxes, garbage cans, planter, and wooden boxes can all be used to grow your favorite edibles. Simply mimic the sheet-composting techniques in the larger containers or add straight compost to potting soils in the smaller containers. Using
<table>
<thead>
<tr>
<th>CONTAINER</th>
<th>USE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIRES OR WATER-FILLED INNER TUBES</td>
<td>All vegetables and herbs</td>
</tr>
<tr>
<td>CEMENT BLOCKS</td>
<td>Herbs, small greens, onion family</td>
</tr>
<tr>
<td>CHIMNEY FLUE TILES</td>
<td>All vegetables; hanging/vining plants look decorative</td>
</tr>
<tr>
<td>BUSHEL BASKETS</td>
<td>Peppers, tomatoes, potatoes, squash; large plants</td>
</tr>
<tr>
<td>PEACH BASKETS</td>
<td>Dalikon radishes, carrots and other deep-rooted vegetables</td>
</tr>
<tr>
<td>WAXED CARTONS</td>
<td>All vegetables</td>
</tr>
<tr>
<td>WOODEN BOXES</td>
<td>All vegetables; small fruit</td>
</tr>
<tr>
<td>CRATES (mushrooms, onion, lettuce, etc.)</td>
<td>All vegetables; herbs when shallow</td>
</tr>
<tr>
<td>CARDBOARD BOXES (use with plastic)</td>
<td>All vegetables and herbs</td>
</tr>
<tr>
<td>DRUMS &amp; BARRELS</td>
<td>Anything, including dwarf trees; also good for mixed plantings</td>
</tr>
<tr>
<td>—Fleet drum</td>
<td></td>
</tr>
<tr>
<td>—Wine/whiskey barrel</td>
<td></td>
</tr>
<tr>
<td>—Ball/cow log</td>
<td></td>
</tr>
<tr>
<td>—Plastic/metal drum</td>
<td></td>
</tr>
<tr>
<td>1-GALLON MILK CARTONS</td>
<td>Herbs, onion family, leafy greens</td>
</tr>
<tr>
<td>1-GALLON PLASTIC JUGS (with tops cut off)</td>
<td>Herbs, onion family, leafy greens</td>
</tr>
<tr>
<td>2-GALLON BUCKETS</td>
<td>All but the largest vegetables</td>
</tr>
<tr>
<td>3-GALLON ICE CREAM Containers</td>
<td>All but the largest vegetables</td>
</tr>
<tr>
<td>5-GALLON PAULS</td>
<td>All vegetables and herbs</td>
</tr>
</tbody>
</table>

*Adapted from Penn State University’s Urban Gardening Program and the University of Illinois/Cooperative Extension’s Urban Gardening Program*
PORTABLE PLANTING CONTAINER from Organic Gardening

MATERIALS

LUMBER
6 pcs. ¾ x 7¼ x 21¾ (bottom)
12 pcs. ¾ x 7¼ x 23½ (side slats)
4 pcs. ¾ x 1½ x 25¾ (band)
4 pcs. ¾ x 2 x 26½ (cap)
16 pcs. ¾ x 1½ x 22¼ (battens)

HARDWARE
1 box galvanized wood screws #6 x 1½
12 to 16 galvanized wood screws #6 x 1½ (for side corners only)
4 corner braces, 3½
4 heavy-duty casters
CWF clearwood-finish for exterior wood, or other ultraviolet inhibitor
FUNCTIONS OF COMPOST from *How To Grow More Vegetables*:

*Improved Structure*—breaks up clay and clods, and binds together sandy soil. Helps make proper aeration in clayey and sandy soil possible.

*Moisture Retention*—holds 6 times its own weight in water. A soil with good organic matter content soaks up rain like a sponge and regulates the supply to plants. A soil stripped of organic matter resists water penetration thus leading to destructive compaction, erosion and flooding.

*Aeration*—plants can obtain 96% of the nutrients they need from the air! A loose healthy soil assists the exchange of nutrients and moisture. Carbon dioxide released by humus decomposition diffuses out of the soil and is absorbed by the canopy of leaves above in a raised bed miniclimate.

*Fertilization*—compost contains some nitrogen, phosphorus and potassium but is especially important for trace elements. The important principle is to return to the earth all which has been taken out by use of plant residues and manures.

*PH Buffer*—a good compost will lower the pH of an alkaline soil and raise the pH of an acid soil.

*Soil Toxin Neutralizer*—important recent studies show that plants grown in organically composted soils take up less lead and other urban pollutants.

*Nutrient Release*—Humic acids dissolve soil minerals and make them available to plants. As humus decomposed, it releases nutrients for plant uptake and for the soil microlife population.

*Food for Microbiotic Life*—good compost creates healthy conditions for soil organisms that live in the soil. Compost harbors earthworms and beneficial fungi that fight nematodes and other soil pests.

*The Ultimate in Recycling*—the earth provides us food, clothing, shelter, and we close the cycle in offering fertility, health, life through the shepherding of materials.
compost tea can also be helpful in a container situation (see section on composting). An additional advantage of containerizing is that the garden can become mobile—moved around the porch, patio, or lawn—to suit your decoration needs, to take advantage of the morning sun or afternoon shade, or to extend the growing season by moving indoors.

**Composting.** In nature, living things die and their death allows life to be reborn. Animal excretions and decaying plant and animal bodies serve as food for new organisms. In addition, compost improves the structure of the soil. As organisms decompose, they leave voids in the soil—allowing air and water to infiltrate. The combination of improved texture and nutrient supply produce a healthy or fertile soil. And a healthy soil produces healthy plants better able to resist insect and disease attacks. With a few simple steps, anyone can help to regenerate their earth—first, by building a compost pile and second, by incorporating the decomposed nutrient concentrate into the soil. No commercial fertilizers; no synthetic chemicals. Only soil, local wastes, a shovel, and perhaps some recycled materials for a container are needed. Compost keeps soil at a maximum health with a minimum expense.

**Quick Compost.** The basic recipe for compost is by weight: 1/3 dry vegetation, 1/3 green vegetation and kitchen wastes, and 1/3 soil piled in layers. The ground underneath the pile should be loosened to a depth of 12-24 inches to expose the bottom layer of the pile to bacteria and organisms in the soil and to provide good drainage. The materials should be added to the pile in one to two inch layers with the dry vegetation on the bottom, green vegetation and kitchen wastes second and a 1/4-1/2 inch layer of
EXISTING SOIL

LOOSENED OR FILL SOIL: CONTAINS HELPFUL MICROORGANISMS, TAMES UNPLEASANT ODORS, AND PREVENTS FLYING FROM LAYING EGGS IN THE GARBAGE.

TWIGS, SMALL BRANCHES, CORN AND SUNFLOWER STALKS.

DRY VEGETATION: DRIED AND SHREDDED LEAVES, GRASS CLIPPINGS, WOOD, PRUNINGS, ETC...PROVIDES CARBON SOURCE AND AIDS IN AERATION AND WATER INfiltrATION.

GREEN VEGETATION & KITCHEN WASTES: FRESH GRASS CLIPPINGS, WEEDS, TABLE SCRAPS (BONES, TEA LEAVES, COFFEE GROUNDS, CITRUS RINDS...EXCEPT MEAT AND OILY SALAD), ETC... PROVIDE NITROGEN SOURCE AND AID IN THE FERMENTATION PROCESS.
soil third—and repeat the process, with substantial waterings after each soil layer (Jeavons p. 30).

With the exception of the layering sequence, there is no magic arrangement for the pile. It is recommended that the minimum pile size be three feet by three feet by three feet in order to provide adequate insulation for proper heating; but in terms of containment, convenience and economics are the rules of thumb.

When using the quick compost method, one may want to increase the decomposition rate in the pile. One way is to increase the amount of nitrogen. Nitrogen serves as food for bacteria that help breakdown the materials in the pile—especially those materials that are high in carbon, such as wood. Simply add more materials high in nitrogen when fast results are necessary. (See Appendix A at the end of this chapter for a list of materials and their nutrient content.) A second way is to increase the amount of air—for certain helpful bacteria. Proper layering and periodic turning of the pile will accomplish this. However, if the pile becomes too dry as a result of turning, adding water is recommended. The third way to speed up the decomposition process is to increase the surface area of the materials. The smaller the size of the materials, the greater the amount of their exposed surface area. Breaking twigs and stalks before placing in the pile will usually suffice. However, larger materials may need to be run through a shredder first. Jeavons suggests that the compost is ready when it is dark and rich looking, “You should not be able to discern the original source of materials from the texture and the materials should crumble in your hands. Mature compost even smells
FOUR TYPES OF COMPOST PILES from *How To Grow More Vegetables*

- **pile**
- **pallet type**
- **large wire-fabric type**
- **modular box type**
good—like water in a forest spring."

The biggest advantage of quick compost is time. If the appropriate attention given, the quick process can produce ready to use humus in as little as ten days. In addition, since the materials are already decomposed, planting can take place immediately after application. However, though quick composting is an excellent method for recycling wastes, there are some materials, Jeavons urges, that one should avoid adding to the pile:

--Plants infected with a disease or a severe insect attack where eggs could be preserved or where the insects themselves could survive in spite of the compost pile's heat.
--Poisonous plants, such as oleander, hemlock, and castor bean, which harm soil life.
--Plants which take too long to break down, such as magnolia leaves.
--Plants which have acids toxic to other plants, such as eucalyptus leaves.
--Plants which may be too acidic or contain substances that interfere with the decomposition process, such as pine needles. Pine needles are extremely acidic and contain a form of kerosene. (Special compost piles are often made of acidic materials, such as pine needles and leaves, however. This compost will lower the soil's pH and stimulate acid loving plants like strawberries.)
--Ivy and succulents, which may not be killed in the heat of the decomposition process and can regrow when the compost is placed in a planting bed.
THREE-BIN COMPOSTER from Organic Gardening

PROCEDURE FOR BINS

Base. Nail a header to each end of the center floor joist, using 16d nails. Nail the outside joists, front and back, across the ends of the headers. Nail the brace blocks in place between the joists. Locate and nail the four short floorboards across the joists where the partitions will be located, using 8d nails, as shown.

Partitions. For each of the four partitions (two outside and two inside), nail six partition boards to connect two corner posts. Nail the inside door tracks to the partition boards, 1 inch back from the front corner posts.

MATERIALS FOR BINS

<table>
<thead>
<tr>
<th>LUMBER*</th>
<th>1 pc. 2 x 6 x 96&quot; (cut to fit for post blocks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 pc. 2 x 6 x 108&quot; (center joist)</td>
<td>14 pcs. 2 x 6 x 34½&quot; (floorboards)</td>
</tr>
<tr>
<td>2 pcs. 2 x 6 x 30&quot; (headers)</td>
<td>6 pcs. 1 x 6 x 11½&quot; (backboards)</td>
</tr>
<tr>
<td>2 pcs. 2 x 6 x 111&quot; (outside joists)</td>
<td>18 pcs. 1 x 6 x 33½&quot; (door slats)</td>
</tr>
<tr>
<td>2 pcs. 2 x 6 x 14¼&quot; (brace blocks)</td>
<td>3 pcs. 1 x 3 x 35½&quot; (door slats)</td>
</tr>
<tr>
<td>4 pcs. 1 x 6 x 33&quot; (short floor boards)</td>
<td>HARDWARE</td>
</tr>
<tr>
<td>8 pcs. 2 x 6 x 41½&quot; (corner posts)</td>
<td>22 carriage bolts ¼ x 3½&quot; with</td>
</tr>
<tr>
<td>24 pcs. 1 x 6 x 36&quot; (partition boards)</td>
<td>nuts and washers</td>
</tr>
<tr>
<td>6 pcs. 2 x 2 x 34&quot; (inside door tracks)</td>
<td>1 box galvanized nails 16d</td>
</tr>
<tr>
<td>2 pcs. 2 x 2 x 35½&quot; (outside door tracks)</td>
<td>1 box galvanized nails 8d</td>
</tr>
</tbody>
</table>
PROCEDURE FOR LIDS

Lids. Construct two of the three lids. Using a drill and galvanized screws, fasten six lid boards to the front and back battens; allow approximately 1/4 inch between boards. Each lid will measure 36 inches across. Construct the third lid in the same manner, but leave out the two middle boards.

Hatch. Fasten the hatch battens to the two remaining lid boards, one batten approximately 2 inches from the end of the boards and one batten 18 inches from the same end. Fasten the header batten to the boards, 20 inches from the end, just behind the back hatch batten. Cut between the header batten and the back hatch batten to separate the hatch. Fasten the two remaining boards and header batten to the partially constructed lid. Hinge the hatch to the lid.

Finish. Hinge the three lids to the bins with the 8-inch hinges, so that they are centered over the compartments. Attach a chain to the bottom of both end lids, at about the middle of the end boards, with screw eyes. Attach a chain to the bottom of both middle-lid end boards, as shown. Mount snap hooks on the ends of the chains. Locate and use a pliers to attach screw eyes to the bin partitions, as shown.

—Victoria Mattern

*Editor’s Note: If you prefer, use untreated pine rather than pressure-treated lumber. Paint with a low-toxicity preservative, such as copper naphthenate.

MATERIALS FOR LIDS

LUMBER*
18 pcs. 1 x 6 x 37" (lid boards)
3 pcs. 1 x 2 x 36" (front battens)
3 pcs. 1 x 2 x 34" (back battens)
2 pcs. 1 x 2 x 11 1/4" (hatch battens)
1 pc. 1 x 1 x 22" (header batten)

HARDWARE
6 strap hinges 8" (lids)
2 strap hinges 4" (hatch)
4 lengths jack chain, approximately 36" each

8 heavy screw eyes
4 snap hooks
1 box galvanized screws #6 x 1 1/4"

TOOLS
Electric drill
Saw (jigsaw or handsaw)
Hammer
Pliers

Floor. Nail the floorboards in place across the joints. (There will be five for each of the two end compartments and four for the middle compartment.)

Back. Nail the backboards in place, covering back corner posts.

Front. Feed door slats horizontally into door tracks.

Nail the outside door tracks flush with the front of the two interior partitions. Position the assembled partitions—one on each end of the base and one on each side of the interior compartment: drill and bolt the corner posts to the outside joists.

Post Blocks. Cut the 2 x 6 in three pieces, to fit snugly between the bottoms of the front corner posts. Bolt the post blocks in place, flush with the floor surface.
--Pernicious weeds such as wild morning glory and bermuda grass, which will probably not be killed in the decomposition process and which will choke out other plants when they resprout after the compost is placed in a planting bed.

--Cat and dog manures, which can contain pathogen harmful to children. These pathogens are not always killed in the heat of the compost.

*Long-Term Compost.* Once all of your planting beds have been regenerated with the initial quick compost, you will not need to spend as much time preparing the compost. Larger piles consisting of unchopped materials and substances that require longer decomposition time—such as manure and other elements listed in the to-avoid category for quick compost—can be established. The larger piles are layered the same way, but are only turned once and are made with a flat top in order to collect rain water. Covering the top with a layer of straw is recommended to conserve moisture.

*Sheet Compost.* Another method of introducing nutrients into the soil is by spreading uncomposted organic materials over the soil and then digging them into the soil where they decompose. The advantage of this method is that extra space for storing compost is not required; however, the soil is unusable for at least three months because the nitrogen is not available to the plants during the decomposition process (Hirshberg, Calvan p. 35). If this method is used, the application of organic material should take place on empty beds during the winter months so as not to impede the growing season.
Green Manure Compost. A green manure is a crop planted expressly to produce organic material that will be turned into the soil. Crops such as alfalfa, vetch, clover, bean, pea, or similar legumes fix nitrogen, making it available to other plants. In addition, many legumes are deep-rooted, drawing important nutrients from deep within the soil and helping to break up compacted soils as their roots decay. And although this method does protect the soil from erosion and allows for extended solar gain during the cold season, like sheet composting, green manures can impede the growing season. However, if used along with a crop rotation plan, green manure composting becomes a feasible method for regenerating the soil.

Anaerobic Compost. The only materials needed to begin this method are a large sheet of plastic and some organic waste. Although any plastic will work, black plastic is recommended because black encourages the heating process. Simply lay the plastic on the ground; layer all compostables on or in the plastic; dampen ingredients if not already thoroughly moist; pull the top over the pile; and bank dirt up around the edges to seal off air. As soon as air is kept out, decomposition begins to work (Britz p. 159).

This process can also be used inside a plastic bag, box, drum, or garbage can. The important thing is to seal compost off from air. Other than that, there are no major complications—requires no soil; no turning; has no odors; and takes only four to eight weeks to create non-leached, high-bulk compost. In fact, this method could take place within the dwelling if choosing only to use kitchen wastes as the source of organic material.
Worm Culture Compost. The science of raising earthworms is known as vermiculture. And the conversion of organic wastes into castings, or excretions from earthworms, is known as anelidic consumption (Britz p. 160). Worms have the capacity to turn kitchen wastes—such as spoiled food, fruit rinds, coffee grounds, vegetable peels, eggshells—into a rich, valuable plant fertilizer. Anelidic consumption is a no-odor, pest-free, low-cost, low-maintenance method of recycling organic wastes. And like other composts, it replaces chemical fertilizers, poses not threat to groundwater and surface water contamination, and promotes life in soil.

The red worm (lumbicus rubellus) is most ideally suited for intensive culture. This is because the red worm grows well in small areas, thrives in high population censities, is a prolific breeder, and is able to utilize a wide variety of foods. In addition to the kitchen wastes listed above, worms feed on dairy manure, rabbit manure, shredded wet cardboard, non-resinous wood shavings, wet newspapers, garden foliage, deciduous leaves, orchard wastes, sheep and goat manure, wood stove ashes, sewer sludge, peat moss, crushed cottonseed and sunflower hulls, chopped hay or straw, and grass clippings (Britz p. 161).

As one can see, worms are living garbage disposals. However, like any fine-tuned machine, worms need occasional maintenance and come with care manuals. In his book The Edible City Resource Manual, Richard Britz offers a list of precautions:

--Need adequate moisture (not soggy) for respiration, digestion, excretion, and movement.
--Aerate these food and bedding wastes once a month [or more] after placement in worm bed, with 5-6 spline pitchfork.

--Worms are light-sensitive (to ultraviolet light). When exposed for one hour, will become paralyzed; in two hours, will die. (Keep bed covered when not maintaining beds.)

--The bed temperature should be between 55\(^\circ\) and 100\(^\circ\) F (ideally 60\(^\circ\)-75\(^\circ\)) for the worms to be active feeders. Their waste consumption drops considerably between December and February due to low bed temperatures. Insulate the bed well (preferably place inside building) and feed one foot of manure in winter to keep consumption progressing....

--Maintain a pH of between 6.8 and 7.2 (near neutral) within bed....

--Worms have no teeth. They absorb food directly into gizzard, crop, and stomachs. They must have moist, partially decomposed food, chopped and shredded as much as possible....Place your chopped organics in one corner of bed or in a separate container for initial decomposition, then add to worm bed after it passes the heating stage. (Minute amounts of alcohol by-products and methane gas are harmful to worm's digestive tract.)

--Most of your leftover kitchen scraps can be added directly to bed, but chop solid particles. Do not add banana peels because of chemical sprays on skins [unless organically grown--without chemicals].

--Do not use citrus, pine, black walnut, siquoia, cypress, or cedar leaves or needles; they give off tannic acid or resinous sap.

--Preferably, most manure (with the exception of rabbit manure), less than two years old, should be leached (soaked in water) ahead
of time to reduce acidity and salt content.

--Animal fats/oils coat the digestive tract; don't use.

**Compost Tea.** Another way to add organic matter to the soil is to apply the nutrients while watering. This method is especially appropriate for small containerized and indoor plants. Simply measure four to five cups of manure into a burlap bag and tie it closed. Place the bag into a bucket and fill to the top with water. Let sit over night, pull out the bag the next day, let bags drain, and use tea directly on plants. The tea bags are reusable for two to three more batches of manure tea. Caution, if the tea looks very dark or very strong, dilute it with water, so as not to burn the plants' roots (Britz p. 28).

**Burn Compost.** A final method of replenishing the soil with nutrients is to burn the plant wastes. This concentrates the nutrients and breaks down the wastes immediately. This method saves time and space. However, if hot enough temperatures are not achieved to kill dormant seeds, the burning may actually increase weed activity. In addition, local ordinances may prohibit burning.

**Mulching.** A mulch refers to any material that is put directly on the garden surface to conserve moisture, inhibit weed growth, moderate temperature, and--if the mulch is of an organic origin--to add organic matter as it decomposes. There are two basic types of mulches, organic and inorganic. Organic mulches include wood and bark chips, straw, grass clippings, and seed hulls. Inorganic mulches include polyethylene film, landscape fabrics, fiber mats, and gravel. (See Appendix B for a more
complete list of mulches and their characteristics.) The ideal mulch does not compact readily. It does not impede air and water movement, is not a fire hazard, and breaks down slowly. In addition, the ideal mulch is uniform in color, weed free and attractive, and will not blow away.

**Inorganic Mulches.** The advantages of inorganic mulches rest in their relative inexpensiveness, their excellence in weed control, their longevity, their uniform appearance, and their ease of application, dismantling, and transportation (with the exception of gravels). Unfortunately, the disadvantages seem to outweigh the advantages. Although they are excellent weed suppressants, plastics reduce air and water penetration into the soil. In addition, plastics create an environment that promotes shallow root growth—thus subjecting plants to severe stress from both heat and cold. And although fabrics are less susceptible to these problems, the higher costs may inhibit their use—especially if substantial coverage is necessary. And while gravels may be more cost-effective, they can become near permanent fixtures after compaction (Feucht, Butler. p. 105-107).

**Organic Mulches.** Although there are many materials used as organic mulches, all of them can be categorized into two groups, permanent mulches and living mulches. Permanent mulch is somewhat of a deceptive term, for these mulches do not last forever; rather, permanent means that they stay in place year after year not tilled in, but renewed annually to maintain the adequate thickness of four to six inches. Permanent mulches are much more representative of natural processes than inorganic mulches. In nature, organic matter falls to the ground, accumulates, and
decomposes; and although much slower than composts, permanent mulching is a way of stimulating this process and maintaining the nutrient supply in a good soil (Hirshberg, Calvan p. 114-115).

Living mulches, on the other hand, are even more representative of natural processes. A living mulch is an established cover crop into which a food crop is planted. The cover crops are pretty much the same as those listed under green manures; except, these crops are usually not tilled under. Dead mulches obviously have to come from somewhere; either they’re grown on the farm, harvested, and applied, or they’re transported in from outside. A living mulch grows on site and provides nutrients to crops growing in the same field or bed. One might say that living mulches are more PERMANENT than permanent mulches. Once established, the only maintenance required is an occasional mowing before the growing season, and that’s only if the cover is anticipated to compete for sunlight or moisture.

The ideal living mulch is a low growing perennial plant that will make a dense cover to control weeds, will overwinter well, and requires less moisture than the food crop. It is important to realize though, that this method may be difficult on raised beds due to the annual digging and/or compost applications, unless you find that the harvests are not diminishing and the soils not compacting (Hirshberg, Calvan p. 114-115).

Successional Planting. Another important aspect of mini-farming is successional planting. This means keeping all your garden space in use throughout the growing season by following one crop with another. Plant a
fall crop in the same place that a spring or summer crop was planted. There are lots of possibilities. In *Gardening for all Seasons*, Gary Hirshberg and Tracy Calvan offer a few examples:

--- Early cabbage followed by late lettuce.
--- Early lettuce followed by beets or carrots for fall use and winter storage.
--- Early bush beans followed by broccoli, cauliflower, or kale seedlings.
--- Earliest corn followed by bush beans.
--- Peas followed by cucumbers.
--- Spinach followed by okra started in peat pots.
--- Radishes followed by dill.
--- Early beets followed by Chinese cabbage.

*Catch Cropping.* In addition to following early crops with late crops, you might try slipping in a quick crop while a slower one is maturing. Plant lettuce, spinach, or radishes around your small tomato, eggplant, okra, or pepper plants and have the early crop out of the way before the later crop needs the space. Also, early bush beans can be grown under corn (Hirshberg, Calvan p. 117). The important thing is to keep your growing space in use. (See Appendix C for a planting table and Appendix I for maturation times for common plants.)

*Companion Planting.* Companion planting is planting together certain crops that enhance one another’s growth or protect one another from pests. According to Jeavons, for example, green beans and strawberries
thrive better when they are grown together than when they are grown separately. And to get a really good bibb lettuce, one spinach plant should be grown with ever four bibb plants. However, it is not enough to simply consider which plants grow well together. Certain plants like tomatoes are narcissistic. They like to be grown in compost made from their own bodies. They also like to be grown in the same place for a five year period. Jeavons also says that some plants are even offensive to others. For instance, no plants grow well near wormwood due to its toxic leaf and root excretions.

Companion planting is a complex field. A healthy relationship may exist between two plants in your neighborhood, but not in mine. Or an unhealthy relationship may occur at a given ratio of plants, and be healthy by merely offsetting the balance slightly. But one thing is certain; all plants have their place in the natural order of things. It's a matter of realizing the signs and relationships. Jeavons offers some companion planting techniques that you might try and experience.

*Health Relationships.* The growing together of green beans and strawberries and bibb lettuce and spinach has already been mentioned. On the other hand, onions seriously inhibit the growth of beans and peas. And somewhere in the middle, bush beans and beets can coexist without any apparent side effects—good or bad. However, there are a few plants that seem to be helpful to all others. (See Appendices G and H for companion planting guidelines.) Jeavons' list is below:

---Lemon Balm. Creates a beneficial atmosphere around itself and
attracts bees. Part of the mint family.

--Marjoram. Has a 'beneficial effect on surrounding plants.'

--Oregano. Has a 'beneficial effect on surrounding plants'.

--Stinging Nettle (Urtica dioica). 'Helps neighboring plants to grow more resistant to spoiling.' Increases essential oil content in many herbs. 'Stimulates humus formation.' Helps stimulate fermentation in compost piles. As a tea, promotes plant growth and helps strengthen plants. Concentrates sulfur, potassium, calcium and iron in its body.

--Valerian (Valeriana officinalis). 'Helps most vegetables.' Stimulates phosphorus activity in its vicinity. Encourages health and disease resistance in plants.

--Chamomile (Chamomile officinalis). A lime specialist. 'Contains a growth hormone which...stimulates the growth of yeast.' In a 1:100 ratio helps growth of wheat. As a tea, combats diseases in young plants such as damping off. Concentrates calcium, sulfur and potash in its body.

--Dandelion (Taraxacum officinale). 'Increases aromatic quality of all herbs.' 'In small amounts' helps most vegetables. Concentrates potash in its body.

--Oak Bark. Concentrates calcium in its bark (bark is 77% calcium). In a special tea, it helps plants resist harmful diseases. The oak tree provides a beneficial influence around it which allows excellent soil to be produced underneath its branches. An excellent place to build a compost pile for the same reason, but keep the pile at least 6 feet from the tree trunk so an environment will not be created near the tree which is conducive to disease or
attractive to harmful insects.

Note: Lemon balm, marjoram, oregano, and valerian are perennials. They are traditionally planted in a section along one end of the bed so they need not be disturbed when the bed is replanted.

There are plants that we call weeds, like Stinging Nettle and Sow Thistle, that take very well to sterile soil which needs to be built up. Weeds are good indicators of poor soils. Instead of eradicating, try allowing them to grow for a season or two. Weeds are able to draw phosphorus, potash, calcium, trace minerals, and other nutrients from deep within the soil and concentrate them in their bodies. Use dead weeds in compost to return the nutrients back to the soil. Or let the weeds draw noxious elements out of the soil, discard, and then plant your edibles.

Nutritional Relationships Over Time. Some plants take nutrients from the soil and some give back to the soil. If a plant that takes from the soil is planted in the same area year after year, the soil can be depleted of its nutrients, or become infertile. The soil must be regenerated before healthy plants can survive. This is often the case with monocultures such as corn. On the other hand, if plants that take are followed by plants that give, a healthy balance is achieved, and the soil can sustain life for an indefinite length of time. Today's farmers have only recently rediscovered this ancient technology of crop rotation. Heavy feeders are followed by heavy givers and then by light feeders. And the process is repeated. Jeavons calls this approach agricultural recycling a process in which man and plants return to the soil what they have taken out. This approach fits especially well with the successional planting concept. (See Appendix I
for a list of common feeders and givers.)

*Nutritional Relationships In Space.* As an alternative to crop rotation, feeders and givers can be grown together in a single season. For example, corn, beans, and beets can be intermingled in the same bed. This approach can be complex. Not only do you have to find the right combination of feeders and givers, but you need to take into account the health relationships mentioned above. For instance, the beans in the corn-bean-beet trio must be bush beans since pole beans and beets are not compatible. However, if a corn-bean-carrot trio were established, then the pole beans would do fine. In his book Jeavons gives an equation for figuring out proper spacings in polycultures so as to avoid competition for sunlight due to the varying plant heights; simply add each of the spacings for the individual plant types together and divide by the number of types. Perhaps an easier and equally effective method of companion planting in space is to divide your planting bed into separate sections for each vegetable, and plant feeders and givers next to each other. (See diagram.)

*Sun-Shade Relationships.* Each plant has different requirements for the amount of sun they need, or don't need. Cucumbers, for example, are very hard to please. They like heat, moisture, a well drained soil, and some shade. Jeavons suggests that one way to provide these conditions is to grow cucumbers with corn. The corn has similar temperature, soil, and moisture requirements, but needs the sun. The taller corn reaches for the sun, while the cucumbers nestle below in the shade of the stalks.
Circles show average root growth diameters

A spacing example for 3 crops grown together—corn (a heavy feeder), bush beans (a heavy giver) and beets (a light feeder)—is given below. You should note that this approach to companion planting in space uses more bush bean and beet plants than corn and also contains some gaps in which still more bush beans and beets can be planted.
MULTI-CROP COMPANION PLANTING “IN SPACE”

An easier, and probably just as effective method of companion planting “in space” is to divide your planting bed into separate sections (or beds within a bed) for each vegetable. In this method, a grouping of corn plants would be next to a group of bush beans and a group of beets. In reality, this is a kind of companion plant “over time” since there are heavy feeder, heavy giver and light feeder sections within a bed. Plant roots extend 1 to 4 feet around themselves, so it is also companion planting “in space”. We recommend you use this approach. Additional spacing patterns no doubt exist and will be developed for companion planting “in space”.

Shallow-Deep Root Relationships. Not only do plants differ in height above the ground, but roots also vary in length and breadth. Some root systems are shallow and others are deep. And if grown together, plants with varying root depths and breadths can coexist without competing for space and nutrients.

Fast-Slow Maturation Relationships. Jeavons says that the French intensive gardeners were able to grow as many as four crops in a growing bed at one time due to the staggered growth and maturation rates of different vegetables. The fact that the edible portions of the plants appear in different vertical locations also helped. Radishes, carrots, lettuce, and cauliflower were grown together in such a combination. (See Appendix I.)

Weed Control Relationships. Some plants, like beets and cabbage, are slowed down significantly by the presence of weeds. To minimize the weed problem, you can grow other plants during the previous season, or along with the food crop, that discourage weed growth. In his book How To Make $100,000 Farming 25 Acres, Booker T. Whatley discusses what are called allelopathic mulches--plants such as annual rye, sunflowers, sorghum, and oats that release substances that are toxic to other plants. These toxins inhibit germination and growth of weeds, benefitting the source plants and, if the grower plays his cards right, the cash crop. According to Whatley, allelopathic mulches can be twice as potent as 2,4-D. Most of the crops listed above, are traditionally row crops and are used here as cover crops. However, Jeavons suggests several other weed fighting plants that may perhaps be better suited for your growing beds--
like kale, rape, and the Mexican Marigold. He also cautions that one should be careful to test the soil after harvesting weed killers like Mexican Marigold due to the fact that some allelopathic mulches are so toxic as to contaminate edibles, too.

*Insect/Pest Control Relationships.* At least two elements are important in companion planting for insect control. Older plants with well developed aroma and essential oil accumulations should be used. You want the insects to know the plant is there. Second, it is important to use a large variety of herbs. "There are at least five different herbs that discourage the Cabbage Worm Butterfly, "Jeavons says, "and one herb may work better than another in your area." The more unpleasant plants there are in a garden, the sooner harmful insects will get the idea that your garden is not a pleasant place to eat and propagate. This approach is somewhat touchy in that the number of plants used may make or break your harvest. Too few plants will not control an insect problem and too many may reduce your yields. (See Appendices J1, J2, and K for a more complete list.) Below is a short list of insect controls from Jeavon’s book:

---White flies: Marigolds (but not Pot Marigold (Calendula)) and Flowering Tobacco. The first is supposed to excrete substances from its roots which are absorbed by the other when the White Flies suck on the other plants, they think they are on a bad tasting marigold and leave. The Flowering Tabacco plant has a sticky substance on the underside of leaves where White Flies stick and die when they come there for a meal.

---Ants: Spearmint, Tansy and Pennyroyal. (Mint often attracts White
Flies so you may want to grow a few Marigolds around for control, but not so many as to possibly impair the taste of the mint and certainly not one of the more poisonous Marigolds. This is another area for compromise. A few insects are probably less of a problem than mint with a strange taste.)

--Nematodes and Root Pests: Mexican Marigold (Tagetes minuta) 'eliminates all kinds of destructive eelworms...wireworms, millepedes and various root eating pests from its vicinity.' The French marigold (Tagetes patula) eliminates some 'plant-destroying nematodes...at up to a range of three feet...The beneficial...eelworms which do not feed on healthy roots were not affected'.

--Aphids: Yellow Nasturtiums are a decoy for Black Aphids. They may be planted at the base of tomatoes for this purpose. Remove the plants and aphids before the insects begin to produce young with wings. Spearmint, 'Stinging Nettle, Southernwood and Garlic also help repel aphids.

--Tomato Worms: Borage reportedly helps repel tomato worms and/or serves as a decoy. It also attracts bees.

--Gophers: Elderberry cuttings placed in gopher holes and runs reportedly repel these animals. Daffodils, castor beans and Euphorbia lathyris are all poisonous to gophers. Be careful with the latter two, however, as they are also very toxic to children.

_Birds-Bees-Animals Relationships._ The right combination of plants can provide an environment pleasing to helpful birds and insects. Hummingbirds and Bees can be lured to your garden to help pollinate your
EXAMPLES OF COMPANION PLANTING from How To Grow More Vegetables

Staggering early and tomatoes. Good garden companions.

Beans can provide the shade which cucumbers enjoy.

Snow and sprouts with lettuce is one example of shallow/deep cropping.

Lettuce plants can be nestled among other larger plants for partial shade.

Birds and plants can work together too. The flowers plant seeks attract the bees which eat eggs from the cabbage.
food crops. Or seed plants can be used to attract omnivorous birds who will stay for a main course of insects after a seed snack. It is also possible, if you study plant-animal relationships long enough, to propagate varieties that are more desirable to pests than your food crops. Or perhaps, if the room is available, you might simply plant extra amounts to make up for any yields that might be lost. As an aside, you might consider the fertilizing attributes of using animals to control garden pests. Geese and chicken provide weed and insect control while adding organic matter to the soil through their excretions. (See Appendix M for a brief list of bird-attracting plants.)

Companion planting in all its aspects can be a complex and often mind boggling exercise. Discovering nature's secrets can be an exciting experience. But don't let too much thinking spoil the fun.

Astronomic Planting. Planting seeds and transplanting seedlings by the phases of the moon is perhaps one of the most controversial aspects of mini-farming. Some gardeners and farmers swear by it while others remain skeptical. You may choose to think of this approach as another one of nature's secrets. According to Jeavons, planting by the phases of the moon is a nuance which improves the health and quality of plants. However, if you do not follow the moon cycles, your plants will still grow satisfactorily. Below, he explains how the process works:

Looking at the drawing, you can see that there are both increasing and decreasing lunar gravitational and light force influences that recur periodically during the lunar month. Sometimes the forces
work against each other and sometimes they reinforce one another. When the lunar gravitational pull decreases and the amount of moonlight increases during the first 7 days, plants undergo a period of balanced growth. The decreasing lunar gravity (and the corresponding relative increase in the earth's gravity) stimulates root growth. At the same time, the increasing amount of moonlight stimulates leaf growth.

During the second 7 days, the lunar gravitational force reverses its relative direction and increases. This pull slows down the root growth as the earth's relative gravitational pull is lessened. The moonlight, on the other hand, continues to a peak and leaf growth is especially stimulated. If root growth has been sufficient during previous periods, then the proper amounts of nutriment and water will be conveyed to the above ground part of the plant and balanced, uninterrupted growth will occur. In this time of increasing gravitational, moonlight and magnetic forces, seeds which have not yet germinated receive a special boost from nature. If they did not germinate at the time of the New Moon, they should do so by the Full Moon. It is during this period that Alan Chadwick says seeds cannot resist coming up and in which mushrooms suddenly appear overnight.

During the third seven days, the amount of moonlight decreases along with the lunar gravitational pull. As the moonlight decreases, the above ground leaf growth slows down. The root growth is stimulated again, however, as the lunar gravitational pull decreases. This is a good time to transplant, since the root growth is active.